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A systematic literature review of empirical studies and agenda for further research

Raffaella Manzini, Akhatjon Nasullaev*

Abstract

This paper presents a systematic literature review of empirical studies on Technology intelligence with an objective to identify main characteristics and trends of the literature on the implementation of Technology intelligence. To achieve this, we reviewed 138 documents systematically (following a scientifically robust methodology) in terms of research methodology, research context and content. Citation network analysis was adopted to generate thematic clusters. The presented investigation provides (i) an overview of the methodologies used in literature and the types of empirical studies (case studies, surveys, evolution investigations, interviews, experiments, etc.) as well as the related diffusion; (ii) a summary of the research content (topics, thematic areas) in the practice of Technology intelligence; (iii) a picture of the various contexts and levels in which the practice of Technology intelligence has been studied (industries, sectors, technologies, countries). The paper also draws some conclusions in terms of managerial implications and areas for future research.

1. Introduction

While the strategic importance of understanding technological changes for the sake of successful business is burgeoning, the ability to analyze external environment, forecast current and future technology trends have never been significant as now. Hence, companies which keep abreast of the latest technological information tend to be more innovative and competitive (Kerr et al., 2006; Dang et al., 2010; Mortara et al., 2008; Yoon and Kim, 2012). This is even more substantial in the era of Open Innovation, as openness requires having information about the competitive context, the potential partners, the evolution of existing and emerging technologies, the risk of technological discontinuities and the needs of present and potential customers (Manzini et al., 2016). “Smart organizations do not wait for change to happen but actively monitor and take advantage of changing environments and new innovations” (Chesbrough, 2003). According to Reger (2001), “in theory and practice there is a considerable agreement about the importance of an accurate and early anticipation of future needs and technological developments/trends”. Systematic technology management ensures the companies to anticipate the direction and impact of technological change, to react to technology-based threats and opportunities in timely manner and benefit from them

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(Utterback and Brown, 1972; Arman and Foden, 2010). Being one of the core processes of technology management, Technology Intelligence (TI) intends to identify promising niches of technologies. In addition to this, as defined by Kerr et al. (2006), TI aims to "capture and delivery of technological information as part of the process whereby an organization develops an awareness of technology threats and opportunities". But this is not the only purpose of TI. Companies also do TI to have a knowledge about the social and cultural context where the technology is meant to be applied, to generate new ideas, to open the company to outside world and find strategic partners and so on (Maya, 2015). In the growing body of the literature one can find various terms to define the activity of analyzing and evaluating technological information, such as *TI* (Brockhoff, 1991; Ashton and Klavans, 1997; Norling et al., 2000; Lichtenthaler, 2003, Savioz et al., 2003; Porter, 2005; Kerr et al., 2006), *Technology forecasting* (Wissema, 1982; Prasad and Somasekhara, 1990; Tschirky, 1994; Du Preez and Pistorius, 1999; Savioz and Blum, 2002; Daim et al., 2006; Robinson et al., 2013), *Technology monitoring* (Nosella et al., 2008; Lee et al., 2011), *Technology scouting* (Wolff, 1992; Rohrbeck, 2010) and so on. The term of TI is widely diffused and generally accepted in the current literature; therefore in this paper we refer to it.

The concept of TI has existed for more than four decades. Already from 1970's several authors called for a more systematic observation of technological trends (Lichtenthaler, 2004). With the emergence of recent developments in science and technology, interest in TI was revitalized. Although the essence and role of the TI is very well recognized and realized by managers, more and more companies are failing in their strategies while implementing this powerful tool (Iansiti, 2000; Lichtenthaler, 2003). The first and foremost reason of this failure is, companies lack systematic methodology of organization of TI, as in most companies it tend to be carried out haphazardly and spontaneously (Lichtenthaler, 2007; Ranjbar and Tavakoli, 2015). Furthermore, operationalization of TI requires resources, competences and capabilities of what not all companies may possess, especially small and newly established firms. For instance, Mortara (2015) highlighted communication incompetence of decision-makers and intelligence analysts as one of the obstacles of TI. What is more, traditional TI, monitoring and scanning processes in companies are largely arbitrary and contingent on the informal information (Arman and Foden, 2010). This entire puts in force the necessity of formal practical investigations that would serve as a guideline for managers.

Hitherto a lot of studies have been carried out on various aspects of TI and one can follow a growing interest in this area of research. For instance, a search engine Scopus gives 1457 publications obtained from a combination of several keywords relevant to the TI concept. But very limited work (138 articles respectively) has been dedicated to the empirical study of TI. Furthermore, to our best of knowledge any large-scale systematic review of empirical evidence has not been conducted so far in this research domain. This paper tries to fill that gap. By pursuing a systematic literature review of practice of TI, current study aims to identify main characteristics and trends of the literature on the implementation of TI. This investigation will enhance our understanding of TI in practice by answering two research questions:

1. What are the main characteristics and trends of literature on the implementation of TI and what research gaps can be identified from them?
2. How do these empirical studies can be utilized by managers and practitioners towards successful implementation of TI in companies?

Particularly, the present study provides the following findings: (i) an overview of the methodology used in available literature and the types of empirical studies (case studies, surveys, evolution investigations, interviews, experiments, etc.) as well as the related diffusion; (ii) a summary of the research content (topics, thematic areas) in the practice of TI; (iii) a picture of the various contexts and levels in which the practice of TI has been studied (industries, sectors, technologies, countries). The paper also draws some conclusions in terms of managerial implications and areas for future research.

This paper begins by explaining the methodology. It will then go on to the findings of the analysis by presenting the general characteristics of the considered literature, the research design, context and content. The last part of the paper discusses the major findings and proposes an agenda for future research.

