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Technology intelligence process in practice: building an extensive empirical study

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Abstract: One can observe an exponential growth in Technology intelligence literature recently which enriches current state of knowledge with interesting research topics, approaches, findings and conclusions. However, we believe that all of these different literature streams are fragmented and do not provide a consolidated overview of the research field only with some exceptions. Moreover, there is a lack of empirical evidences in Technology intelligence that is making difficult job of the managers to bring successful practices of Technology intelligence into their own companies. The main purpose of this paper is to describe development process of questionnaire in Technology intelligence. In doing so, we describe three stages of building effective questionnaire in Technology intelligence providing a comprehensive framework and show how this questionnaire can be tailored to different areas of investigation. We also build book of constructs where measurement questions are directly linked with the concepts already proposed in literature. This paper can be beneficial to researchers, who can partly or fully adopt the questionnaire to study Technology intelligence in practice, which consequently fills the knowledge gap in terms of empirical studies in the field. The findings of this first analysis will be the object of a deeper investigation, in order to test and enforce the validity of the questionnaire. By following the questionnaire, managers can assess the scale and scope of their efforts put in Technology intelligence. Furthermore, the questionnaire with clearly defined constructs by itself can be a guideline for managers to plan and carry out their future Technology intelligence activities.

1. Introduction

Amid accelerating changes in business and technological environment, it is difficult, almost impossible to find a company that innovates, learns and grows in isolation. Shorter product and technology life cycles (Nijssen, 2001), increasing complexity of new products (Wang, 2012), dearth of resources (Gassmann and Enkel, 2004) and growing need for multidisciplinary knowledge (Song et al., 2016) prompting firms to reconsider their internal R&D and collaborate with external actors. An interactive model of innovation implies the use of internal and external sources of knowledge where learning becomes an important process (Lundvall and Johnson, 1994; Pavitt, 1998). Open innovation paradigm following the same logic compels organizations to observe and analyse the external environment in order to tap new opportunities for inbound and/or outbound flows of knowledge, ideas, work in progress innovations. Indeed, the increasing popularity of Open innovation practices confirm the importance of "periphery analysis" (Haeckel, 2004; Day and Schoemaker, 2005) in order to stay tuned for external technology acquisition and exploitation opportunities (Chesbrough, 2003; Laursen and

Salter, 2006; Lichtenthaler, 2008). As Chesbrough (2003; 2006) stated, today the job of R&D managers is not only associated with managing inside the company but also looking beyond the boundaries, mastering the network relations and benefiting from the technological efforts of the other companies. A recent study of Rus et al. (2016) found that the task of open innovation managers is diverse and it encompasses some essential activities such as providing strategic linkages to external stakeholders, developing tools and processes to work with outside partners and also technology intelligence. In order to recognize technological innovations and new ideas outside the company managers have to analyse and keep track a huge amount of information from wide range of sources. Managers have already realized that, just searching online may not be enough to provide insightful and vigorous understanding about latest technological developments: a systematic and formal approach is needed. In this respect, Technology intelligence can be a robust tool to support Open innovation activities within companies. Indeed, Technology intelligence fuels Open innovation with systematic and on time delivery of information "to develop an awareness of technology threats and opportunities" (Kerr et al., 2006). The objective of technology intelligence is to aid the decision-making process of the company with early identification and understanding about breakthrough innovations, technological trends, changes in competitor movements and markets that are linked to technology innovations. Beyond these objectives, Technology intelligence may facilitate Open Innovation in many aspects, such as it is used to detect new product, process or collaboration opportunities (Ashton and Stacey, 1995); to observe political, economic, social, legal or environmental attributes of a technology (Mortara, 2007); to search technology commercialization and acquisition opportunities (Rohrbeck, 2007; Huston and Sakkab, 2006; Lichtenthaler, 2008); to search and identify alternative technology applications (Bianchi et al., 2010). Despite a great importance attached to it, the literature documented a few cases where the companies failed to implement Technology intelligence practices successfully (Lichtenthaler, 2003; Ranjbar and Tavakoli, 2015). The reasons of this failure are explained with the lack of systemized and organized methodology of Technology intelligence (Savioz, 2004), absence of theoretical approaches describing how to operationalize Technology intelligence in practice (Lichtenthaler, 2003) and deficiency of empirical evidences (studies) to serve as a manual for managers. To remedy this limitation, a couple of months ago the pioneer of the British society, The Telegraph launched a journalism initiative - "Technology intelligence" to report success and failure stories of companies in implementing Technology intelligence practices, technological developments and their effect to society; considering it as a "story of everything". Existing literature in the field mainly discussed how the companies determine information needs (Ashton et al., 1991; Ashton and Stacey, 1995; Mortara et al., 2008), how the process of Technology intelligence is coordinated (Reger, 2001; Lichtenthaler, 2004; Savioz, 2004), different sources of information acquisition (Reger, 2001; Lichtenthaler, 2005), what methods and tools are applied to analyse collected information (Lichtenthaler, 2005; Savioz and Blum, 2002; Yoon, 2008; Yoon and Kim, 2012), communication practices (Mortara, 2015). However, it should be already clear that all of these literature streams are fragmented and do not provide a holistic overview of the research field with some exceptions (Kerr et al., 2006; Mortara et al., 2009). For instance, Lichtenthaler (2006) called for further studies to investigate Technology intelligence in a holistic way rather than treating it as a formal company unit. Savioz (2006) suggested to review different elements of Technology intelligence more in detail through empirical studies and to find answers to very specific questions through quantitative research. Survey has been acknowledged as an accurate research tool which allows to collect generalized and standardized data about specific phenomenon. Recently, an extensive literature review on empirical studies in Technology intelligence carried out by Manzini and Nasullaev (2017) stated that, there is a room for future contributions to determine general overview of the implementation of the Technology intelligence and called for applying other types of empirical studies, i.e. surveys, interviews or experiments in extensive context for the investigation of Technology intelligence. The aim of this paper is to fill aforementioned research gaps. For this, we describe a construction process of survey questionnaire that will be primarily used to evaluate overall picture of Technology intelligence. We also show how this questionnaire can be tailored to different areas of investigation. The paper is structured as follows: in the second section we discuss Technology intelligence and its main elements in order to identify the concepts (topics) that will be used in the questionnaire. The third section deals with research questions and methodology. In the fourth part we describe the process of development of questionnaire in three stages. The fifth section discusses overall process and areas of investigation where elaborated questionnaire can be implemented.

2. Theoretical framework

According to Durand (2014) Technology intelligence is a broad concept and it feeds both organizational strategy and innovation processes. Technology intelligence takes part in strategy development process of a firm with technology related information which in turn will enhance innovative capacity of the company. Technology intelligence includes activities like scanning potentially important technologies for future, technology mapping, competitive intelligence gathering, surveying technology markets, monitoring patents and other intellectual property rights databases. Technology intelligence as a concept has a long historical standing and one can observe an exponential growth in the literature (Figure 1). The first ideas in this concept have sprung from theories about early identification of weak signals in turbulent business environments (Ansoff, 1975; Utterback & Abernathy, 1975; Quinn, 1985). It was believed that based on early identified signals companies can timely recognize potential technological threats, anticipate consequences and benefit from opportunities.

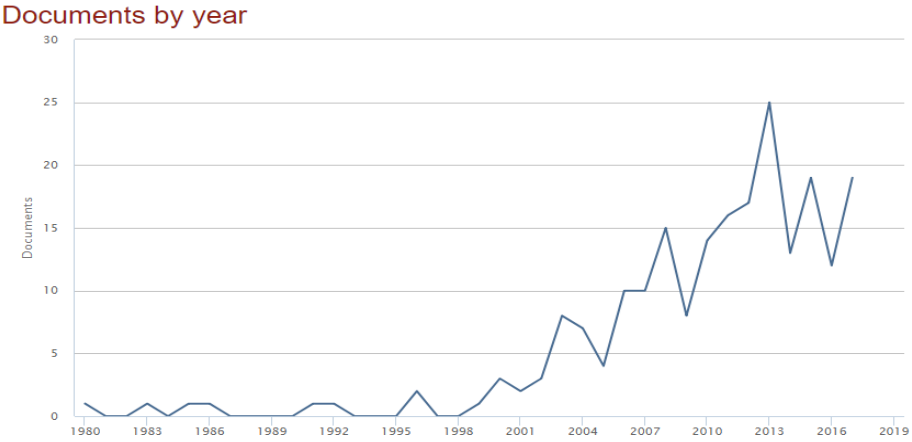

Figure 1. Evolution of concept of Technology intelligence in the scientific literature: 1980-2017. Source: Scopus

In early 90's the literature started to delve more deeply into discussions how the collected information from external environment can be integrated to the strategic planning of the company. Brockhoff (1991) argued that in order to reserve first mover position the companies should centralize analysis of information and institutionalize competitor intelligence. Ashton and Stacey (1995) stated that many companies practice Technology intelligence, but more often it is not recognized as a valuable resource of the firms by managers. Therefore, the authors called for a systematic organization of a science and technology intelligence. Benefits of Technology intelligence and scouting are: it avoids surprises, reduces risks and identifies early trends (Brenner, 1996). Lichtenthaler (2003; 2004; 2006) treated Technology intelligence as a task to support decisions of the company with "activities related to the collection, analysis and communication of relevant information on technological trends". The scope of Technology intelligence may go beyond observation of technological developments, it may also encompass individual competitors, universities, clients, suppliers, interesting start-up companies. The empirical literature documented several approaches of conducting Technology intelligence: a systematic and formal way, a spontaneous way and mixture of them. Norling et al. (2000) emphasized on positive relationship of structured Technology intelligence process to the success of Technology intelligence activities. Arman and Foden (2010) explained that, companies face difficulties in formalizing such practices because of the exploratory nature of Technology intelligence. Savioz (2006) asserted that, most companies aim to follow formal and systematic approach but they do it without defining the degree of formalization and systematization. We believe that to meet this requirement, managers should be aware of certain elements of Technology intelligence system.

