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Quick and Dirty Technology Intelligence for SMEs

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SMEs are increasingly opening their innovation process, but in order to find and evaluate opportunities for openness they need a technology intelligence process, able to provide information about the competitive context, the potential partners, the evolution of existing and emerging technologies. At the moment, contributions specifically dedicated to technology intelligence for SMEs are still very limited. The aim of this paper is to make a step further in research in this field, proposing a framework for building a "quick and dirty" technology intelligence process, suitable for SMEs. By integrating the suggestions drawn from the extant literature on the topic, with the experience collected in 4 cases, the proposed framework distinguishes the technology intelligence process and methods according to three main areas of investigation: the WHO area (concerning players), the WHAT area (concerning technology) and the HOW area (concerning the evolutionary dynamic). The idea is that in order to make technology intelligence affordable for SMEs, it is necessary to focus on a specific area of investigation, by tailoring the TI process (be it mine, trawl, target or scan) as well as the TI methods, in coherence with such area. The framework brings into evidence how to select among different types of TI processes, TI methods and TI areas of investigation, in order to narrow the process and make it coherent with the SME company specific competences and resources.

1. Introduction

Small and medium enterprises are increasingly opening their innovation process, in spite of the risks deriving from sharing competences and know-how (Van de Vrande et al., 2009; Lee et al., 2010). But in order to find and evaluate opportunities for openness they need to have information about the competitive context, the potential partners, the evolution of existing and emerging technologies, the risk of technological discontinuities, the needs of present and potential customers. They need a Technology Intelligence process (Veugelers et al., 2009; Mortara et al., 2012, Lichtenthaler, 2005, 2007; Schoemaker et al., 2013), i.e. "a process of systematic acquisition, assessment and communication of information on technological trends in order to detect opportunities and threats in a timely manner" (Lichtenthaler, 2007). Technology intelligence is considered by SMEs as an expensive, complex and time consuming process, that requires skilled resources and a dedicated organisational process. So SMEs face a tension: they need to conduct TI in order to exploit open innovation, which potentially allows them to overcome their limits in terms of competences and resources, but they lack the competences and resources for conducting the TI process. SMEs need to identify new technologies of interest, potential partners for technology development, centres of excellence in the production of knowledge, but they generally lack an intelligence activity.
Hence, it is necessary to develop an efficient and effective model for technology intelligence, able to ensure to SMEs that most relevant information are actually collected, by exploiting sources, models and tools really coherent with the competences and resources available within the company, and with the specific information need. This is crucial to help SMEs recognise that technology intelligence could actually be affordable.
The literature on TI for SMEs is really very limited at the moment, with very few relevant exceptions (Manzini et al., 2015; Savioz et al., 2006; Bianchi et al., 2010, Zabala-Iturrigagoitia, 2014). This lack of research investigation is

serious in the open innovation era, in which large companies and small ones may generate mutual benefits by means of collaborations and alliances, licensing of innovative technologies, outsourcing of innovation (Enkel et al., 2009).
The aim of this paper is to make a step further in research in this field, proposing a "quick and dirty" approach to technology intelligence, specifically dedicated to SMEs that want to adopt an open approach to innovation.