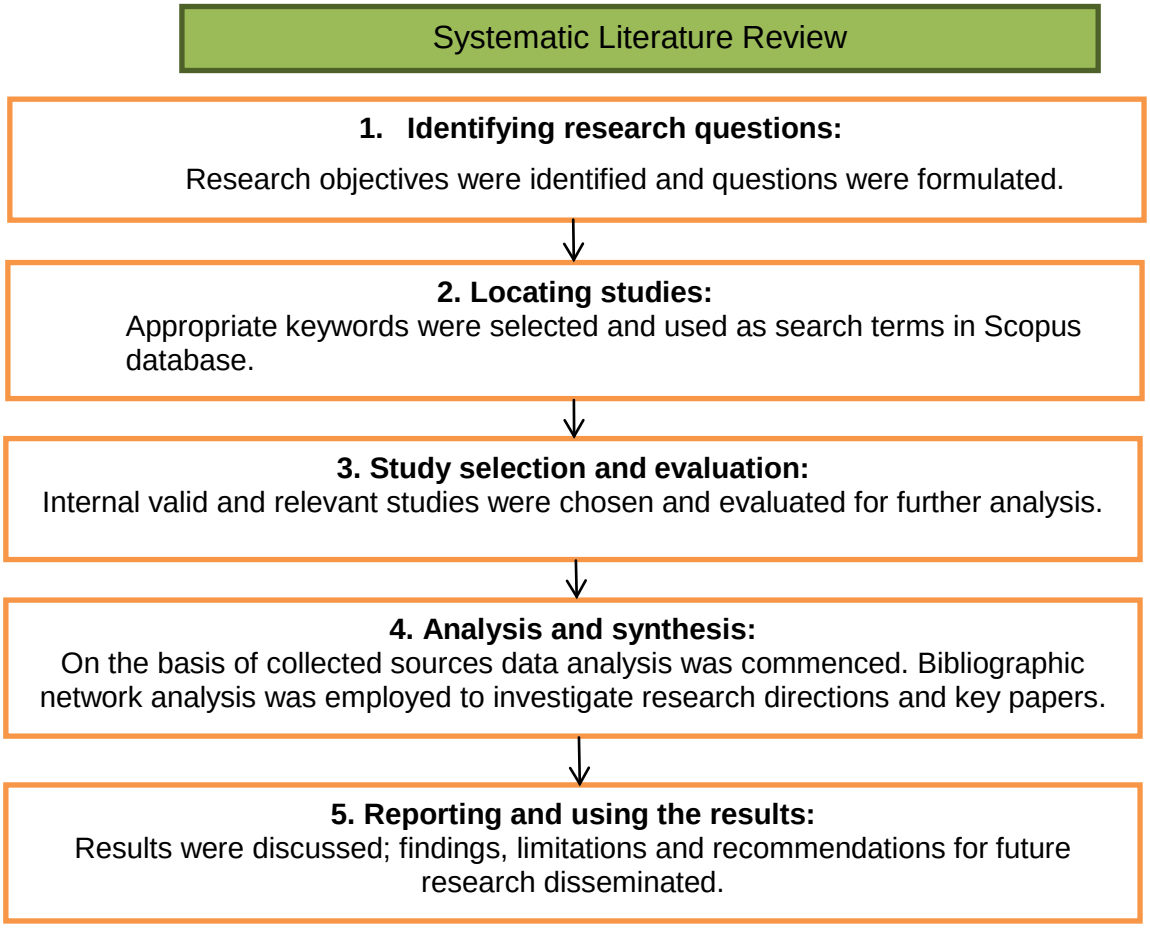
2. Methodology

This study adopts systematic literature review proposed by Denyer and Tranfield (2009) because of its “transparency, inclusivity, explanatory and heuristic nature”. Indeed, according to the authors, this type of review is well suited for management and organizational studies. Current paper follows the guidelines recommended by the authors and the Figure 1 describes the proposed steps of systematic literature review.

2.1 Question formulation

This study sets out to investigate the concept of TI from empirical point of view. As it was stated in the introduction part the practical nature of TI remains unclear in contemporary literature and this paper purposes to mitigate this gap. On the first stage of systematic literature review we identified research objectives through outlining the protocol of the study based on the theoretical background of the investigated topic. Then research questions were formulated and tested using Denyer and Tranfield's (2008) CIMO (Context, Intervention, Mechanism and Outcome) logic for validity and preciseness.

Figure 1



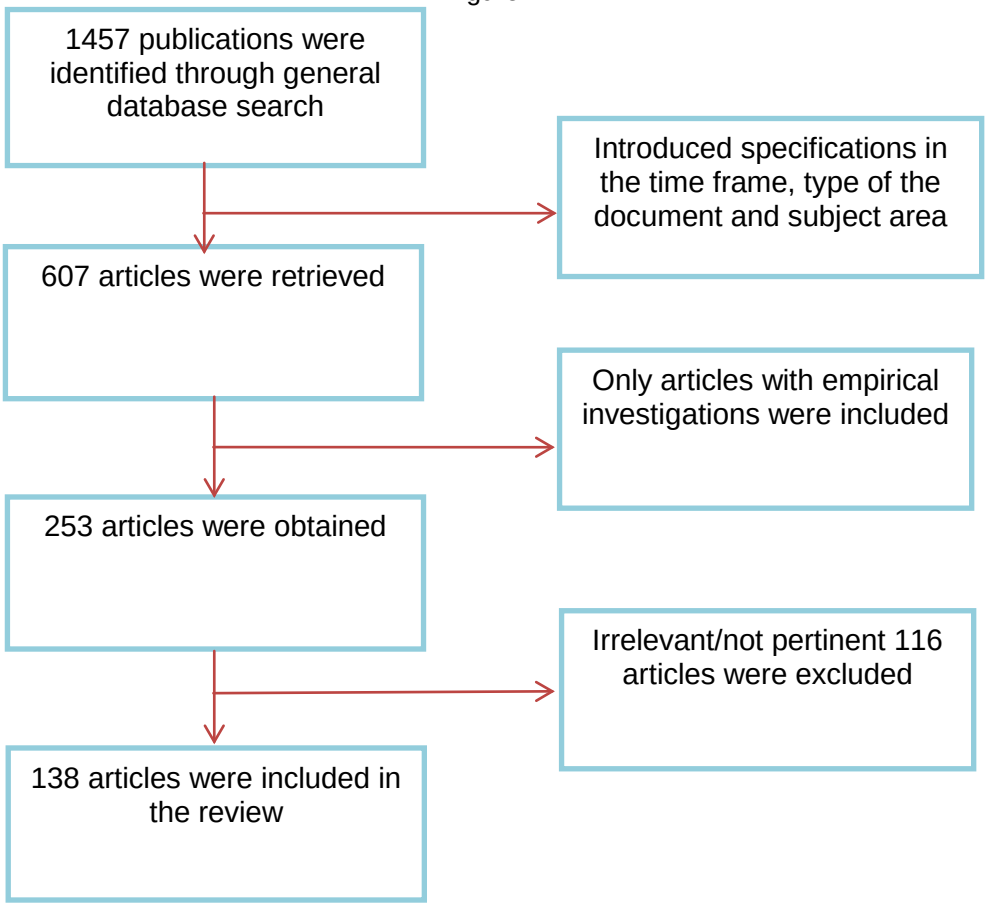
2.2 Locating the studies

On the next stage we identified appropriate keywords for bibliometric search in Scopus database, the largest source of high-quality publications. As the term “Technology Intelligence” has different synonyms in the literature, such as “Technology foresight”, “Technology scouting”, “Technology scanning”, “Technology forecasting”, “Technology monitoring”, all of them were included in search query. The search in the database was conducted in late March of 2017. At first the database provided 1457 publications which have aforementioned terms their title, abstract and/or keywords. Then we decided to introduce some specifications and restrictions in our search query. For instance, we aimed to search only peer-reviewed journal articles as they are usually considered as the most reliable sources. We restricted the timeframe to published articles from 1987 to onwards in order to see a 40 year trend. Moreover, articles only in business; management, accounting and economics; engineering; economics, econometrics and finance; social sciences and decision-sciences subject areas were included to avoid irrelevant results. As an outcome we retrieved 607 documents from the database. Since our primary concern was to analyze the literature with empirical investigations in TI, we refined our search query and introduced terms such as “empirical”, “survey”, “case-study”, “practice” and “quantitative” to be appeared within the fields of title, abstract or/and keywords. The search result gave us 253 documents and they were considered for further analysis.