2.1 Technology intelligence system and its elements

According to Boulding (1985), system is: "… anything that is not chaos. We could turn the pattern around and define a system as any structure that exhibits order and pattern". Hence, Technology intelligence as a system constitutes set of elements and activities that represent hierarchic, continuous and holistic behaviour. Primarily, the literature distinguishes two dimensions of Technology intelligence: technology monitoring – observing already existing, state-of-art technologies & research (directed perspective) and technology scanning - identifying, observing and analysis of new technologies outside the firm (undirected perspective) (Reger, 2001; Lichtenthaler; 2004). In Peiffer (1992) these two dimensions are given as inside-out and outside-in perspectives. It is the interaction of the firm with internal context and external environment to operationalize Technology intelligence. In his analysis, Savioz (2004) defines information need formulation, collection, analysis, dissemination and application of information as direct activities of Technology intelligence system and there are some other supporters (indirect activities) that enable primary activities (Figure 2). These are: Technology intelligence management, mission and goals, structure, tools (methods and infrastructure). Technology intelligence management is a basic function of the system which deals with designing, directing and development of elements. Management of Technology intelligence is not an element or result, rather that it is a guiding process of the system. It supports direct activities and contributes to the value creation. Technology intelligence mission and goals denote the reasons why companies conduct Technology intelligence. As mentioned in introduction part of this paper the literature lists several aims of doing Technology intelligence. However, the primary concern of Technology intelligence is to support business decision of the company with on time and accurate information. Technology intelligence structures include organization and coordination of intelligence activities and human resources. In Kerr et al. (2006) coordination process is described as planning the activities, allocating resources and designating intelligence agents. Quinn (1985) delineating five types of intelligence structures suggests centralized monitoring structure for keeping abreast of technological changes. Lichtenthaler (2004) distinguishes three parallel layers of coordination of technology intelligence processes: structural, informal and hybrid coordination.

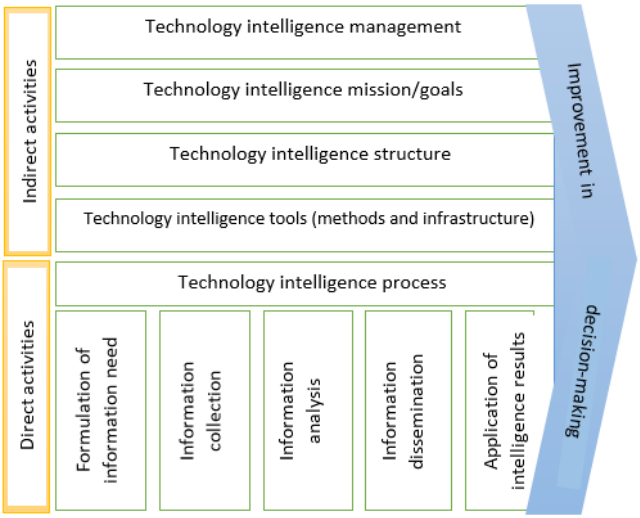

Figure 2. Technology intelligence system adopted from Savioz (2004).

A number of studies tries to bring the factors that impacts on the organization of Technology intelligence activities. In Quinn (1985) these factors are: size of company, its capital intensity, planning horizon, degree of diversification and importance of technological factors in the strategic planning of the company. Correspondingly, Savioz (2004) lists corporate culture, technology life-cycles, company structure, innovation strategy, decision-making process and industrial sector as influencing factors. Nosella et al. (2008) identify four factors influencing technology monitoring process of the firm, namely the industry which company belongs to, business model, corporate culture and R&D structure of the company. Technology intelligence structure also includes people (agents of Technology intelligence) and their roles. Assignment of roles to a single individual or a group of people can derive from the structure of the company and nature of the task. Reger (2001) binds different players of the Technology intelligence to different organizational levels. The author highlights that regardless the approach, bottom-up or top-down, the intelligence activity is generally carried out either by researchers, engineers or technology agents. Savioz and Blum (2002) suggest that whole process of Technology intelligence and decision-making shouldn't be performed by the same person. If it is the case of small firms, the scale of Technology intelligence activities should be reduced. And finally the last part of our system is followed by Technology intelligence tools including methods and technical infrastructure. The literature is rich with contributions about specific type of method (or combination of two or more methods) and its application in defined areas of knowledge (i.e., Boon and Park, 2005; Zhu and Porter, 2002; Jun et al., 2012 – patent analysis; Cheng and Chen, 2008; Yeo et al., 2015 – bibliometric analysis; Daim et al., 2006 – patent and bibliometric analysis; Cheng et al., 2008 – Delphi and case study). Lichtenthaler (2005) analyzes factors influencing the selection of Technology intelligence methods in a certain situation. Some intelligence tools are proposed by Yoon (2008) - Techpioneer; Yoon and Kim (2012) - TrendPerceptor and Savioz and Blum (2002) – Opportunity landscape, for instance to detect technological opportunities.

Castellanos and Torres (2010) characterize Technology intelligence system in three components and subsystems: 1) implementation of tools; 2) creation of knowledge and 3) implementation of strategies. Like the model explained above this system is also open system and it interacts with external environment and other components. The main output of this system is a knowledge for decision making. Dynamism, flexibility and systematicity are the main attributes of this complex Technology intelligence system.

Integrating all of these contributions from literature it is now possible to develop a theoretical framework of our study (Figure 3). If we recall everything that was mentioned above, Technology intelligence is a process that is constituted from direct activities: identifying information need, coordination, collection, filtering, analysis, documenting and communication of information. There are some indirect activities that are embedded in the internal context of the organization. For example, technology management, technology intelligence methods and tools, infrastructure, skills and capabilities, company culture. Technology intelligence process also interacts with external environment, in particular with business, technological, legal, political, socio-economic environment. Two perspectives: directed which is monitoring already existing technologies and undirected, scanning new technologies outside the company demonstrate the interplay of internal and external contexts of the firm. This framework will help us to understand concepts and constructs of the questionnaire that will be explained in the following sections.

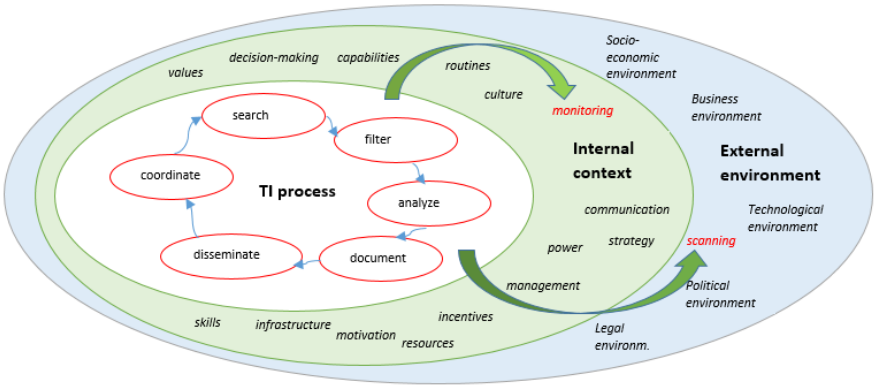

Figure 3. Theoretical framework

3. Research questions and methodology

To make a step forward towards better understanding the overall nature of Technology intelligence this study describes a construction process of survey questionnaire in Technology intelligence. To meet this aim we investigate following research questions:

- How to construct an effective survey questionnaire to explore empirical nature of Technology intelligence?
- How this survey questionnaire can be tailored to different areas of investigation?

The questionnaire technique in survey method can be considered as an effective and cost-efficient way of collecting data on specific topic (Parker and Rea, 2014). As a self-administered way of surveying, questionnaires allow researchers to collect the data from the large samples, allow contact with inaccessible participants, require minimal staff and enable to analyse the collected information in a structured way (Cooper and Schindler, 2014). According to Sheatsley (1983) a well-designed questionnaire should fulfil three conditions: 1) it should meet the research objectives; 2) should collect most complete and accurate information; 3) should be cost and time efficient. The international handbook of survey methodology highlights three main stages of effective survey development: construction or design, administration or implementation and analysis (Leeuw et al., 2008). This article describes the first, construction stage of survey development.

The overall process of questionnaire development is performed in three stages. Each stage is followed by subsequent activities (Figure 4).