2. Literature on Technology Intelligence for SMEs

The literature on technology intelligence (TI) is very rich, as it has been widely recognised that it is fundamental for strategic decision-making within companies. In particular, TI helps companies in understanding the evolution of technologies, identifying emerging technologies and evaluating their impact on competition, analysing technology players and competitors, discovering emerging players, identifying and evaluating opportunities and risks for competitive sustainable advantage (Rouach and Santi, 2001; Lichtenthaker, 2004, 2005, 2007; Arman and Foden, 2010).
This huge literature has deepened several aspects of technology intelligence.
Many authors, since the early contributions of Ashton et al., (1991) studied the activities that compose the TI process. With various levels of detail, most authors agree that the main activities of the TI process are: definition of information needs, information search, information analysis and filter, documenting and reporting, communication and dissemination. (Lichtenthaler, 2004; Mortara et al., 2009; Kerr et al., 2006; Arman and Foder, 2010).
Other contributions focus on the methods for TI (among others, Lichtenthaler, 2005; Drew, 2006; Van Reedt Dortland, 2014), discussing the related advantages and limits and hence the most suitable context for their application. Among the most cited methods, S-curves, patent and publication analysis, scenario analysis, technology roadmapping, Delphi studies, technology positioning matrixes, benchmarking, brainstorming, QFD, Lead User analysis. These methods can be classified according to (Lichtenthaler, 2005): (i) their relevance for information generation, distinguishing among extrapolative, explorative and normative; (ii) their relevance for organisational and individual learning; (iii) their qualitative versus quantitative nature; (iv) their time horizons. This classification brings into evidence that, for example, benchmarking, QFD and lead user analysis have a short-medium time horizon a qualitative nature; scenario analysis, and Delphi studies have a very long time horizon and, respectively, a qualitative and a quantitative nature; S-curves have a medium-long time horizon and a quantitative nature; patent and publication analysis and simulations have a short-medium time horizon and a quantitative nature.
Finally, several studies have investigated the organisation of the TI process, in terms of people involved, sequence of decisions and actions, roles and rules. Lichtenthaler (2004) for example describes three models (that he calls "layers") of coordination of the TI process within companies: structural coordination (where tasks are delegated through a hierarchical position), hybrid coordination, (where TI is conducted for specific problems and hence with a temporary structure) and informal coordination (where TI is based upon autonomous information gathering). Mortara et al., 2009, provide a framework for the organization of the TI process with both a top-down and a bottom-up approaches, according to which information goes from the sources to the decision makers, and vice versa, though intelligence streams and actions.
Most of the contributions mentioned above imply for a complex TI process, with skilled human resources, dedicated tools for accessing and elaborating information, time, money and strong commitment. This is caused not only by the complexity of the methods of technology intelligence, but also by the fragmentation of information sources and by the cost of elaboration tools and the need to have excellent competences (both technical and business competences) in order to gather meaningful interpretation from data and information. This makes TI, as represented in the literature, not easily affordable for SMEs. As a matter of fact, SMEs usually have limited resources, in terms of competences, money, and time and managerial attention. And in fact, earlier studies on TI assumed that SMEs did not had any TI activities, or at least not within a formal process (Savioz et al., 2006). This assumption is no more valid (Savioz et al., 2006) and more recently some authors have proposed approaches that can be affordable even for SMEs (Savioz et al., 2006; Bianchi et al., 2010; Zabala-Iturrigagoitia, 2014). In particular, Bianchi et al., suggests a TRIZ-based approach for identifying alternative application for an existing technology; Savioz et al., (2006) provide examples of TI implementation in New technology-Based firms (NTBFs) and shows that there is no one best way to undertake technology intelligence, but, on the contrary, "situational best solutions" are to be identified, taking into consideration the specific organisational attributes of the company, its surrounding environment and the owner-manager characteristics. Zabala-Iturrigagoitia (2014) describes a tool, the Technology Watch (TW), which consists in a "systematic observation, analysis and use of technological information, allowing companies to be aware of their external environment and learn from it", and implements such a tool in SMEs. However, research on this topic is still very limited and this paper is aimed at making a step further in this field of study. This is especially necessary in the era of open innovation, as companies need to be able to investigate the technological external environment, in order to capture opportunities for partnerships, collaborations, outsourcing, licensing, acquisitions. And the literature confirms that open innovation is a paradigm already meaningful for SMEs as well (Van de Vrande et al., 2009; Lee et al., 2010). SMEs may find in open innovation the opportunity to complement their limited resources (competences, money, but also complementary assets, such as production capacity, distribution channels, marketing and promotion capacity) (Verbano et al., 2015). So the research question can be synthesised as follows: how can SMEs define a "quick and dirty" approach to technology Intelligence?