2.3 Study selection and evaluation

Selected 253 articles were assessed according to following criteria: (i) if the paper treat TI or concept close to this area as a major source; (ii) if the paper includes an empirical investigation. For fulfilling these criteria we screened the abstracts of the papers. In cases where the abstracts were very restricted, difficult to understand or too ambiguous we referred to the entire articles. Finally 138 articles were chosen as “key studies” to be investigated in-depth in this systematic literature review. Figure 2 describes second and third steps in the form of flowchart:

Figure 2



2.4 Analysis and synthesis

The selected literature was analyzed in following steps. Initially, we provided general overview of the articles by their publication journals, geography and trend. Then we went on with synthesis of research design (methodology) of papers by grouping them according to categorization schema of Orlikowski and Baroudi (1991) of conceptual and empirical literature. Meanwhile, findings in terms of level of analysis and number of cases studied in the literature were provided in this step. Afterwards we explored the research context by identifying the countries where the data was collected and technology or industries on what the studies were focused. We applied non-statistical methods to track all of these aforementioned steps. Then in order to investigate the research content we applied citation network analysis using software Pajek. Louvain method of community detection retrieved six clusters and each of them was analyzed in-depth. In order to identify the dynamic perspective and to investigate the key studies thoroughly we conducted a main path analysis.

2.5 Reporting and using results

The final stage of the literature review provides discussion of the main results. Then we outline academic and managerial implications of the study and limitations. We conclude the study with the agenda for future research.

3. Results

General characteristics of the included studies

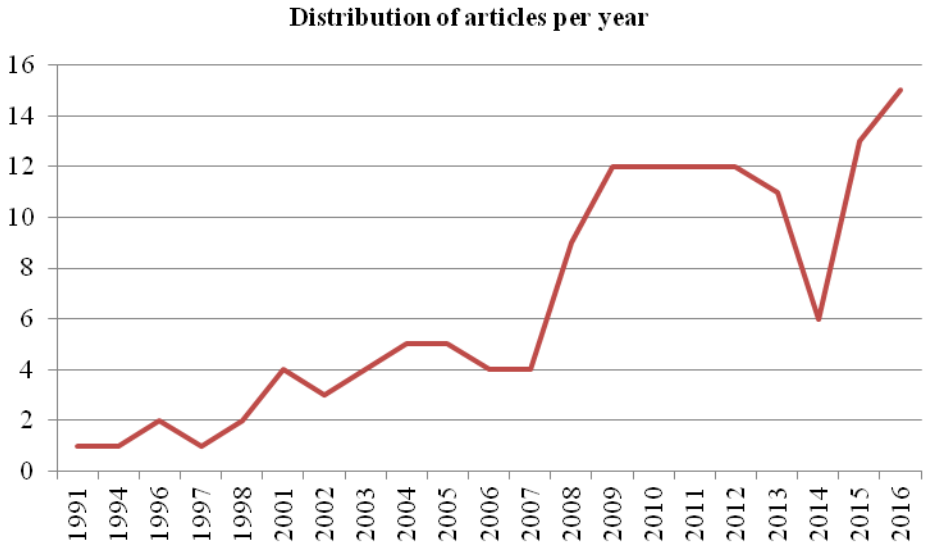
As we have mentioned in the methodology part, this systematic literature review is based on 138 articles. The papers come from different sources, mainly from leading and most influential academic journals of investigated area. Most of the articles are published in journals, such as Technological Forecasting and Social Change (31 occurrences), International Journal of Technology Intelligence and Planning (10), International Journal of Foresight and Innovation Policy (9), Technology Analysis and Strategic Management (7), Foresight (6), R and D Management (5), Expert Systems with Applications (4), Futures (4), International Journal of Technology Management (4) and etc. The table below illustrates top journals with more than two papers:

Table 1

Journals	Number of Occurrences
Technological Forecasting and Social Change	*31*
International Journal of Technology Intelligence and Planning	*10*
International Journal of Foresight and Innovation Policy	*9*
Technology Analysis and Strategic Management	*7*
Foresight	*6*
R and D Management	*5*
Expert Systems with Applications	*4*
Futures	*4*
International Journal of Technology Management	*4*
Journal of Intellectual Property Rights	*3*
Technovation	*3*

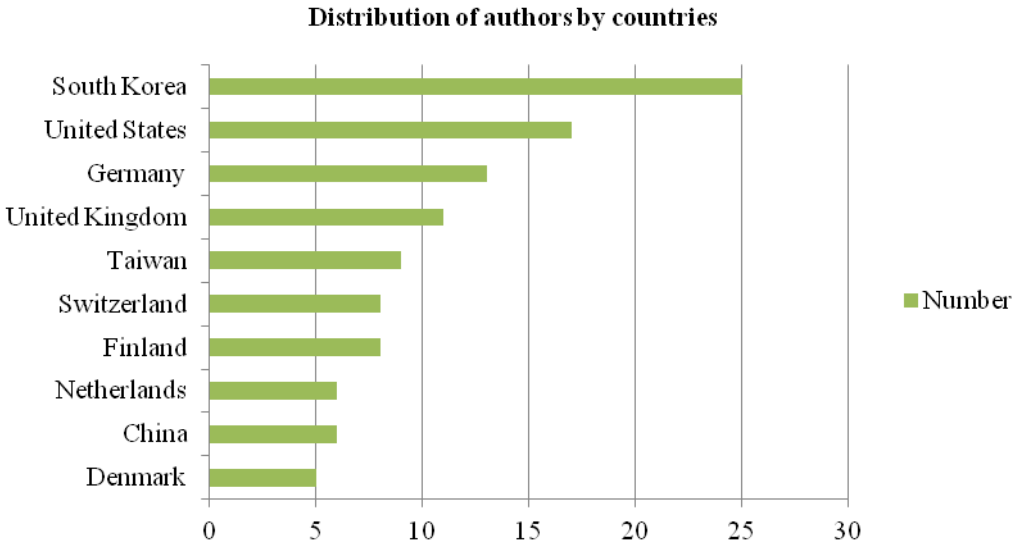
The reviewed studies clearly indicate that last two decades have seen growing trend towards this strand of research and a considerable amount of literature has grown up around the theme of TI during this years. If 1-5 articles have been published every year before 2000, 10-15 papers have been issued after 2000:

Figure 3



It is worth noting that geographical spread of these papers is also diverse. Our literature includes contributions of authors from 25 different countries. Interestingly, authors from South Korea, United States, Germany, United Kingdom and Taiwan constituted largest part of our sample. Distribution of authors by their countries can be better understood from the figure below:

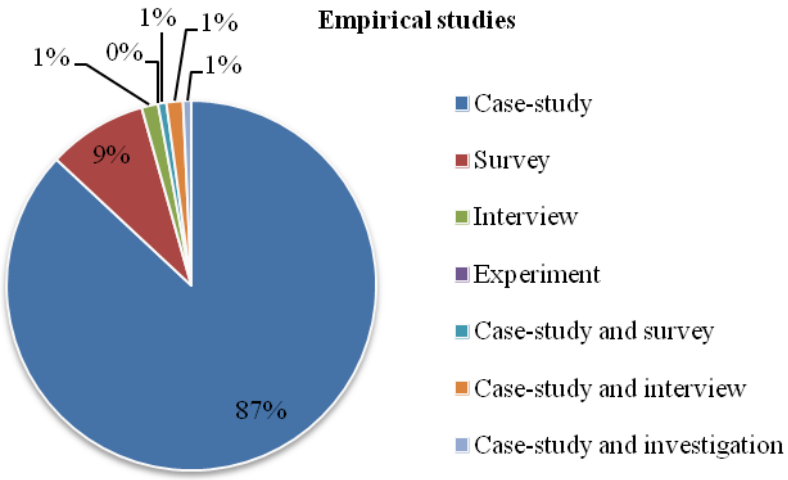
Figure 4



Research methodologies adopted in the literature

In order to identify research design exploited in papers we followed a categorization schema of conceptual and empirical research proposed by Orlikowski and Baroudi (1991). According to this study, empirical research refers to (a) surveys, (b) interviews, (c) case studies, (d) experiments or (e) diffusion of one of these methods. 138 papers were grouped in terms of this categorization, and the analysis revealed the following results. Case-studies appeared to be the most frequently used method for empirical study of TI (120 occurrences). Respectively, surveys were conducted in 12 cases, interviews in 2 cases. The review didn't detect any experiment in the sample. Moreover, the mixed method approach was retrieved in following three forms: case-study and interview (2 occurrences), case-study and survey (1 occurrence), case-study and investigation (1 occurrence). The figure below summarizes reviewed empirical literature on TI by research design briefly:

Figure 5



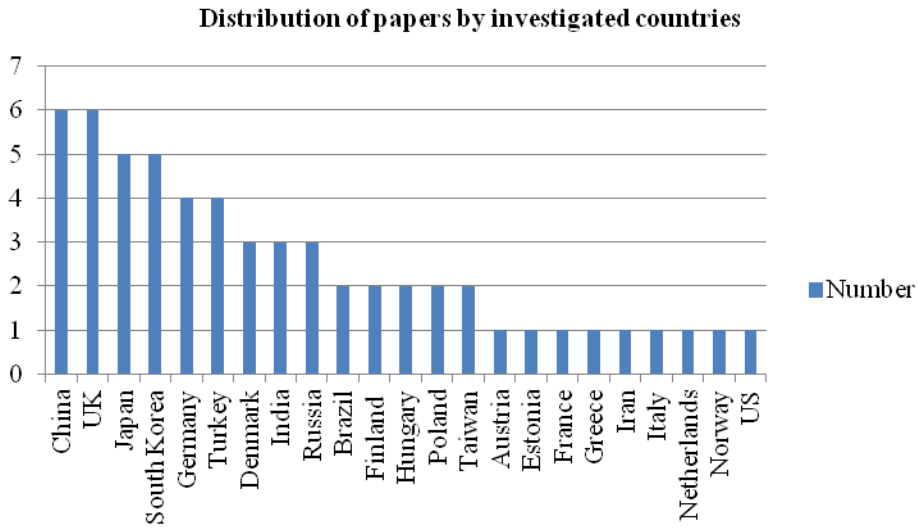
The study has found out that, most of the published empirical studies are with exploratory and explanatory nature. Our thorough analysis led us to assume that greater part of the papers used single type of case studies (89 articles, 72%). 35 articles (28%) respectively chose multiple contexts to be investigated. In terms of level of analysis, country level was employed frequently in the studies than firm level.

Research contexts investigated in the literature

Our findings on research context are built on two characteristics of the papers: the country where the data come from and the technology or industry on what the empirical studies are grounded. With respect to the country, it was found that most of the articles

were designed in the single-country case (49 papers, 86%). Other 8 papers (14%) collected data in more than one country or used cross-country comparison in their studies. Lin et al. (2013) collected sustainable energy related data from strategic foresight reports of countries, such as Japan, South Korea and China, and made use of it as sources for future technology identification analysis. Lichtenthaler (2003; 2004a; 2004b; 2005; 2006) conducted his case-studies in European and North American multinational companies. Breiner et al. (1994) studied replication of Japanese Delphi survey in Germany in order to analyze possible dissimilarities and to find out the cultural influences on technology assessment. From our results, China, United Kingdom, Japan, South Korea and Germany emerged as top countries with higher number of empirical research dedicated followed by Turkey, Denmark, India and Russia. The Figure 6 sets out the distribution of articles by investigated countries.

Figure 6



Concerning industries and technologies the results indicated that studies examined diverse sectors and type of technologies. In order to group them we adopted general classification of World Economic Forum, OECD, Horizon 2020 – Societal challenges for industries and classification of Strategic Business Insights (SBI) Research Center for technologies. Results showed that automotive, ICT, healthcare and aerospace industries as well as nanobiotechnology, electronic displays, collaboration tools and fuel cell technologies were put into the most cases (Figure 7 and 8):