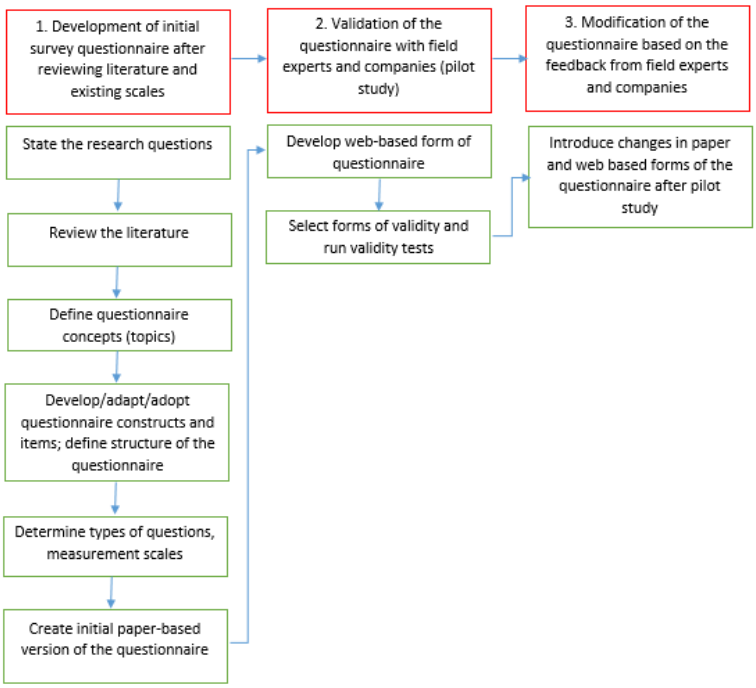

Figure 4. Overall process of questionnaire development

The suggestions for these activities were collected from different strands of methodological literature on survey questionnaire development. For instance, Peterson (2000) pointed out seven tasks to achieve good questionnaire: 1) check the information requirements entailing the questionnaire; 2) list potential questions that will answer to information requirements; 3) evaluate each question carefully; 4) select types of questions that are going to be asked; 5) decide specific wording for each question; 6) define the structure of the questionnaire and 7) evaluate the questionnaire. Passmore et al. (2002) delineated eight steps of survey development that allow researchers to obtain useful results: 1) define the problem or need; 2) plan the project; 3) determine research questions; 4) review the literature; 5) develop or adapt survey items; 6) construct the survey; 7) conduct pilot tests and 8) administer the survey. Based on these suggested steps we developed a questionnaire to investigate overall picture in Technology intelligence. The questionnaire has been verified and improved with experts in the practice of Technology intelligence, in order to capture not only theoretical, but also implementation, practical issues. We also provide a complete "book of construct" where measurement questions are directly referred to the concepts already proposed in literature. Each stage will be extensively discussed in the following section.

4. Building an extensive empirical study in Technology intelligence

4.1 Development process of the initial version of the questionnaire

The development process of initial version of survey questionnaire started with defining knowledge gaps and stating research questions. The need for comprehensive survey in Technology intelligence as a lacuna to be meet by future works emerged from an extensive literature review conducted by the members of our research group (Manzini and Nasullaev, 2017). This in turn allowed us to formulate research questions and move along each step of the process with reviewing state of art literature. Who, when, what (which), why, where and how (5w 1h) framework assisted us to place the elements of Technology intelligence system and draw a roadmap to follow (Figure 5). Furthermore, the research group had already prior experience in managing extensive studies and related questionnaire development process which granted to go the process smoothly.

Figure 5. 5W1H framework of Technology intelligence

Our idea was not to observe a single element of Technology intelligence, but to study the phenomenon in a holistic way instead as it was suggested by the literature. Consequently, following research questions were identified to build a questionnaire:

1. How companies handle the process of Technology intelligence?
   - 1.1 Which needs (reasons) get the firms to conduct Technology intelligence?
   - 1.2 How the information need is defined in companies?
   - 1.3 How the process of Technology intelligence is coordinated in companies?
   - 1.4 How companies search for information?
     - 1.4.1 Which sources companies use to get information?
   - 1.5 How do they filter collected information?
   - 1.6 How do they analyze collected information?
     - 1.6.1 Which methods do they use for analyzing the information?
     - 1.6.2 Which tools (infrastructure) do they apply for analyzing the information?
   - 1.7 How companies manage (store, document) results of analyzed information?

1.8 How companies disseminate and communicate the results of intelligence?

2. How companies measure the outcome (quality) of intelligence results?
3. Do companies have organizational capabilities to make Technology intelligence?
4. What issues companies face while operationalizing Technology intelligence?
5. How external environment influences on implementation of Technology intelligence practices?
6. How Technology intelligence is linked with Open Innovation (what is the relationship)?

These questions were collected from different streams of literature that investigated various aspects of Technology intelligence: the overall process, main activities-phases-of the Technology intelligence, evaluating the effectiveness of intelligence results, skills and capabilities that are required for Technology intelligence, effect of external environment to intelligence process and etc. After research questions being determined, we conducted another cycle of literature review to come up with questionnaire concepts (topics). This was necessary to formulate the questionnaire framework. Based on our findings from literature review and a theoretical framework presented in the previous section following ten topics were chosen to be investigated in-depth: 1) objectives and motives of conducting technology intelligence; 2) information need definition; 3) coordination of Technology intelligence activities; 4) search for information; 5) filtering collected information; 6) analyzing collected information; 7) documenting and disseminating intelligence results; 8) measuring effectiveness of Technology intelligence results; 9) General issues related to Technology intelligence; 10) Overall context in which Technology intelligence activities are carried out. The questionnaire also included some starting information about the company and respondent. The reason behind such kind of structure is that, we followed a Technology intelligence process cycle proposed by Kerr et al. (2006) which is the most comprehensive and latest framework to our best of knowledge. We also selected this framework in order to facilitate a systematic and sequential process of response collection. In addition to this framework we included a section about goals and objectives of conducting Technology intelligence activities to understand what reasons get the companies to operationalize Technology intelligence. A section about assessment of Technology intelligence activities aimed to explore if the companies measure effectiveness of Technology intelligence results, the ways how they do it and measurement metrics they use. In order to find out the issues the companies are coming across while performing Technology intelligence a dedicated section to this topic was included. Technology intelligence cannot exist in solitude: it is one of the main tasks within the internal context and it interacts with external environment. Internal context of the organization contains important elements like culture, routines, management, capabilities, skills, power, communication etc., as shown in the theoretical framework. And external environment comprises competitive, technological, business, political or legal factors that influence company's operations. To show this interaction between Technology intelligence and overall context (external, internal) a section was devoted in the questionnaire. Figure 6 presents selected topics of the questionnaire with a reference to each research question:

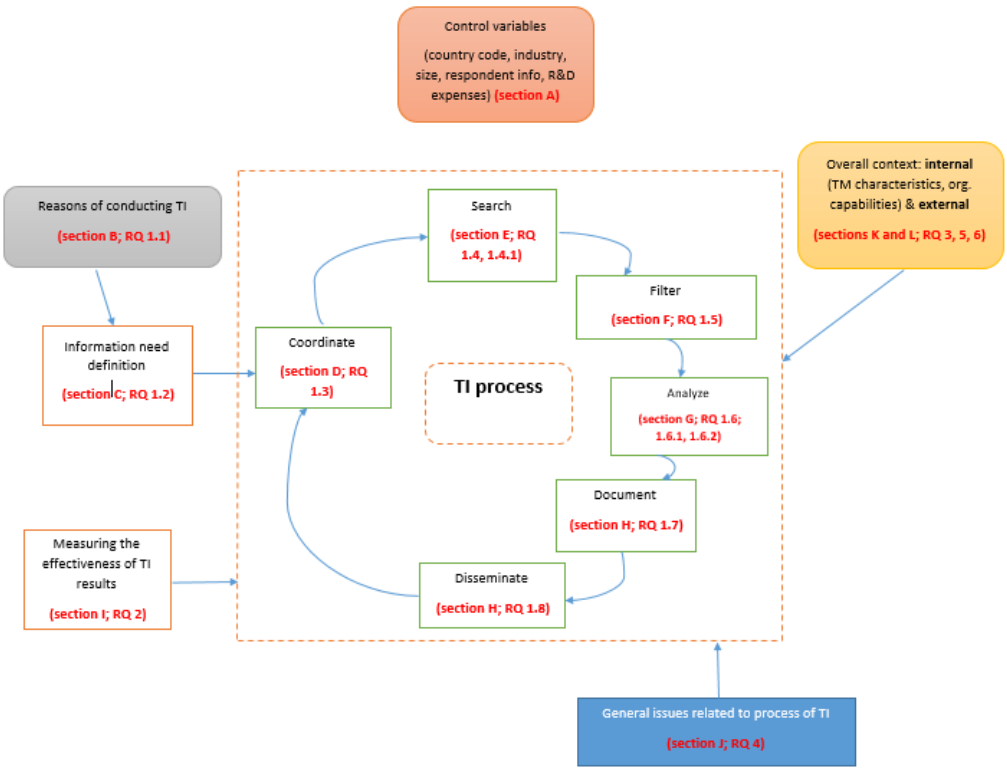

Figure 6. Questionnaire framework

After defining questionnaire topics, we stepped into the process of building constructs (questions), items and measurement scales of the questionnaire. An introductory statement was included at the beginning of questionnaire about objectives of this survey, request for collaboration and confidentiality terms. We also provided list of sections and some instructions how to use this questionnaire. Majority of the questions depicted from the concepts already existing in the literature and only few questions were adapted from other published surveys. Then we elaborated a first version of the "book of constructs" (Appendix 1) that enabled to clarify theoretical foundations of the questionnaire. As a matter of fact, in book of constructs each concept (sections), construct (questions) and items was linked with the literature in order to show that the questionnaire is scientifically robust and with knowledge embedded value. Indeed, book of constructs was important to show the source and origins of each concept, question and item. Having a knowledge about questionnaire development methodology we selected closed-ended form of questions in order to keep uniformity and simplicity in a given construct although in exploratory studies open-ended questions are preferred. We applied different types of measurement scales, for instance dichotomous (yes/no answers), multiple choice, checklist, rating and free response forms of scales with interval, nominal, ordinal or ratio data types. In our most questions we applied numerical scales (for example, strongly disagree 1 2 3 4 5 6 strongly agree 7) to measure respondent's overall attitude. Even in some closed-ended questions "other" free response boxes were included in order to obtain additional information from the respondent assuming that answers may go beyond the given choices. Discussions about the selection of right questions and measurement scales were performed during several rounds of meetings among the authors. At the end the first version of questionnaire was to ready for the circulation and validation with internal, external experts and companies.