3. The empirical study

This paper analyses the experience of TI collected in 4 cases involving one small and three medium enterprises, operating in the electrical appliances, mechanical components, medical components, dental devices industries (see table 1). Using case studies for supporting theory building represents a consolidated approach (Eisenhart, 1989). Two of the authors were directly involved in the TI study, as experts in TI studies. All the cases concern companies that are facing open innovation as an opportunity and want to increase their knowledge about the technological context: assessing the offering of competitors in order to identify a potential commercial partner; evaluating the technological capabilities of a competitor for a technical agreement, studying the state of the art of competing technologies for deciding about internal product development (and launch) versus alliances.

Company	Size	Industry	TI objectives (why a TI process)
A	Small company	Electric appliances	Assess the technical value of a new product against similar products already available on the market. The assessment aims at verifying the acceptability of the product by installers and the opportunity to identify a commercial partner
B	Medium company	Mechanical components	Assess the technical capabilities of a competitor and its eligibility for a technological agreement
C	Medium company	Medical and automotive components	Assess the state of the art of a specific technology and the competitors' patent portfolio before the launch of a new product
D	Medium company	Dental devices	Identify trends and new products in the dental devices and aesthetic treatment field

Table 1. The cases

The cases have been studied with the following steps:

Phase of the TI process	Information source / people involved
definition of information needs, of TI results for final users, selection of TI methods	1-2 meeting(s) involving two authors and the TI process owner, identified by the company
information search, information analysis and filter	Two authors, back office work, contacts with the TI process owner in case of need
documenting and reporting	Two authors, back office work, contacts with the TI process owner in case of need
communication and dissemination, discussion of results in terms of usefulness, relevance, timeliness, reliability	2 meetings, two authors, with the TI process owner (and, in some case, other people identified by the company)

Table 2. the steps of the empirical study

Information collected in the case study has then been analysed with a cross case approach, searching for a pattern connecting the aim and scope of the intelligence process, the characteristics of the different methods for technology intelligence, the resources, competences and time available. As the aim of the paper was theory building, in the cross-case analysis we decided not to use pre-defined categories, but to let them emerge from the facts.
The emerging pattern has then be investigated in the light of the existing literature and the underlying logic has been used as the base for building a framework.

4. Results analysis

Following the conclusions drawn from the literature analysis, concerning the need to tailor a TI process for each specific case and to reduce the complexity and the need of resources (time, competences, money), we analysed the results of the cases by focusing on the specific information need, i.e. on the specific aim and scope for which the TI process was carried out. In fact, in coherence with a specific information need, it is possible to define the time horizon fitting with the purpose and especially the "area" of information most important for that need. In fact, we observed that a given information need leads to focus on a specific object of analysis: some of the cases investigated were more focused on technology players, others on the technology itself and on the related products, while others on the evolution of one of the two (or both). The idea emerged that, whatever the TI method used, patent analysis or Delphi study or benchmarking, the complexity could be reduced by focusing the effort only on data and information relevant for the specific need. With this idea in mind, we elaborated the results of the empirical study according to the following

categories: TI objective (or information need), main areas of investigation, methods adopted, effort dedicated (expressed in days /persons). The analysis is synthesised in table 3.