Figure 7

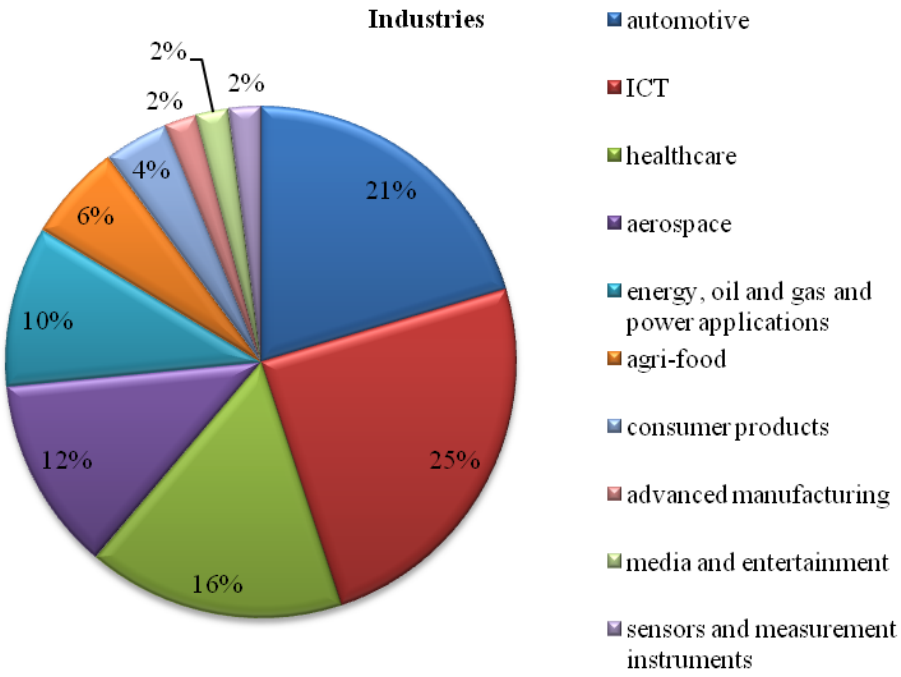
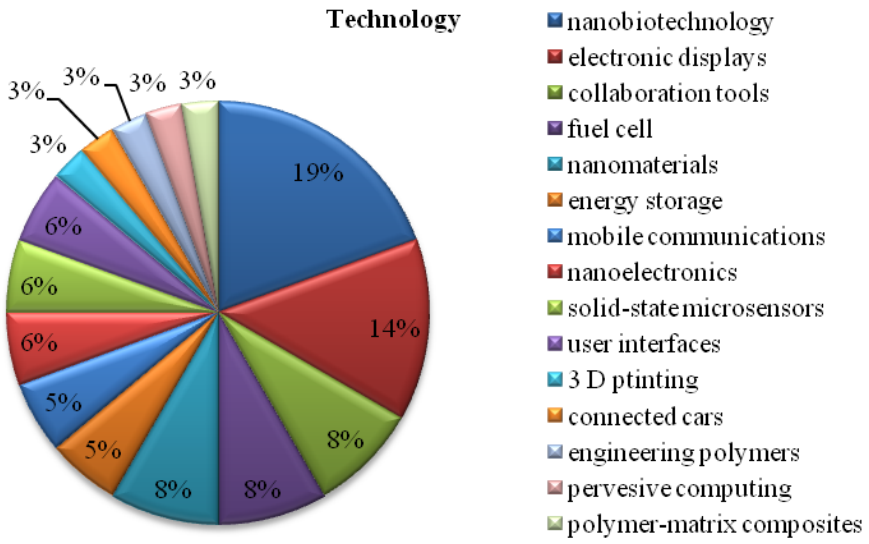


Figure 8

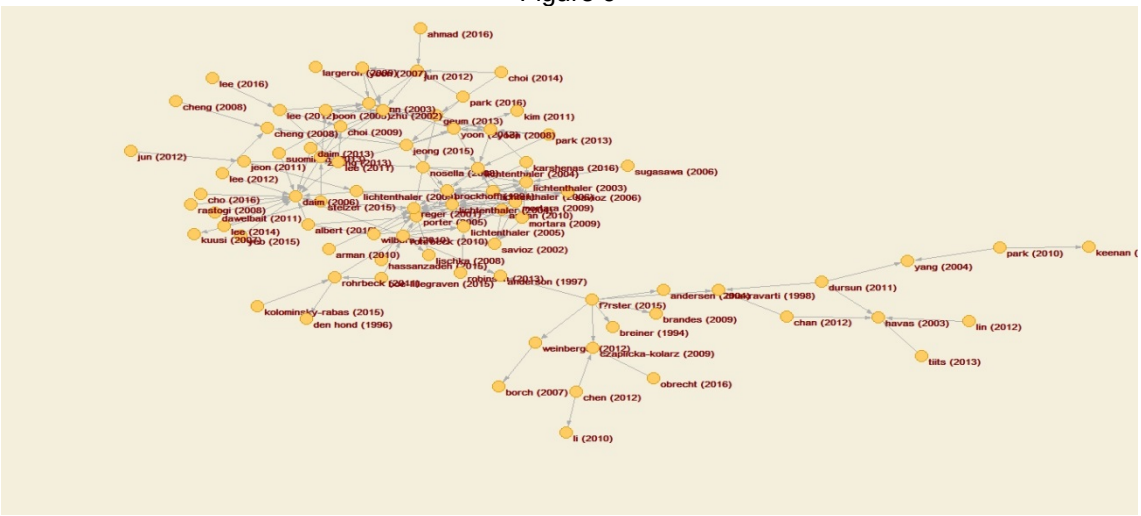


Research content investigated in the literature

As it was mentioned earlier, as a part of our systematic literature review we adopted citation network and main path analysis which is reckoned as a comprehensive and novel systematic method for analyzing the literature (Randhawa et al., 2014). “Citation network analysis is a network which nodes are articles connected by links indicating citations among them” (Strozzi and Colicchia, 2012). The flow of knowledge is represented by arrows that go from cited to citing paper. The primary objective of using

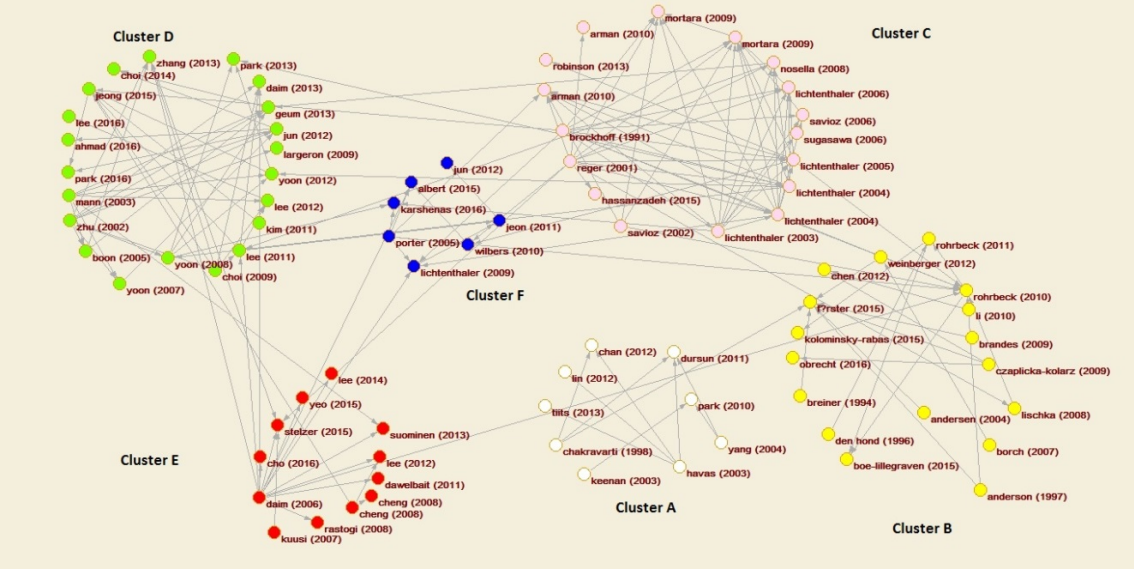
citation and keyword network analysis was to observe the diffusion process of the empirical studies in TI and to identify the main streams of the research. One of the advantages of citation network analysis is to provide consolidated view of the thematic areas of papers by dividing them into clusters. As far as our main goal was to analyze the research content we applied this method to our study. We created a network of documents using software Pajek, one of the most used programs for the analysis and visualization of large networks. We found out that some of the papers are not citing other papers (isolated nodes), therefore we focused on the largest connected component with 83 articles. As a result, the following network illustrated in Figure 9 was retrieved.