4.2 Validation process of the questionnaire

In the second stage we validated the first version of the questionnaire with four different groups of specialists. The first group comprised experts from our own Institution who had a thorough knowledge and experience in the field. Then we discussed the questionnaire with the filed experts from consultancy firm Strategie & Innovazione who is active in the field of Technology intelligence since the '90s. The third group of our experts were the managers of large, small and micro start-up companies located in Estonia and France or people responsible for Technology intelligence activities in this firms. We conducted a pilot test with them during explorative case-studies treating it as a complementary to interview protocol. And finally the fourth group of experts included the panel of scholars from two European Universities who had a research and practical background in this domain of knowledge. In fact, literature differentiates three ways of evaluating a measurement tool: validity, reliability and practicality (Cooper and Schindler, 2014). Validity is a way of measuring what we actually want to measure. There are three types of validity: predictive validity, content validity and construct validity (Nunnaly 1978). We mainly referred to content validity in the initial stage of questionnaire development because content validity may be based on the judgement and assessment of experts. Abramson and Abramson (2008) suggested that the questionnaires should have at least face validity, put it differently the questions should be asked if they are necessary. In order to ease the validation process with aforementioned four groups of experts we developed a set of questions to be answered by our experts to assess the quality of the questionnaire. These questions and feedback collected from experts are synthesized in the following Table 1. To make the questionnaire more accessible, we launched a web-based form of the work.

Table 1. Content validation of the questionnaire with experts and managers

Some examples of the questions provided to experts to assess the quality of questionnaire (checklist): Do respondents understand the meaning of the questions? Is the questionnaire free from ambiguity, confusion and vagueness? Is the questionnaire accurate, concise and clear? Is the questionnaire reliable and practicable? Are the questions linked with state of art literature? Does the questionnaire use appropriate language? Are the questions measured with appropriate scales? Does the questionnaire follow sequential and logical order?	
Group of researchers	**Conducted activities and examples from their feedback**
First group of internal experts	*Activities:* analysis of content of questionnaire; verification of relevance of selected constructs; checking the relevance of questions and linked sources; checking the use of terms and definitions in the questions; testing measurement scales *Feedback:* some questions and items are difficult to understand, some parts can be considered redundant and not so appropriate. In particular, several questions in Open Innovation section (section L) should be eliminated as the idea is already considered in some of the other questions. Section about TI process is well

	given, although some questions could be simplified or reformulated.
Second group of external experts from the field (Strategie e Innovazione)	*Activities:* verifying the practical applicability of questionnaire; checking if the questions are clear to companies; controlling the relevance of chosen constructs; evaluating the importance of each selected item. *Feedback:* questionnaire should be simplified in its wording; the questionnaire should be sent also to the "users" of technology intelligence and not only to persons responsible for TI within the company. The two types of respondents should have a different set of questions between them. A specific type of questionnaire, with another specific set of questions, could be addressed to intermediaries specialised in TI activities. A clear flowchart could be added to the questionnaire, for each type of respondent (user / internal specialist / external intermediary), which specifies how to use the questionnaire.
Third group of external experts (companies; pilot study)	*Activities:* to check if managers perceive the meaning of questions on the same way as authors; to test the questions if they are understandable; to define if the selected constructs appropriate to firms. *Feedback:* the questionnaire should be reduced as it is too long. Some questions should be more specified, in some cases, terms are not clear (for example question about Technology intelligence methods); to cut repetitive questions and items.
Fourth group of external experts (University researchers)	*Activities:* to check overall structure of the questionnaire; to verify if the concepts derive from up to date literature; to control measurement scales. *Feedback:* to check measurement scales in the starting section of the questionnaire (section A), particularly to avoid open-ended items; to eliminate some redundant and self-evident questions; to merge some similar items; to reconsider some questions about overall context.

4.3 Modifying questionnaire based on the feedbacks and pilot study

When all feedbacks from expert groups were collected we took another round of final discussion with authors to refine and make decisions concerning updated version of the questionnaire. Consequently, we modified both paper-based and web-based forms of the work according to the conclusions and judgements of experts gathered during the third stage. We introduced changes to the questions based on the collected feedbacks always referring to the literature. Even some new constructs (not necessarily drawn from literature) were included when it was required. We also revised a book of constructs obviously, with a reference to literature after what a final version of the document was ready to be used. Our future plan is to share the questionnaire with target companies and run exploratory factor analysis and other internal and external validation tests so that researchers and practitioners could benefit from exhaustive and reliable version of the work. The book of constructs will be detailed in appendix section of this paper.

5. Discussion and conclusions

This study set out to describe the process of building effective questionnaire in Technology intelligence aiming to tackle research gaps related with scarcity of empirical studies in the field. In fact, this need derived from the various literature strands that emphasized the importance of practical contributions to explore overall nature of Technology intelligence by applying different qualitative and quantitative methodologies, such as action research, surveys or observations in extensive context (Lichtenthaler, 2003; 2006; Savioz, 2006; Mortara et al., 2009; Manzini and Nasullaev, 2017). Our findings from literature review brought into evidence Technology intelligence system and its elements that

are necessary to consider while building such kind of empirical studies. In doing so, we built a conceptual framework integrating different strands of literature in order to better understand the concepts that are orchestrated in the questionnaire. After informing ourselves with methodological suggestions on building survey questionnaires (Leeuw et al., 2008; Peterson, 2000; Passmore et al., 2002) we defined the steps of performing this activity. More precisely, we constructed the questionnaire in three main stages: developing initial version of the questionnaire, validating it with field experts and pilot study with companies and modifying the questionnaire according to the collected feedbacks. Each stage was followed by subsequent activities. For example, first stage was commenced by identifying research questions and reviewing the literature. The research questions were put forward by the literature that we investigated in our previous projects. When we came up with questions we conducted another cycle of literature review to decide about the concepts (topics) of the questionnaire. As a result, ten concepts were determined from literature that required in-depth exploration. After this action we build, adapted or even adopted (where it was necessary) the constructs of the questionnaire always referring to the literature. Type of the questions and measurement scales were also agreed during this stage. As an outcome of this process we elaborated a book of constructs where we provided source of each concept, question and item to be congruent with the literature and to provide theoretical foundations of our work. In the second stage we validated the questionnaire with four group of specialists: internal experts from our own institution, external experts from the field (consultancy firm), managers or people who are responsible for Technology intelligence from companies and researchers from two other European Universities who had a knowledge in Technology intelligence. Four groups of Technology intelligence specialists provided their conclusions and feedback grounded on the terms of reference prepared in advance by us. Feedbacks given by the specialists helped us to improve the quality of the questionnaire to a considerable level. Even some of the comments collected during the validation are kept to be used in the next steps of our research, that will be dedicated to the implementation of different types of survey. When the results of evaluation were collected from experts and managers we modified the questionnaire and book of constructs always bounding them with specific literature or source to make the work scientifically robust and vigorous. The book of construct presented in Appendix 1 is the final version of our work and further steps should be taken towards implementing and testing this questionnaire, as well as validating with other types.

We believe that this work is important in several major respects. As it already became clear, in our elaborated questionnaire we tried to concentrate on different elements of Technology intelligence to investigate consolidated perspective of the concept. Indeed, our questionnaire comprehends important building blocks, such as mission and goals, structure, methods, tools, people, infrastructure, process of Technology intelligence which are adaptable to different areas of investigation. The questionnaire can be useful to study aforementioned areas of Technology intelligence separately or in combination depending on research settings. In fact, the questionnaire gives theoretical foundations for many different kinds of possible empirical researches. Then, from the potentially interesting research settings point of view, the questionnaire can be equally tailored to different contexts: large firms, small and medium-sized companies spin-offs or even start-ups; country-specific contexts, for instance developed, catching-up or emerging countries. Although our questionnaire is primarily designed for manufacturing firms, it can be also employed to other industries and sectors. For instance, Ranjbar and Tavakoli (2015) and Khosropour et al. (2015) highlighted the lack of works in Technology intelligence that designed to study service organizations and companies. So this questionnaire can give a hand with understanding how technology intelligence in service sector is practiced. And in any case, the availability of the book of construct allows researchers to tailor their investigation without losing the scientific robustness of their study and to argue about their choice about what to ask companies and how, with reference to the literature. The questionnaire may also give some insights to researchers about perspective fields in which further studies should be conducted.

Current work is with research and practical implications. This paper can be beneficial to researchers, who can partly or fully adopt the questionnaire to study Technology intelligence in practice, which consequently fills the knowledge gap in terms of empirical studies in the field. The findings of this first analysis will be the object of a deeper investigation, in order to test and enforce the validity of the questionnaire. By following the questionnaire, managers can assess the scale and scope of their efforts put in Technology intelligence. Furthermore, the questionnaire with clearly defined constructs by itself can be a guideline for managers to plan and carry out their future Technology intelligence activities.