company	**TI information needs**	**Main areas of information collected (technology players / technology and products/evolution of players or technologies)**	**TI methods adopted**	**Effort (days / persons)**
A	Assess the technical value of a new product against similar products already available on the market	Comparison of the device with other products solving the same problem Analysis of the ease of use of the device and its acceptability by experts and end users Identification of a viable way to get to the market	Patent search and analysis; opportunity map (identification of overlapping/complementing products) Focus groups with installers Interviews with companies in the industry	12 man/days
B	Assess the technical capabilities of a competitor and its eligibility for a technological agreement	Understanding technical capabilities of the competitor Observe and evaluate the competitor's products characteristics and performance Assess the financial stability of the competitor and its performance on the market	Patent search and analysis Interviews with clients and distributors Official accounts statements acquisition and analysis	6 man/ days
C	Assess the state of the art of a specific technology and the competitors' patent portfolio before the launch of a new product	Understanding the competitor's technical capabilities Understanding the innovation path in the industry Draw the competitive scenario Define the best strategy to rapidly put the product on the market	Patent search and analysis Competitive landscape Open innovation approach	15-20 man/days
D	Identify trends and new products in the dental devices and aesthetic dental treatment field	Technical landscape in dental treatment and emerging technologies applied to the dental care Observation of current practices in dental aesthetic treatments and new products launches Identification of products to be added to the product portfolio Identification of potential commercial partners	Patent search and analysis Market information analysis Product mapping and benchmark Company profiles	20 man/days

Table 3. cross case analysis

By integrating the suggestions coming from the literature, in terms of methods and processes, with the evidence emerging from the cross-case analysis, a tentative framework for quick and dirty technology intelligence for SMEs has been drawn. The framework identifies three main areas of investigation for technology intelligence, related to different objectives of the process: (i) the WHO area, concerning the analysis of players (competitors, potential partners, emerging relevant companies); (ii) the WHAT area, concerning the technology under investigation (state in the technology lifecycle, functionality, competitive impact); (iii) the HOW area, concerning the behaviour of players and technologies (how they evolve over time). For example, case A was focused mainly on the product and the embedded technology (what), case B on competitors (who), case C on competitors and the dynamic of competition (who and how), case D on technologies and players (what and who). The cases investigated show that the same TI method can be used for various purposes and with a specific focus. Obviously, in coherence with the specific focus, the implementation of the method is different. For example, a patent analysis focused on technology players requires the use of indicators such as the number of patents per competitor, the top assignees, the patent intensity by player, the co-patenting. The same TI method, patent analysis, in order to be focused on technology should be based upon indicators such as patent classes, the number of applications over time, the citation analysis, and the semantic analysis is often required. Finally, in order to understand the evolution of players and technologies, more complex indicators should be used, such as the filing strategy of assignee, the number of patent applications by patent applicants, in different countries, or the number of assignments (Abbas et al, 2014; Yoon and Kim, 2011, Ma and Porter, 2014). Hence, depending on the focus of the investigation, the same method – patent analysis – is implemented in a different manner. The cases also suggest that the complexity of the analysis is also different, in terms of cost and time: lower in the case of "who" investigation, rather high in the cases of "what" and "how" TI studies: in fact, cases C and D required a greater effort.

A similar evidence emerged for the other TI methods adopted in the cases, for example with reference to benchmarking, brainstorming, competitive landscapes, as adopted in cases B, D, A. And, finally, the same observation was drawn with reference to the type of TI process (mine, trawl, target, scan): a target TI process conducted on competitors, such as in case B, was less complex than in case A, where the area of investigation was the technology.

So in the end, the empirical study suggests that the complexity of the TI process does not depend only on the type of TI methods adopted, or on the type of process (scan, target, trawl, mine) but especially on the focus of the TI process.

A tentative representation of this evidence is given in figure 1, which suggests that:

- Many TI methods are "general purpose", as they allow to investigate technologies, technology players and their dynamic evolution; in order to be focused on a specific unit of analysis, the implementation is determinant, as it defines the specific areas (or variables, or topics, or elements) of investigation;
- The focus of the implementation determines the level of complexity of the investigation; from the empirical study of this paper it emerges that the "who" area of investigation is less complex than the "what" area, and the "how" area is probably the most complex. Complexity is obviously inversely related to the timeliness and directly related to the cost of the investigation.
- Multi-purpose investigations, i.e. TI processes in which several areas of investigations are included, become really very complex, even if a single TI method is used (or a few), as each purpose asks for a dedicated and specific analysis