Figure 9



Looking at the figure, it is possible to notice that the links between papers are oriented from the newest to the oldest: it means that the links are based on citation: the most recent paper is citing the older one. We are interested in the flow of knowledge instead, that is in the path of knowledge which moves from the cited paper (the older one) to the citing paper (the most recent one), since we aim at understanding the latest trends and evolution of the field. Therefore, we transposed the type of connection. Consequently, using Louvain method of community detection, we obtained 6 clusters of reviewed literature (labeled with letters), eventually referred as thematic areas (Figure 10):

Figure 10



Cluster A: Technology foresight at national and institutional level

The papers included in this cluster discuss predominantly the implementation of national foresight programs by governments for science and technology policy making, long-term planning and decision-making. Some papers highlight the effect of national foresight programs on innovation systems and strategy (Chan and Daim, 2012), priorities of key emerging technology developments (Chakravarti et al., 1998; Keenan, 2003; Yang et al., 2004; Park and Son, 2010) and post-evaluation of technology foresight policies (Dursun et al., 2011). Havas (2003), Tiits and Kalvet (2013) by introducing recent foresight experience of Hungary and Estonia, propose a model for transition, small and catching-up economies. Particularly, Lin et al. (2012) deal with adaptive foresight modular design in the example of Taiwan which may serve as a roadmap in national technology foresight designing for emerging and developing countries with restricted resources.

Cluster B: Technology forecasting at firm level

Another significant part of our literature brings into evidence forecasting development paths and trajectories of some technologies and industries, as well as the process of monitoring their evaluation speed, readiness, performance and maturity in the organizational level. The papers which fall under this categorization may provide some valuable insights in terms of technology, area where the technology has been applied and the method how to identify such kind of technologies in practice. For instance, Andersen et al. (2004) investigate future attractiveness of six types of sensor categories. Förster (2015) highlights the role of technology foresight to identify the

technologies and processes, which might be relevant for sustainable production in the German automotive industry in the future. Lischka and Gemünden (2008) in the case of Siemens AG emphasize the necessity of solid systematic assistance of technology management that could focus on anticipated activities such as technology foresight and strategy development as well as observing mechanism of individual projects until their entire influence in the efficiency of the company. They propose technology roadmapping approach that aims to diminish actual risks and barriers and test it in a manufacturing business unit for Gas Turbine Parts.

Cluster C + Cluster F: implementation of TI in practice

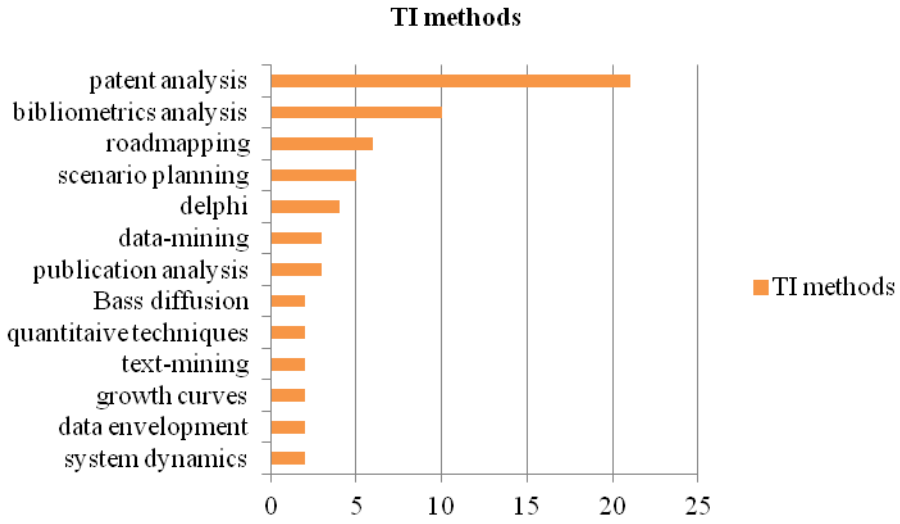
There always has been a spirited debate on organization of TI process in companies. Accordingly, during this systematic literature review it was found that, considerable number of our investigated studies concentrate on the quest how the process of TI is implemented, maintained and how it operates. We discovered that the considered literature comprises two clusters which share similar topics and issues: cluster C with a rather general perspective, cluster F by focusing on specific methods or contexts of application. Therefore, we presented them as one cluster. As TI is concerned about acquisition, assessment and proliferation of technology-related information, it is necessary to understand how this activity is carried out by companies in practice. In their two works Arman and Foden (2010), Arman et al. (2010) describe ontology-based knowledge management framework structure and application within technology-driven manufacturing firm. They argue that this tool has been successful because of its ongoing practice and formalization as a technology management tool within the case-study company. Mortara et al. (2008) by analyzing eight UK technology-based companies aim to understand how the TI systems are currently operationalized in industry and to obtain knowledge on implementation of TI. Authors differentiate six steps of TI process: search, filter, analyze, document, disseminate and coordinate. These six phases guide to obtaining and dissemination of the information. In contrast to these phases, Lichtenthaler (2006) identifies three types of TI process in the context of radical technological change: the hierarchical, the participatory, and the hybrid TI processes. One strand of the literature within this cluster stresses on diffusion of TI process in small companies. Savioz and Blum (2002) argue that, due to restricted resources and competences SMEs lack to implement technology planning tools as they usually do not match with the peculiar need of SMEs. Therefore, it is necessary to model certain type of planning tools that could correspond to the expectations and capabilities of SMEs. As a remedy, authors propose a new concept: the Opportunity

Landscape which aims to ensure pertinent technological information to decision-makers of the companies in order to envisage potential technological changes and to proceed in line with it. Moreover, Savioz (2006) in his next paper tries to explore overall picture of organization of a technology intelligence system and similar and diverse representations deriving from different company sizes. The findings of the explorative case-studies report that, small companies may possess corresponding elements of TI system what large companies also have. However, it is essential to select and adapt these elements according to the specific need of the company. In this process decision-making and planning, as well as culture of the company have a crucial role.