Appendix 1. Book of constructs

Construct (Question)	Operationalization	References
Section B: Objectives and motives of conducting Technology intelligence		
Objectives of operationalizing TI BQ-1	(1) to identify latest developments in science and technology (2) to follow development (path) of specific technologies (3) to identify potential technological threats (4) to track the activities of specific organizations and related competitive environment (5) to observe political and/or economic and/or social and/or legal and/or environmental attributes of a technology (6) to determine strategies for internal R&D programs (7) to incorporate new technology advances into products and processes (8) to increase the quality and performance of the existing products (9) to find out new ways in order to decrease the design and production costs (10) to satisfy the customer's new requirements and expectations (11) to detect new collaboration opportunities (12) to identify opportunities for technology investment (13) to search technology commercialization opportunities (14) to search and identify alternative technology applications	The literature provides various motives of conducting TI. Most of these items are found in Ashton and Stacey (1995, p. 83): item (1), item (2) and item (3). Durand (2014, p.4) highlights competitor tracking function of Technology intelligence (item 4). Kerr et al. (2006, p. 74) believe that technology intelligence does not just focus on the technical attributes of technology but just as importantly encompasses the complete spectrum of political, economic, social, legal and environmental attributes of a technology (item 5). Items 6, 10, 11 are given in Ashton and Klavans (1997). Items 7, 8, are taken from Ali-Kilic (2016, p.86): in the case of techno parks in Turkey specifies motivations of Technology intelligence that firms may have. Item 12 was introduced by us. Bianchi et al. (2010) outline role of TI in searching alternative technology applications (item 14). Hustton and Sakkab (2006) and Lichtenthaler (2008) delineate technology commercialization opportunities with TI.
Product focused TI BQ-2	(1) New or disruptive technologies that might affect our business (2) Complementary technologies that our new products or services may require (3) New skills and capabilities we have to possess in order improve our offered product or services	Mortara et al. (2007, Cambridge, p. A5-A6) suggest to build two types of technology watch-list. The first type is product focused technology watch-list. Items 1-4 come from this source.

	(4) Legislative, social, political or environmental factors that might affect us during the use of technologies	
Competitor focused TI BQ-3	(1) Technologies and products that they are developing (2) Their future business strategies (3) Their market strategies in different geographical areas (4) If they collaborate and who are they partners? (5) If they patent, their patent activity and in which technological areas they patent (6) Their strength, weaknesses, opportunities and threats	The second type of the technology watch-list is competitor focused in Mortara et al. (2007, Cambridge, p. A5-A6): items 1-6.
Areas of manufacturing-related technologies to undertake TI efforts BQ-4	(1) Supply processes (inbound or outbound logistics, stocking, etc.) (2) Manufacturing processes (3) Quality insurance (4) Production control (IT, production systems) (5) Material engineering (new material technologies)	Gerhard and Voigt (2009) show different areas of manufacturing where TI activities are performed. Items 1-5 are fully adopted from this source.
Section C: Information need definition for TI		
Ways of defining information need CQ-1	(1) It is not possible to define information need in our company because this process is isolated from decision-making and decision-makers. (2) Information need is defined through intensive interaction with key customers, business partners in top-management. (3) Our company defines information need through participation in decision-making processes and interaction with customers and business partners.	Lichtrenthaler (2003, p. 367-368) identifies three generations of technology intelligence. Items 1-3 correspond with these 3 generations in terms of information need definition.
Typical users of intelligence CQ-2	(1) scientists and engineers (2) R&D staff (3) technical staff (4) marketing personnel (5) senior executives (6) technology/product planners and developers (7) strategy planners (8) business executives (9) internal policy analysts	Ashton et al. (1991, p. 97) and Ashton and Stacey (1995, p. 89) bring the list of typical users of information in organizations and link them with the type of information they may need. Items are taken from these 2 sources.
TI approaches in companies CQ-3	(1) In our company decision-makers ask TI experts to gather the information.	Kerr et al. (2006, p. 80) and Mortara et al. (2008, p. 116) differentiate two approaches in Technology intelligence: top-down (I want to know) and bottom-up

	(2) In our company TI experts know who would be interested in receiving particular information acquired. (3) In our company the information is gathered following decision-makers request and also with the initiative of intelligence agents without a specific request.	(You need to know). Item (1) characterize top-down approach, item (2) bottom-up approach. item (3) mixed approach was introduced by us.
If decision-makers part of TI process or not CQ-4	(1) Yes (2) No	Mortara et al. (2007, Cambridge, p. 6), Savioz (2004) and Savioz and Blum (2002) highlight role of decision-makers in TI process.
Communication of TI needs (means) CQ-5	(1) During individual meetings (2) Through presentation (3) Through formal report (4) By e-mail (5) Through intranet or company online platform	Mortara et al. (2007, Cambridge, p. 6) give a list of questions to explore the context of technology intelligence in companies. Items 1-4 deal with means of communication during the process of information sharing. Item 5 is introduced by us.
Frequency of receiving information about TI needs CQ-6	(1) daily (2) weekly (3) monthly (4) on request	Items 1-4 are about frequency of information obtaining in Mortara et al. (2007, Cambridge, p. 6).
Ways of advertising intelligence interests CQ-7	(1) Through conversation with colleagues (2) Through personal webpage (3) Through mailing list	Mortara et al. (2007, Cambridge, p. 6) about communication of intelligence interests in item 1-3.
Section D: Coordination of TI activities		
Availability of formal TI dedicated unit / function / department / group/person in your organization? DQ-1	(1) Yes (2) No	This question was newly created, however considerable number of works in the field question if company has formal TI structure or not. For instance, in Quinn (1985), Kerr et al. (2006) and Lichtenthaler (2004).
Age of formal TI dedicated unit / function / department / group/person in your organization? DQ-2	(1) Just started (2) 1-2 years (3) 3-5 years (4) 6-8 years (5) 9-10 years (6) Older than 11 years	This question was newly created.
TI structures DQ-3	(1) Dedicated unit (2) Inclusion within a central group function, which performs also other activities. (3) Decentralization to operational divisions (4) Diffusion throughout the company (5) No institutional arrangement for TI	Quinn (1985, p.73) identifies five main approaches of monitoring technological environment (items 1-5). This is confirmed also by Kerr et al. (2006, p. 86).

Availability of systematic TI process DQ-4	(1) yes, we had a systematic TI process but abandoned it (2) yes, we have a systematic TI process in our company (3) no, we do not have a systematic TI process in our company, but plan to implement one (4) no, we do not have a systematic TI process in our company and do not plan to implement one.	This question is adopted from Gerhard and Voigt (2009).
Availability of dedicated budget for TI DQ-5	(1) Yes (2) No	Ali-Kilic (2016, p.88) highlight regulations and resource allocation of the firms to conduct the Technology intelligence process in firms.
Size of the budget DQ-6	Free response box	Newly created construct.
Nature of TI activities DQ-7	(1) Our TI activities are issue driven (2) Our TI activities are continuous	Rohrbeck and Gemunden (2008) delineate two types of foresight activities: project-based (issue driven) and continuous. The same differentiation can also be applied to TI.
Collaboration for TI DQ-8	(1) Only by our company (2) with customers (3) with suppliers (4) with competitors (5) with companies from different industries (6) with universities and research centers (7) with specialized TI companies (consultancies) (8) with other collaborative partners	The question is adapted from Gerhard and Voigt (2009). However, Miemis et al. (2012), Daheim and Uerz (2008) propose concept of Open or collaborative foresight. This question is given to check if such practices is also applicable for TI as well.
Section E: search for information		
Focus area/scope of search of new technologies EQ-1	(1) Search for defined areas on regular basis (2) Search for defined areas on irregular basis (3) Search for all kind of areas on regular basis (4) Search for all kind of areas on irregular basis	Literature gives two dimensions of TI: monitoring (search for defined areas) and scanning (search for all kind of areas) (Reger, 2001; Lichtenthaler, 2004; Peiffer, 1992). This construct is adapted from Gerhard and Voigt (2009).
Sources of information for TI EQ-2	(1) Internet, web-sites (2) Journal, books, annual reports, newspapers, conference proceedings (3) Statistics, statistical data (4) Patents, licenses (5) Trip reports to technical sites or meetings, correspondence, briefing materials, meeting notes (6) Field publications (7) Non-field publications	The sources of information are collected from Ashton et al. (1991, p. 100); Ashton & Stacey (1995, p. 91); Reger (2001); Lichtenthaler (2004); Savioz (2004); Mortara et al. (2008) and Mortara et al. (2009); Durand (2014)

	(8) Libraries (internal and external) (9) Intranet (eg. idea databases) (10) Internal and external databases (online and CD rom) (11) Governmental foresight studies (12) External intelligence reports (13) Conferences, fairs, seminars, exhibitions, international congresses, events, etc. (14) R&D cooperation with Universities (15) R&D cooperation, joint ventures and alliances with firms (16) Participating in public R&D projects, programs (17) Government bodies (18) Expert circles (norming committees, opinion leaders, professional associations) (19) technical and professional bodies (20) Online communities, web forums (21) Consultants (22) Suppliers (23) Customers (24) Competitors (25) Manufacturers (26) Job rotation (27) start-ups (28) VC-funds (29) Acquaintances, friends and relatives	
Estimating information sources from easier and cheaper perspective EQ-3	The items are the same as in the previous question	Newly-created construct.
Issues while collecting information EQ-4	(1) There are difficulties in obtaining information from individuals within our company (2) It is hard to access private or closed companies (3) It is hard to access foreign companies (4) It is hard to access divisions or subsidiaries of the companies (5) Sometimes we are late to identify competitor's new product introductions (6) Sometimes we are late to catch new technology opportunities	This question is partly adapted from competitive intelligence survey (Sugasawa, 2004).