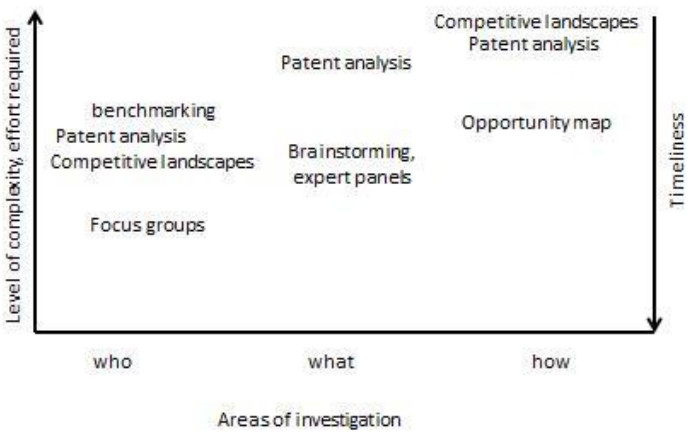


Figure 1. Results form the empirical study

5. Discussion of results and conclusions: the proposed framework

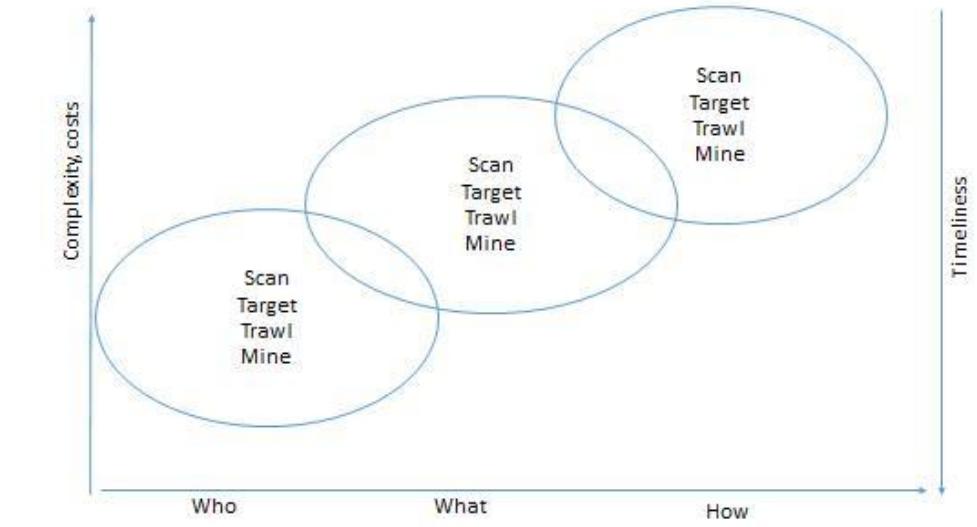
This paper presents a contribution in a stream of literature that received limited attention so far: technology intelligence for SMEs. Given the growing need for technology intelligence activities in the open innovation era (Mortara et al., 2012) and the relevance of openness also for SMEs (Van de Vrande et al, 2009), it is crucial to investigate whether and how the technology intelligence process can be affordable for SMEs. In this sense the paper can be relevant first of all for academics. From this point of view, the paper offers an analysis in which the characteristics of technology intelligence, as depicted in literature, are discussed according to the needs of SMEs and to their specific objectives in the open innovation era. Thanks to the empirical investigation, the paper suggests that a new dimension – the area of investigation - should be considered among the relevant characteristics of the TI process and methods. We highlight here the role of this dimension with reference to some of the most widely cited contributions on technology intelligence: Kerr et al., (2006) and Lichtenthaler (2004; 2005).

