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THE EXTENDED MAP METHODOLOGY: TECHNOLOGY ROADMAPPING FOR SMES CLUSTERS

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ABSTRACT

For small medium enterprises, customization of roadmapping is required. Although the phases of its process are solid and shared in the literature, the sub-phases and specific activities to be undertaken are only mentioned and do not provide sufficient guidance for implementation. The paper proposes a new methodology for the implementation of technology roadmapping.

The research strategy is based on action research with two cycles of action. The first cycle (Opportunity profile) simplifies the traditional methodology. The second cycle (Extended Map) relies on collaboration of small medium enterprises coordinated by an intermediary and adds an ecosystem view to the methodology.

1. INTRODUCTION

For their strategic and innovation activities, companies need access to diversity, they need to be open to collaboration, and they need to obtain *selected knowledge* (Lichtenthaler, 2008a, Lichtenthaler, 2008b, Van de Vrande et al., 2009) – focused and connected to their technologies, products, markets and resources. The systematic application of *technology intelligence systems* to the decision-making and product development processes of companies is a fundamental support for strategy and innovation in terms of selecting and supplying knowledge (Becker, 2002, Will, 2008, Rohrbeck, 2010). Small medium enterprises (SME) lack specific and tailored technology intelligence systems that are normally thought and fitted for large companies. In this sense, *SMEs are disadvantaged* by applying traditional practices and tools thought for SMEs because they experience access barriers to obtaining specific knowledge, specific competences and resources.

A tool of technology intelligence that can help in facing a changing environment and enabling the technology transfer process is the *Technology Roadmap* (TRM) (Kostoff and Schaller, 2001, Phaal et al., 2004). Technology Roadmapping draws a map of present and (possible) future technologies, products and markets, identifying alternative technological and market "roads" in terms of linkages among technologies, products and markets and organizational resources and objectives (Garcia and Bray, 1997, Rinne, 2004). The majority of the works on technology roadmapping concentrate on the process of TRM applied in different contexts and sectors (Bruce and Fine, 2004, Lee and Park, 2005, Cosner et al., 2007, Gerdsri et al., 2009). However, in the literature, there is a lack of structured approaches specifically for SMEs. TRMs are particularly tailored for large companies or contexts of good availability of specific competences and financial resources.

This paper proposes a *methodology of technology roadmapping specifically designed for SMEs.* We designed it following the action-research methodology: diagnosing, planning, taking action and evaluating. The specific context for "taking action" is the main Science and Technology Park in Italy, AREA Science Park (AREA). From an "action" point of view, as an innovation intermediary, it had a specific need to support its SMEs' technology transfer services with a theoretical and applicable methodology for TRM.

The proposal is to use an ecosystemic approach, tailoring the methodology for SMEs' clusters in a context of low availability of financial resources and knowledge, with an important role for an innovation intermediary, obtaining what we called the *Extended Map methodology*. This proposal follows a first proposal, based on an idea to simplify the traditional methodology, obtaining what we called the *Opportunity profile methodology*. However, the field test and the evaluation of the

results showed that the proposal only partially resolves the problem. Therefore, we decided to perform a second cycle of research, maintaining some parts of the previous methodology and changing others.
The paper is organized as follows. Section 2 is the literature review, in which we highlight the technology intelligence processes and technology roadmapping methodologies, the barriers for SMEs to those processes and the role of the intermediary in supporting companies.
Section 3 presents the research strategy. The research methodology is an action research with two subsequent cycles. Section 4 refers to the *Opportunity Profile methodology* that we tested in an association of high-tech companies in Belluno (Italy) and briefly describes the idea and the results (which feed into the next cycle). Section 5 describes in detail the *Extended Map methodology* that we tested in the Coffee Cluster in Trieste (Italy). Section 6 compares the traditional roadmapping methodology (from the literature) and the *Extended Map methodology*. The comparison is made in terms of process, role, structure, architecture and tools. Section 6 draws comparisons, evaluating the *Extended Map methodology* and discussing the specific differences for SMEs between the traditional methodology and our proposal. Section 7 presents the conclusions.