	(7) We have budget constraints for collecting information (8) We have time constraints for collecting information (9) We cannot always verify accuracy of the collected information	
Section F: Filtering collected information		
After collection of information do you discuss it in project teams, research groups or in TI units? FQ-1	(1) Yes (2) No	Reger (2001) associates filtering information with actions like: discussing it in project teams, research groups and TI units before analyzing.
After collecting the information do you check the quality i.e. (1) newness; (2) appropriateness (3) validity of the information? FQ-2	(1) Yes (2) No	Kerr et al. (2006) emphasize on following questions during the filtering stage of collected information: is the information new to me? is the information at correct level and coverage? if the information proper to our context? This construct was inspired from this source.
Section G: Analyzing collected information		
Approach for information analysis GQ-1	(1) Qualitative (2) Quantitative	Reger (2001); Lichtenthaler (2003); Lichtenthaler (2005); Porter et al. (2004); Porter (2010); Arman and Foden (2010) distinguish 2 approaches in information analysis: quantitative and qualitative.
TI methods GQ-2	(1) Publication frequency analysis (2) Publication citation analysis (3) Quantitative conference analysis (4) Patent frequency analysis (5) Patent citation analysis (6) S-curve analysis (7) Benchmarking studies (8) Market analysis (9) Competitor analysis (10) Portfolios (11) Delphi studies (12) Expert panels (13) Flexible expert interviews (14) Technology roadmaps (15) Product technology roadmaps (16) Product roadmaps (17) Experience curves (18) Simulations (19) Options pricing models	The list of sources is formulated from multiple sources, such as: Lichtenthaler (2005); Reger (2001); Porter (2004); Savioz (2004); Rohrbeck et al. (2007); Mortara et al. (2008); Rohrbeck et al. (2009)

	(20) Scenario analysis (21) Lead user analysis (22) Quality function deployment (23) Trend extrapolation (24) Relevant trees (25) Cross-impact analysis (26) Interviews (27) TRIZ (28) Vision generation (29) Focus groups (panels, workshops) (30) Cost-benefit analysis	
Factors that influence choice of TI methods GQ-3	(1) if selected method generates knowledge about the future or internalizes already known information (2) Corporate decision-making style and corporate culture (3) Time, personnel and financial restrictions (4) Familiarity with the method (5) Time horizon of the assessment (6) Uncertainty of the assessment situation (7) Industry-specific technology development (8) Perceived importance of the assessment	All eight items adapted from Lichtenthaler (2005).
Use of special program or software for intelligence purposes GQ-4	(1) Yes (2) No	Newly created construct.
Use of TI methods and tools GQ-5	(1) In our company TI methods or tools are not used systematically, but adopted case by case, with participants usually making decisions themselves. (2) Our company has a coordinated set of different methods. Our TI unit/department has a suitable toolbox of TI methods and it cultivates existing methods and introduces new ones. (3) We prefer methods/tools that allow us to give clear visualization the results. (4) We use methods that facilitate internal communication. (5) We use methods that facilitate external communication.	Item 1 is given in Reger (2001), item 2 is taken from Burgel et al. (2000), item 3 is newly developed and items 4-6 are adapted from Rohrbeck et al. (2009).

	(6) We use methods that enable to integrate market and technology perspectives as well as different time horizons.	
Section H: Documenting and disseminating intelligence results		
The TI results delivered to decision-makers are: HQ-1	Not very timely (1) Timely (7)	The question is inspired by Yugasawa (2004).
Diffusion of collected information across the company HQ-2	(1) TI results are regularly reported to top management (2) TI results are kept in database that is accessible for whole organization (3) TI results are discussed in daily meetings (4) TI results are shared within whole organization via e-mail, newsletters, abstracts, minutes of meeting etc.	The items are adapted from Ali-Kilic (2016, p. 93-94) about application of data gathered for TI. Mortara et al. (2008) and Reher (2001) give explanation to all of these items.
Means of disseminating TI results HQ-3	(1) E-mails (2) Company intranet (3) Written reports to decision-makers (4) Newsletters (5) Bulletin boards (6) Presentations (7) Computerized databases (8) Regular meetings (9) Special retreats (10) Special memos (11) Personal communications (12) Training seminars (13) Teleconferences	Lichtenthaler (2004) broadly describes communication media for TI dissemination. Most of the items are adapted from this source. Some of them are newly created.
Use of collected information and intelligence results HQ-4	(1) TI results are input for selecting new business partners (2) TI results are shared with the project or business partners (3) TI results are input for technology transfer decisions (4) TI results are integrated to R&D and new product development process (5) TI results are the input for project selection (6) TI results are input for strategic goals development process	The items are given in Ali-Kilic (2016, p. 93-94). Ashton et al. (1991) and Ashton and Stacey (1995) also provide similar items.

Approach for communication of intelligence results HQ-5	(1) TI results are communicated through long reports without any action implications. (2) TI results are communicated through short and operational reports with implications for action. (3) TI results are communicated through mainly oral presentations.	Lichtenthaler (2003) describing three generations of TI puts forward three approach for each generation respectively.
Issues in communicating intelligence results HQ-6	(1) Different groups do not communicate and interact between each other. (2) Lack of common language (3) TI results are communicated in a format that is difficult to understand and interpret. (4) Sometimes decision-makers do not get proper information.	Communication incompetence of companies or major issues in communicating are extensively portrayed in Mortara (2015); Mortara et al. (2007). The items are adapted from these sources.
Did you ever share the results of your TI with other companies? HQ-7	(1) Yes (2) No	Newly developed construct
Section I: Evaluating effectiveness of TI results		
Important quality dimensions to evaluate outcomes of TI IQ-1	(1) credibility (2) relevance (3) reliability (4) understandability (5) accessibility (6) objectivity (7) accuracy (8) uniqueness (9) clarity (10) verifiability (11) granularity (12) interpretability (13) informativeness (14) importance (15) timeliness (16) completeness (17) volatility (18) semantic integrity	All of these items are adapted from Mortara et al. (2007); Loh and Mortara (2016) and Kerr et al. (2008).
Measures that are used to evaluate TI process and outcomes IQ-2	1) Number of TI leads 2) Number of ideas generated 3) Number of patents reviewed 4) Number of TI leads incorporated in project 5) Project on time	Items are adapted from Loh and Mortara (2016).

	6) Project on cost 7) Specification target met 8) Rate of lead impact on project 9) Geographical coverage 10) Network built 11) TI transferability 12) TI reusability 13) Diffusion of TI message in firm 14) Overall impact on turnover 15) Launches of products with TI knowledge	
Overall evaluation towards activities of TI IQ-3	TI has little influence on decision-making 1 TI has great value on decision-making 7	Newly built construct
Distribution of the time dedicated for TI activities in percentage IQ-4	(1) Coordination of TI activities (information need definition, resource and budget allocation…) (2) Collecting data (3) Analyzing data (4) Filtering data (5) Disseminating data (6) Evaluating the effectiveness of the intelligence results Total: 100%	Newly built construct
Section J: General issues related to TI		
Main issues of TI in your company JQ-1	(1) Managers don't have enough capabilities to integrate results of intelligence to proper decisions (2) Intelligence players and decision-makers don't interact between each other (3) We have a time constraint for TI activities (4) We have a budget constraint for TI activities (5) We don't have enough personnel for conducting TI (6) We don't have trained/competent personnel for conducting TI (7) There is a limited feedback on effectiveness of TI results (8) There are no incentives to share information across organizational departments (9) We have difficulties in evaluating the effectiveness of TI results	The construct is newly developed.

	(10) Managers have limited knowledge about employees' capabilities (11) We rarely communicate with upper management	
Section K: Overall context in which TI process is carried out		
Level of uncertainty, such as the degree of competition, predictability of competitor moves, or changes in the basic ways in which firms compete KQ-1	Highly uncertain (1) Highly certain (7)	The construct is inspired by Yugasawa (2004).
Business environment KQ-2	(1) Increasing technology development cost (2) Shorter product life cycles (3) Customer product demands and preferences are becoming increasingly unpredictable (4) It is difficult to predict changes in customer/consumer needs and preferences	The construct is newly built however the items can be found in many works. For instance: Chesbrough (2006) about growth of technology development costs; Nijssen (2001) about shorter product life-cycles; Wang (2012) increasing complexity of new products…
Technological environment KQ-3	(1) A large number of new product ideas have been made possible through technological breakthroughs in our industry (2) The technology in our industry is changing rapidly (3) Close observing of technological development is important for long-term success in our industry (4) The complexity and inter-sectoral nature of new technologies is increasing (5) Cross-fertilization of scientific disciplines and fields of technology is high (6) Monitoring a spectrum of technologies is necessary	The construct is adapted from Jaworski and Kohli (1993).
Alignment of corporate and technology strategy KQ-4	(1) Our corporate strategy is not linked with technology strategy. (2) There is a weak link between corporate strategy and technology strategy. (3) Strong link between technology strategy and strategies on corporate and business unit level through integrated technology and market planning for all time horizons.	The question is listed in Mortara et al. (2007, Cambridge, p. 6) and multiple answer come from Lichtenthaler (2003, p.367).