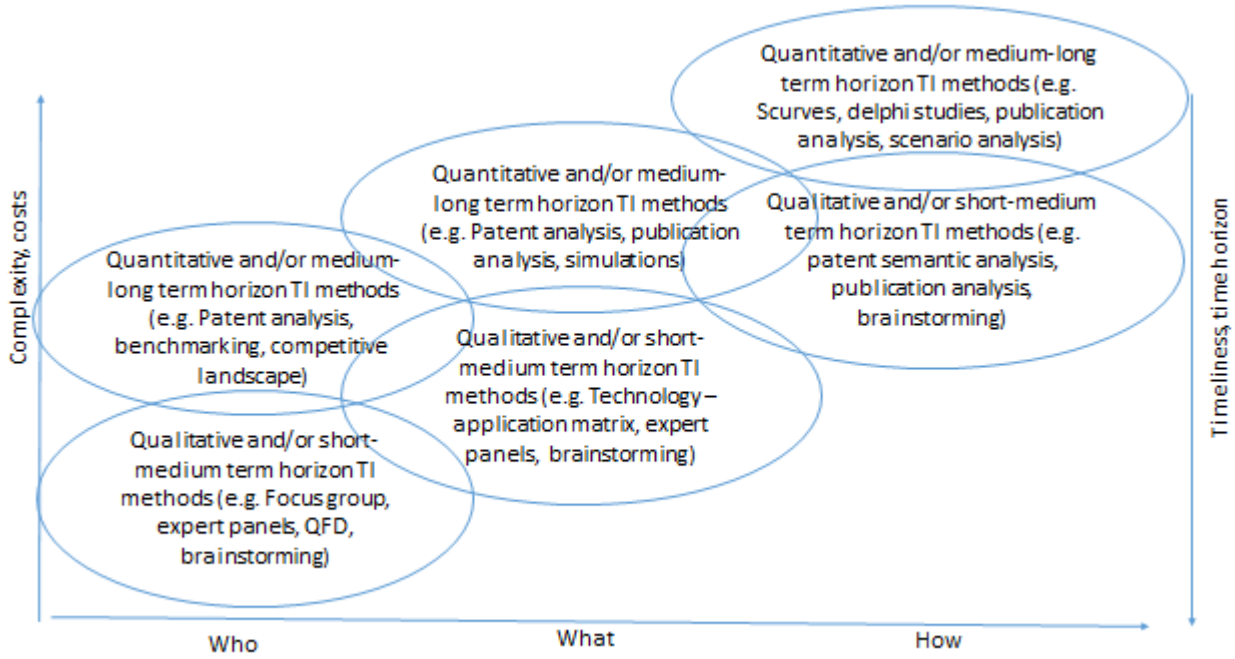
Kerr et al., (2006) distinguish four types of TI process: mine (internal focus, known target), trawl (internal focus, unknown target), target (external focus, known target), and scan (external focus, unknown target). This paper suggests that whatever the type of process – mine, trawl, target or scan – in order to clearly define the type of investigation to be conducted it is also necessary to specify the area of investigation: what (technologies), who (technology players), or how (evolutionary patterns), or a bundle of these areas. And this dimension also impacts on the complexity of the TI process, which is thus influenced not only by the focus of the investigation (internal vs external), by the level of knowledge about the target (known vs. unknown), but also by the areas of investigation (who vs. what vs. how, single area vs. multiple areas of investigation).

With reference to Lichtenthaler (2005), he distinguishes different methods for technology intelligence according to their nature (quantitative vs. qualitative) and their time horizon. We add here that a third dimension, the area of investigation, can be useful to better describe each TI method, its potential use and also its level of complexity. In other words, we argue that each TI method should not be studied and defined "per se", but in relation to the specific area(s) of investigation. As a matter of fact, what emerged from our empirical study is that applying a method with a different focus, who, what or how, (or a bundle of these), asks for a different implementation process that, in turn, leads to different time and costs of the investigation.

This has also an organisational consequence. Lichtenthaler (2004) depicted the organisation of the TI process and identifies the various organisational functions that could be (or should be) involved; our study suggests that, it is true, there is the need to involve various competences and organisational units in order to conduct a TI process. But only those that are actually relevant for the specific area of investigation: R&D for investigations in the "what" area, marketing for investigations in the "who" area, both for investigations in the "how" area. Again, the complexity (and consequently the time and cost) of the TI process increases as the number of different organisational units to be involved increases.