Cluster D: patent analysis as TI and TF method

As our analysis revealed, patent analysis was the most frequently used method of TI in investigated literature (see Figure 11). That's why it emerged as a separate cluster in the network. Jun et al. (2012) in the case of bio-industry propose method for technology forecasting which bases on different data mining techniques for analyzing patents and a patent management approach using with the result coming from technology forecasting. Choi and Jun (2014) employ patent clustering for forecasting vacant technologies. An algorithm suggested by Choi and Park (2009) identifies patent development paths from a large patent citation network by evaluating the weight of citations between patents. Park et al. (2013) propose a Subject-Action-Object (SAO)-based patent intelligence system by exemplifying patent analysis of 3D printing technology. Yoon (2008) and Yoon and Kim (2012) describe two different tools for identifying technological opportunities- Techpioneer and TrendPercepter. The former by using textual information from databases and by applying morphology analysis, depicts promising alternatives and conjoint analysis to evaluate their priority. The latter identifies trends from patents and evaluates them.

Figure 11



Cluster E: bibliometric method for technology forecasting

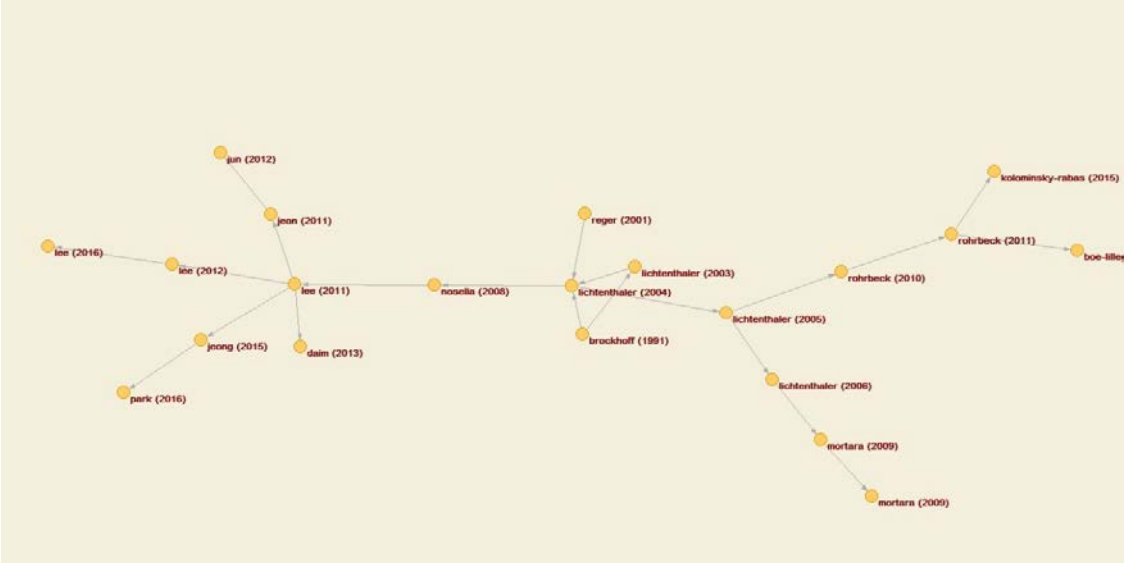
As it is shown in Figure 11, bibliometric method is in second rank after patent analysis according to the occurrence in the studied literatures. Daim et al. (2006) present forecasting fuel cell, food safety and optical storage technologies integrating patent and bibliometric method to well-known growth curves, scenario planning and system dynamics analysis. Stelzer et al. (2015) combine scenario technique with bibliometric method for the sake of conducting technology foresight in personalized medicine. Cheng and Chen (2008) posit that in the fields such as new materials where the historical data is rarely present, bibliometric analysis as a “simple and efficient tool” can close this lacuna and assist the researchers to obtain quantitative and historical data for technology forecasting. Technology performances of nanosized ceramic powders are analyzed in this study using bibliometric method. In the case of mobile phones, Yeo et al. (2015) measure uncertainty of technological innovation applying bibliometric analysis using research papers. Kuusi and Meyer (2007) pinpoint “leitbilder” - a 'guiding images' role of bibliographic coupling for different professions and disciplines to work in the same direction in the case of carbon nanotube.

Key studies in the literature

In order to identify main streams of the considered literature and to gain dynamic perspective, main path analysis was performed. This technique helps to understand the “most relevant papers at different moments that constitute the backbone of a research tradition, ‘walk’ from the present to the pass (that is back in time) in a ‘field’ of papers” (Colicchia and Strozzi, 2012; Medina and Noyons, 2008). Main path analysis

provides connectivity of nodes in a given time and it is calculated on the basis of centrality degree of the node by outlining the path from the node with the highest degree. As Lucio-Arias and Leydesdorff (2008) have asserted, “in citation network, this degree measure considers the number of citations a document receives (indegree) as well as the number of cited references in the documents (outdegree)”. Applying main path analysis in our citation network gave us an opportunity to investigate the key studies thoroughly. After quantifying the citation traversal weights we obtained representation of the following main path:

Figure 12



The articles in our component range from 1991 to 2016. The oldest paper of path is Brockhoff (1991). The article discusses the organizational aspects of the competitive intelligence, showing the process of setting competitor related technological information into a corporate information framework system on external data. The paper stresses the argument that, competitor intelligence should not be developed and handled in isolation. Then the author highlights requirements and institutionalization process of this system. The next step in the path which contributes to the development of further concepts is a paper by Reger (2001). The article presents evolution of three generations of Technology foresight by interviewing 26 multinational companies. The paper can be considered as fundamental, as many concepts related to Technology forecasting, Technology foresight and TI take root from it. It also proposes a model of Technology foresight which includes five core elements: activities, science and technology as the main field of observation, actors under search and investigation, the

storage and distribution of information within the corporation and recommendations and decisions.

Following these ideas, Lichtenthaler (2003) in his paper questions the historical development of TI in 26 pharmaceutical, telecommunication and automotive industries located in North America and Europe. As an outcome of this research he puts forward three generations of TI. In the first generation R&D management is associated with lack of a long-term strategic framework. In the second generation companies started to establish strategic framework for projects and conjunction between the firm and R&D management emerged. In the third generation technology and R&D strategies consolidated to the corporate, or respectively, the business unit strategies. Furthermore, the study identifies contingency factors for the location of technology intelligence activities within technology intensive companies. Furthermore, Lichtenthaler (2004) underlines the knowledge gap on coordination process of TI in multinationals. Structural, hybrid and informal forms of coordination of TI are distinguished. Author also describes different forms of integration of these forms of coordination of TI and communication media used in this process.