Importance of actions regarding the routines or incentives for employees in the innovation environment KQ-5	(1) We give our staff time and resources to generate new ideas (2) We set our staff creative and challenging objectives (3) We allocate resources for our staff continuous professional development (4) Our staff easily adapt to new situations (5) We are open to technologies/knowledge generated outside the company (6) There is a high level of collaboration within functional areas to identify and resolve emerging issues in innovation activities (7) There is a high level of interaction across different functional areas in innovation activities	The construct is adapted from Lazzarotti, Manzini, Nosella and Pellegrini (2016).
Organizational culture KQ-5	(1) We emphasize teamwork, employee involvement, empowerment, cohesion, cooperation, participation and loyalty. We place a high emphasis on commitment and morale, mentoring, and rewarding team players. We favor cooperation, mutual trust, team spirit, learning, fulfilling work, human resource development, and trust in human potential. Our leaders' main responsibilities are to empower employees, and facilitate their participation, commitment, and loyalty (2) We are a dynamic, entrepreneurial, creative and learning organization. We promote experimentation and innovation, and reward risk taking and sharing. We are oriented towards organic growth and/or acquisitions. Our common values are innovation, flexibility, adaptability, risk taking, experimentation, and taking initiative. Our leaders are visionary, entrepreneurial and prepared to take risks (3) We are a competitive and goal-oriented organization. We reward people for acquiring the needed resources to meet organizational goals.	The question is adapted from Quinn and Rohrbaugh (1983), Denison and Spreitzer (1991), Cameron and Quinn (2006) and Do Nascimento Gambi et al. (2015). The scale: new self-typing question, inspired by James and Hatten's (1995) and Slater and Olsen's (2000) strategy scales. Labels: a. Group (or clan) culture b. Developmental (or adhocracy) culture c. Rational (or market) culture d. Hierarchical culture

	We focus on productivity, profitability, market share and penetration, and winning. Our leaders are expected to be hard driving, tough, and demanding competitors. We emphasize decision rules, performance indicators, individual and collective accountabilities, reinforcement, production, and achieving goals and objectives (4) We are a formalized and structured organization, which values efficiency, reliability, predictability, stability, continuity and standardization. Our people have almost no discretion and are rewarded for adhering to rules and regulations. Fast and smooth operations are maintained by strict adherence to rules, policies and procedures. Our leaders are supported for emphasizing order and achieving predictability in operations, and expected to be good organizers	
TI skills, competences and capabilities KQ-6	(1) Knowledge about the competitive context (2) Knowledge about the technological context (3) Participatory cooperation (4) Communication skills (5) Understanding the internal culture of the organization (6) Encouraging discussion of current projects and willingness to ask questions (7) Having common language with other departments/people (8) Knowledge about the methods of TI (9) Knowledge about tools of TI (10) Networking (11) Knowledge management (12) Flexibility, ability to see possibilities in new technologies	Most of the items were developed newly. However, some of them come from Khosropour et al. (2015); Mortara (2010); Janssen (2014).

	(13) Specialized skills, i.e. patent analyzing, database management, digital archivation.	
Organizing trainings for users of TI KQ-7	(1) Yes (2) No	Newly developed question.
Additional trainings that would be helpful actors of TI in your company. KQ-8	(1) Trainings on identification of information need (2) Trainings on data collection (3) Trainings on data analysis, including methods and tools of analysis, i.e., appliance of software tools and programs (4) Trainings on data management, data storage, database utilization, archiving data (5) Trainings on presenting intelligence results (verbal communication) (6) Trainings on presenting intelligence results (data visualization) (7) Trainings on internal communication (communication between employees, communication with decision-makers etc.) (8) Trainings on managerial aspects of Technology intelligence (evaluation, budgeting) (9) Trainings on strategic planning	Newly developed question.

References

Abramson, J. H. and Abramson, Z. H. 2008. Research Methods in Community Medicine: Surveys, Epidemiological Research, Programme Evaluation, Clinical Trials, Sixth Edition: John Wiley & Sons Ltd.

Ansoff, H.I. 1975. "Managing strategic surprise by response to weak signals". California Management Review 18 (2): 21–33.

Arman, H. and Foden, J. 2010. "Combining methods in the technology intelligence process: application in an aerospace manufacturing firm". R&D Management 40 (2): 181-194.

Ashton, W. B., & Klavans, R. A. 1997. Keeping Abreast of Science and Technology. Columbus, Richland: Battelle Press.

Ashton, W.B. and Stacey, G.S. 1995. "Technical intelligence in business: understanding technology threats and opportunity." International Journal of Technology Management 10: 79–104.

Ashton, W.B., Kinzey, B.R. and Gunn, M.E. 1991. "A structured approach for monitoring science and technology developments." International Journal of Technology Management 6 (1/2): 91-111.

Bianchi, M., Campodall'Orto, S., Frattini, F. and Vercesi, P. 2010. "Enabling open innovation in small and medium-sized enterprises: how to find alternative applications for your technologies." R&D management 40 (4): 414-431.

Boon, B. and Park, Y. 2005. "A systematic approach for identifying technology opportunities: Keyword-based morphology analysis." Technological Forecasting and Social Change 7 (2): 145-160.

Boulding, K.E. 1985. The World as a Total System. Beverly Hills: Sage.

Brenner, M. 1996. "Technology intelligence and Technology scouting". Competitive Intelligence Review 7(3): 20-27.

Brockhoff, K. 1991. "Competitor technology intelligence in German companies." Industrial marketing management 20 (2): 91-98.

Burgel, H., Reger, G., Ackel-Zakour, R. 2000. "Technology foresight: experiences from companies operating worldwide." International journal of services technology and management 1 (4): 395-413.

Cameron, K.S., Quinn, R.E. 2006. Diagnosing and Changing Organizational Culture: Based on the Competing Values Framework, San Francisco, CA: Jossey-Bass.

Castellanos, O. and Torres, L. 2010. Technology Intelligence: Methods and Capabilities for Generation of Knowledge and Decision Making. Conference paper.

Cheng A.-C., Chen C.-J. and Chen C.-Y. 2008. "A fuzzy multiple criteria comparison of technology forecasting methods for predicting the new materials development." Technological Forecasting and Social Change 75 (1): 131-141.

Cheng, A.-C. and Chen, C.-Y. 2008. "The technology forecasting of new materials: The example of nanosized ceramic powders". Romanian Journal of Economic Forecasting 9 (4): 88-110.

Chesbrough, H. 2003. "The era of open innovation." MIT Sloan Manage. Rev. 44: 35–41.

Chesbrough, H. 2006. Open Business Models: How to Thrive in the New Innovation Landscape. Boston: Harvard Business School Press.

Cooper, D., Schindler, P. 2014. Business research methods, twelfth edition. New York: McGraw-Hill/Irwin.

Daheim, C. and Uerz, G. 2006. "Corporate foresight in Europe: Ready for the next step?" In FTA Future-oriented Technology Analysis (Ed.), Second International Seville Seminar on Future-Oriented Technology Analysis. Seville. 28–29 September 2006.

Daim, T.U., Rueda, G., Martin, H. and Gerdsri, P. 2006. "Forecasting emerging technologies: Use of bibliometrics and patent analysis." Technological Forecasting and Social Change 73 (8): 981-1012.

Day, G.S., Schoemaker, P.J.H. 2005. "Scanning the periphery." Harvard Business Review 83 (11):135–148.

Denison, D.R., Spreitzer, G.M. 1991. Organizational culture and organizational development: A competing values approach. Research in Organizational Change and Development 5: 1-21.

Do Nascimento Gambi, L., Boer, H., Gerolamo, M.C., Carpinetti, L.C.R., Jørgensen, F. 2015. The relationship between organizational culture and quality techniques, and its impact on operational performance. International Journal of Operations & Production Management 35(10): 1460-1484.

Durand, T. 2014. "Technology intelligence in the era of Open innovation." In Wiley Encyclopedia of Management, edited by Sir Cary L. Cooper, 1-14: John Wiley and Sons, Ltd.

Gassman, O. and Enkel, E. 2004. "Towards a Theory of Open Innovation: Three Core Process Archetypes." R&D Management Conference Proceedings, Lisbon, Portugal.

Gerhard, D. and Voigt, K. 2009. "Technology intelligence systems for manufacturing technologies – an empirical analysis in the context of timing strategies." International Journal of Technology Marketing 4 (4): 368-387.

Haeckel, S. H. 2004. "Peripheral Vision: Sensing and Acting on Weak Signals Making Meaning out of Apparent Noise: The Need for a New Managerial Framework." Long Range Planning 37 (2): 181-189.

Huston, L.L and Sakkab, N. 2006. "Connect and develop: inside Procter & Gamble's new model innovation." Harvard Business Review 84(3): 58-66.

Janssen, W.; Bouwman, H.; Buuren, R.; Hakker, T. An organizational competence model for innovation intermediaries. Europ. Journ. of Innov. Manag. 2014, 17, 2-24.

Jaworski, B. and Kohli, A. 1993. "Market orientation: antecedents and consequences." Journal of Marketing 57 (July): 53-70.