All the above considerations give some guidelines for the development of a quick and dirty technology intelligence process, more affordable also for SMEs. The idea is not to select the roughest methodology, but to focus on a specific area of investigation, by tailoring the TI process (be it mine, trawl, target or scan) as well as the TI methods, in coherence with such area. A tentative synthetic representation of such a framework is given in figures 2 and 3, which are a generalisation from figure 1.





Figures 2 and 3. The proposed framework

From a managerial perspective, all the considerations discussed above give practical guidelines in order to conduct a technology intelligence process. With specific reference to SMEs' managers, the framework brings into evidence how to reduce the complexity, time and costs of technology intelligence, by tailoring the process in coherence with the specific information needs and areas of investigation, avoiding a "one size fits all" approach (in coherence with Savioz et al., 2006). Figures 2 and 3 bring into evidence how to select among different types of TI processes, TI methods and TI areas of investigation, in order to narrow the process and make it coherent with the SME company specific competences and resources.

However, even with a reduced level of complexity, the TI process requires a certain effort, as it is anyway necessary to have deep knowledge about the suitable TI methods, and, furthermore, all methods require access to data and information that may not be available within companies, especially SMEs. Just to make some examples, a "quick and dirty" investigation of technologies by means of a patent analysis requires access to proprietary databases in order to be actually "quick": even if EPO and WIPO provide free access to patent data, the possibility to rapidly download and analyse huge amounts of data is very limited, and proprietary patent databases are much more efficient. Similarly, drawing a competitive landscape requires access to information concerning companies that are not rapidly available

(nor completely reliable) from (in) their websites, or aggregated industry data that, again, are not always free and/or easily accessible. This brings into evidence the need for creating a bridge between research on TI and the empirical implementation of TI within companies. This intermediation role is necessary for allowing SMEs to exploit the benefits of technology intelligence, even when the level of internal competences and the access to data and information is limited. Intermediaries should tailor the TI process, and the TI methods adopted, in coherence with the specific needs of the company.

In our opinion, these conclusions open further directions for future research, that could be dedicated to two main fields, in order to improve the level of adoption of TI in SMEs.

First, the study of the TI methods, in order to improve knowledge about whether and especially how they could be implemented with a specific focus in terms of area of investigation. It would be useful to clarify, for each TI method and for each area of investigation (who, what and how), the type of data and information required, the elaboration requested, the supporting tools (e.g., for statistical elaborations or semantic analyses). These specifications, in turn, will give a more precise idea of the level of complexity, timeliness and cost of the methods.

A second relevant area for future research concerns the role of intermediaries in the adoption of TI within SMEs. The literature on intermediaries in innovation has grown rapidly in recent years (Lee et al., 2010; Spithoven et al., 2011), and we believe that a specific focus on their potential contribution to technology intelligence could be very useful.

Obviously, there are some limits in this paper. First of all, the framework is drawn from the literature and the empirical study, but the number of cases investigated is very limited. Many more cases are necessary to validate the framework. Especially, the study is limited both in terms of type of TI process conducted (mine, trawl, target or scan) and number and type of TI methods adopted. Second, the paper is grounded on a literature focusing on managerial issues in TI (among others, specially Kerr et al., 2006; Mortara et al., 2009; Lichtenthaler, 2004, 2005; Porter, 2005), i.e. a literature more focused on process aspects and on the implementation of technology intelligence within companies. By enlarging the theoretical background to those contributions more focused on the scientific foundations of TI methods, on their robustness and reliability, such as, just to make some example, Park et al., (2013), or Nowack et al., (2011), would give the possibility to improve the understanding of whether and how the TI methods can be tailored to specific information needs, without losing robustness and validity.

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