Mortara et al. (2009) present a toolbox of system elements to structure TI in the case of 14 UK based companies. They group different choices of elements into the four modes of searching (Mine, Trawl, Target and Scan) of a model developed by Kerr et al. (2006). These categories include two additional features: nature of the elements and their functions. At this point we can distinguish two different streams of the research path. The former stream derives from Rohrbeck (2010). On the basis of three case studies and 43 interviews, the study demonstrates the benefits of building technology foresight system through network of scouts. Not being limited with this goal, the study explores the process, design of technology scouting and characteristics of technology scouts. The author in his second paper (Rohrbeck and Gemünden, 2011) delineates three roles of corporate foresight in enhancing the innovation capacity of a firm: a strategist role for identifying new business fields, an initiator role for establishing new innovative projects and an opponent role for challenging towards better quality of products. The second stream of the research passes through the study by Nosella et al. (2008) where authors identify four main factors that may influence on company's conducting way of Technology monitoring: type of industry the company refers to, business model it has, significance of technology in its corporate culture and the level of R&D resources. The last constituent of the path is composed of the articles on methods of TI, more precisely, on patent analysis.

4. Discussion, conclusions and limitations

From our analysis it becomes apparent that TI is a complex phenomenon and interest in this area of research is increasing among academics and practitioners constantly. Although the literature which concentrates on conceptual aspects of the TI is rich, our review found that studies envisaging practical facets of TI are limited. Primarily this can be explained with evolving state of the TI. Even though there were some attempts to conceptualize TI already from 1970's (Ansoff, 1975; Cooper and Schendel, 1976), as a research stream it became popular among scholars only at the end of 1990's. However, knowledge on implementation process of TI is still in embryonic phase and there is a huge demand for contributions which aims to conduct empirical studies on TI.

The first question in this study sought to determine the characteristics and trends of literature on implementation and operationalization of TI in order to identify research gaps and limitations. While answering this question, we have noticed three distinct geographical areas, primarily defined by the origin of the authors and the topics they are addressing: Asia (South Korea, China and Taiwan), North America (USA) and Europe (Germany, United Kingdom and Switzerland). By locating these areas in our thematic clusters, we found that papers coming from Europe deal predominantly with TI, specifically implementation process of it. Papers from USA are biased towards Technology forecasting in national and organizational level. From analyzed literature it can be assumed that in Asia the research is concentrated more on methods of TI.

Concerning research methodology, another important finding was that case-studies were employed widely by authors for empirical research on TI. Since case-studies analyze contemporary real-life phenomena in-depth (Yin, 1984; Eisenhardt 1989), it is more plausible that, most researchers referred to them. Single cases constituted largest part of the study and we argue that this approach allowed researchers "for exploring the phenomenon in its context without sacrificing the richness of the studied incident and its context" (Eisenhardt and Graebner, 2007). In terms of the issues what the empirical studies are addressing to, we can delineate the following groups: cases discussing national programs of Technology foresight in the country level (cluster A), cases forecasting emerging technologies in the company level (cluster B), cases highlighting organization of the TI process both in country and company levels (clusters C and F) and cases discussing particular method of TI or Technology forecasting at company level (clusters D and E). However, future research may concentrate on other types of empirical studies, i.e. surveys, interviews or experiments in extensive context.

It is also interesting to note that geographical spread of the investigated countries shows a great deal of variety. Nevertheless, we can observe that most of the grounded studies were conducted in the case of firms located in developed countries where internal R&D considered to be the most valuable component of their innovation strategy (Shi et al., 2016). Taking into account the fact that the operationalization of TI can be expensive, time and competence requiring (Manzini et al, 2016), it would be interesting to study companies in developing countries which do not possess these characteristics and cannot rapidly develop strong R&D capabilities.

We noticed in particular that, majority papers studied big and multinational companies (Arman and Foden, 2010; Brockhoff, 1991; Haghighat et al., 2016; Jones et al, 2015; Keltsch et al, 2011; Lingens et al., 2016; Lichtenthaler, 2003; 2004a; 2004b; 2005; 2006; 2009; Mortara et al., 2008; 2009; Nosella et al., 2008; Rohrbeck et al., 2011) with only two exceptions which investigated small and medium sized firms (Savioz and Blum, 2002; Savioz, 2006). It puts in force the necessity of further investigations of TI process in SMEs and their corporate culture.

The most relevant finding to emerge from research content analysis was a citation network of papers that enabled us to obtain systematic and holistic view of the investigated literature. Using the software Pajek we generated six main clusters of thematic areas. Main path technique allowed us to analyze the most important papers of our sample and to follow the trend. One unanticipated finding was that patent and bibliometric analysis came out as one of the broadly investigated methods in the literature. A further study with more focus on other TI methods is therefore suggested.

With respect to the second research question, it was found that the studied set of literature is also valuable in terms of practical implications. Particularly, the clusters C and F deal with the successful implementation and organization of TI in companies. For instance, Porter (2005) describes the process of quick TI in the case of solid oxide fuel cells. Wilbers et al. (2010) shed in light the application of standardized TI process “on a large scale while maintaining on-time delivery and the quality of results”. Karshenas et al. (2016) in their paper suggest a conceptual model for the development of TI in the national innovation ecosystem. Considerable amount of the literature discusses coordination and management issues of the TI process (Lichtenthaler 2003, 2004a, 2004b, 2005, 2006, 2009; Mortara, 2008, 2009; Savioz, 2006; Nosella et al., 2008; Rohrbeck et al., 2011; Arman and Foden, 2010).

Observing a global perspective of the studied literature, we have noticed that the research is fragmented by being divided into three areas: TI, Technology forecasting and Technology foresight. We assume that, the reason of this differentiation can be clear to academics as they are conceptually different. This fragmentation provides high quality of studies on separate aspects of the issue, for example, how to foresight emerging technologies in aerospace industry, how to detect signals of user interface technologies applying patent analysis or how to structure TI process in organizational level. However, managers may find difficult to understand such conceptual differences and therefore to find clear managerial guidelines for investigating the technology environment. Albeit, there is abundant room for further progress in determining general overview of the implementation of the TI which would serve as a guideline for managers.

In very brief synthesis, future interesting areas of research in the field could be: (i) applying other types of empirical studies, i.e. surveys, interviews or experiments in extensive context for the investigation of TI; (ii) studying implementation process of TI in companies located in the developing countries; (iii) investigating TI process in the context of SMEs; (iv) analyzing other TI methods different from patent and bibliometric analysis; (v) determining general overview of the implementation of the TI which would serve as a guideline for managers.

The major limitation of this study is that we collected our literature from a single source. Although Scopus is considered as one of the largest database, future studies are suggested to select the publications from multiple sources. Secondly, as our main goal was to designate wide overview of TI, we selected general keywords in our search query. For the further analysis the process of keyword selection may be validated and improved with experts coming from academia, as well as from companies.

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