Jun, S., Park, S.S. and Jang, D.S. 2012. "Patent Management for Technology Forecasting: A Case study of the bio-industry." Journal of Intellectual Property Rights 17 (6): 539-546.

Kerr, C.I.V., Mortara, L., Phaal, R., Probert, D.R., 2006. "A conceptual model for technology intelligence." International Journal of Technology Intelligence and Planning 2 (1): 73–93.

Kilic, A., Cakmak, T., Eren, H. and Sakarya, F. 2016. "Technology intelligence process in technopark firms: an empirical research in Turkey." International Journal of Economics and Finance Studies 8 (1): 74-100.

Laursen, K. and Salter, A. 2006. "Open for Innovation: the Role of Openness in Explaining Innovation Performance among U.K. Manufacturing Firms." Strategic Management Journal 27 (2): 131–150

Lazzarotti V., Manzini R., Nosella A. and Pellegrini L. 2016. "Collaboration with scientific partners: the mediating role of the social context in Fostering Innovation Performance". Creativity and Innovation Management, ISSN: 09631690 25 (1): 142-156.

Leeuw, E., Hox, J., Dillman D. 2008. International Handbook of Survey Methodology.

Lichtenthaler, E. 2003. "Third generation management of technology intelligence processes." R&D Management 33 (4): 361–375.

Lichtenthaler, E. 2004. "Technological change and the technology intelligence process: A case study." Journal of Engineering and Technology Management - JET-M 21 (4): 331-348.

Lichtenthaler, E. 2005. "The choice of technology intelligence methods in multinationals: Towards a contingency approach." International Journal of Technology Management 32 (3-4): 388-407.

Lichtenthaler, E. 2006. "Technology intelligence: identification of technological opportunities and threats by firms". International Journal of Technology Intelligence and Planning 2 (3): 289-323.

Lichtenthaler, U. 2008. "Open Innovation in Practice: An Analysis of Strategic Approaches to Technology Transactions." IEEE Transactions on Engineering Management 55(1): 148-157.

Loh, Y., Mortara, L. 2016. "How to measure Technology intelligence?" Journal of Technology intelligence and planning 11 (3): hiips://doi.org/10.1504/IJTIP.2017.085478

Lundvall, B. A˚. and Johnson, B. 1994. "The learning economy." Journal of Industry Studies 1 (2): 23-42.

Manzini, R., Nasullaev, A. 2017. "Technology intelligence in practice: a systematic literature review of empirical studies and agenda for further research." LIUC-working papers series №2, DOI 10.25428/2532-554X/2.

Miemis, V., Smart, J. and Brigis, A. 2012. "Open foresight." Journal of futures studies 17 (1): 91-98.

Mortara, L. 2015. Communicating Technology Intelligence: a practice guide. Cambridge, UK: Institute for Manufacturing.

Mortara, L. Partners to help with open innovation: the role of intermediaries. University of Cambridge Institute for Manufacturing: Cambridge, UK, 2010; pp. 1-64, ISBN 978-1-902546-91-9

Mortara, L., 2007. Technology Intelligence: identifying threats and opportunities from new technologies. Cambridge, UK: University of Cambridge Institute for Manufacturing.

Mortara, L., Kerr, C.I.V., Phaal, R. and Probert, D.R. 2008. "Technology Intelligence practice in UK technology-based companies." International Journal of Technology Management 48 (1):115-135.

Mortara, L., Kerr, C.I.V., Phaal, R. and Probert, D.R. 2009. "A toolbox of elements to build Technology Intelligence systems." International Journal of Technology Management 47 (4): 322-345.

Nijssen, E.J., Van Reekum, R. and Hulshoff, H.E. 2001. "Gathering and using information for the selection of technology partners." Technological Forecasting and Social Change 67 (2/3): 221-237.

Norling, P.M., Herring, J.P., Rosenkrans, W.A. Jr., Stellpflug, M. and Kaufman, S.B. 2000. "Putting competitive technology intelligence to work." Research Technology Management 43 (5): 23–28.

Nosella, A., Petroni, G. and Salandra, R. 2008. "Technological change and technology monitoring process: Evidence from four Italian case studies." Journal of Engineering and Technology Management 25 (4): 321-337.

Nunally, J.C. 1978. Psychometric theory, 2nd edition. California: McGraw Hill.

Parker, R. and Rea, L. 2014. Designing and Conducting Survey Research: A Comprehensive Guide, 4th Edition. New-York: Jossey-Bass.

Passmore, C., Alison, E., Parchman, M. and Tysinger, J. 2002. "Guidelines for constructing survey." Fam. Med. 34 (4): 281-6.

Pavitt, K. 1998. "Technologies, products and organisation in the innovating firm: What Adam Smith tells us and Joseph Schumpeter doesn't." Industrial and Corporate Change 7 (3): 433–52.

Peiffer, S. 1992. Technologie-Frühaufklärung: Identifikation und Bewertung zukünftiger Technologien in der strategischen Unternehmensplanung. Hamburg: S&W Steuer- und Wirtschaftsverlag.

Peterson, R. A. 2000. Constructing effective questionnaires. Thousand Oaks, CA: Sage

Porter, A.L. 2010. "Technology foresight: types and methods." International Journal of Foresight and Innovation Policy 6 (1/2/3): 36-45.

Porter, A.L., Ashton, W.B., Clar, G., Coates, J.F., Cuhls, K., Cunningham, S.W., Ducatel, K., van der Duin, P., Georghiou, L., Gordon, T., Linstone, H., Marchau, V., Massari, G., Miles, I., Mogee, M., Salo, A., Scapolo, F., Smits, R. and Thissen, W. (Technology Futures Analysis Methods Working Group) 2004. "Technology futures analysis: toward integration of the field and new methods." Technological Forecasting and Social Change 71: 287–303.

Quinn, J.J. 1985. "How companies keep abreast of technological change". Long Range Planning: 18 (2): 69–76.
Quinn, R., Rohrbaugh, J.A. 1983. Spatial model of effectiveness criteria: Towards a competing values approach to organizational analysis. Management Science 29(3): 363-377.
Ranjbar, M. and Tavakoli, G. 2015. "Toward an inclusive understanding of technology intelligence: a literature review." Foresight 17 (3): 240 – 256.
Reger, G., 2001. "Technology Foresight in Companies: From an Indicator to a Network and Process Perspective." Technology Analysis & Strategic Management 13 (4): 533-553.
Rohrbeck, R. 2007. "Technology scouting a case study on Deutsche Telecom Labaratories." ISPIM-Asia, 9-12 January, 2007, New Dehli, India, pp. 1-14.
Rohrbeck, R. and Gemunden, G. H. 2008. "Strategic foresight in multinational enterprises: building a best-practice framework from case studies." R&D Management Conference "Emerging methods in R&D management": 2008; Ottawa, Canada.
Rohrbeck, R., Arnold, H. M., Heuer, J. 2007. "Strategic Foresight in multinational enterprises–a case study on the Deutsche Telekom Laboratories." ISPIM-Asia conference, New Delhi, India – 9th-12th January 2007.
Rohrbeck, R., Mahdjour, S., Knab, S. and Frese, T. 2009. "Benchmarking report: strategic foresight in multinational companies. European corporate foresight group." Available at: hiip://ssrn.com/abstract=1470050
Rus, D.C. and Wisse, B. and Rietzschel, E.F. 2016. "An open invitation to open innovation: guidelines for the leadership of open innovation processes." In Open innovation: academic and practical perspectives on the journey from idea to market, 141-168. New York: Oxford University Press.
Savioz, P. 2004. Technology intelligence: concept design and implementation in Technology-based SMEs. New York: Palgrave Macmillan.
Savioz, P. 2006. "Technology intelligence systems: practices and models for large, medium-sized and start-up companies." International Journal of Technology Intelligence and Planning 2 (4): 360-379.
Savioz, P. and Blum, M. 2002. "Strategic forecast tool for SMEs: How the opportunity landscape interacts with business strategy to anticipate technological trends." Technovation 22 (2): 91-100.
Song, B., Seol, H. and Park, H. 2016. "A patent portfolio-based approach for assessing potential R&D partners: An application of the Shapley value." Technological Forecasting & Social Change 103: 156–165.
Sugasawa, Yoshio 2004. "The Current State of Competitive Intelligence Activities and Competitive Awareness in Japanese Businesses." Journal of competitive intelligence and management 2 (4): 7-31.
Utterback, J. M. and Abernathy, W.J. 1975. "A Dynamic Model of Process and Product Innovation." Omega, The International Journal of Management Science 3(6): 639-656.
Wang, M. 2012. "Exploring Potential R&D Collaborators with Complementary Technologies: The Case of Biosensors." Technological Forecasting and Social Change 79 (5): 862–874.
Yeo, W., Kim, S., Park, H. and Kang, J. 2015. "A bibliometric method for measuring the degree of technological innovation." Technological Forecasting and Social Change 95:152-162.
Yoon, B. 2008. "On the development of a technology intelligence tool for identifying technology opportunity." Expert Systems with Applications 35 (1-2): 124-135.
Yoon, J. and Kim, K. 2012. "TrendPerceptor: A property-function based technology intelligence system for identifying technology trends from patents." Expert Systems with Applications 39 (3): 2927-2938.
Zhu, D. and Porter A.L. 2002. "Automated extraction and visualization of information for technological intelligence and forecasting". Technological Forecasting and Social Change 69 (5): 495-506