2. LITERATURE REVIEW

2.1. Technology Intelligence in Smes

Most SMEs concentrate on short-term sales, cost and profit targets rather than on longer-term goals: normally, they have a planning horizon of only one to three years. Larger companies use more extensive long-term plans and tools of strategic analysis; smaller companies generally have a shorter-term focus, making use of policies rather than plans. Stonehouse and Pemberton (2002) state that for SMEs, there is little evidence of usage of the "tools" of strategic analysis, with the most common tool relating to internal financial analysis. They identify an emphasis on financial analysis, profit targets, and short-term planning horizons, appearing to confirm a predisposition toward business planning rather than strategic thinking and management.
In fact, implementing foresight in SMEs is difficult (von der Gracht et al., 2010, Battistella, 2014). SMEs have so far failed in significant numbers to become involved in a forward-thinking culture (Major and Cordey-Hayes, 2000); explorative surveys (see Z-Punkt, 2008) have shown that some SMEs are developing foresight in their companies, but with important barriers such as organizational silos and policies that restrict dialog, limited attention of internal stakeholders and lack of resources.
Recent explorative papers examined the clusters of foresight practices in 30 SMEs in the biotech industry (Mietzner and Reger, 2009), described how foresight can be integrated in SMEs (Major and Cordey-Hayes, 2000, Battistella and De Toni, 2011) and illustrated the results of a foresight exercise in a SME (Will, 2008). These studies are first steps toward an approach to encouraging small and medium businesses to adopt foresight practices. However, businesses continue to interpret foresight only as a set of methods or as a process, whereas the very recent literature provides a holistic interpretation as a set of strategic, organizational and managerial features or as a capability of "future orientation" (Rohrbeck, 2010).
Technology intelligence processes often are created informally. SMEs are faced with traditional problems of exploitation of technology, limited managerial skills, poorly defined organizational structures and functions, low productivity and regulatory constraints. Moreover, they have several bottlenecks in terms of staff inappropriately qualified for technology intelligence activities. For these reasons, it is very difficult to perform projects involving innovation and technology transfer. In addition to the lack of resources and capacity to conduct internal research activity, negative aspects can include too-weak external contacts, limited training, reluctance to delegate authority and decisions to others, and excessive involvement in decisions at the operational level (Kim and Park, 2010, Narula, 2004, Van de Vrande et al., 2009). In fact, SMEs have limited human resources and insufficient financial resources, particularly to conduct internal research and development. This

results in insufficient information. That result is why it is difficult for them to self-develop technology roadmaps in the planning stage prior to R&D. Moreover, they have difficulties in recruiting qualified personnel and increasing technological assets. Therefore, they find it difficult to create detailed technology development strategies and execution plans. This can be considered an obstacle to the development of their technology transfer actions. It is vital for small and medium-sized enterprises to improve their management skills, their ability to gather information and enhance their technological support.

Moreover, in spite of the economic importance of small and medium-sized enterprises, few studies provide specific concepts addressing the topic of technology intelligence in the context of SMEs. Two such contributions are from Dou et al. and Lanteigne et al., with more structured ones from Savioz and Blum (2002) and Savioz (2004). The technology management literature seems to focus more on large enterprises because the problems are likely to be more complex than those of SMEs (Savioz, 2004). Small and medium-sized enterprises find themselves in a "grey area" in research on technology intelligence, which focuses, implicitly or explicitly, on large enterprises. From a practitioners' point of view, SMEs wish to apply technology intelligence activities but encounter some difficulties. That is why we can identify a literature gap and an action gap; because of limited resources, knowledge and skills, SMEs find it difficult to initiate intelligence activities to support decision-making and strategic processes.

2.2. Technology roadmapping for SMEs

Roadmapping has mostly been associated with government, large companies or technology-intensive industry associations. This association is due to the idea of roadmapping as a complex process to which considerable financial and human resources must be devoted to set up and maintain the activity. From a literature point of view, although TRM has been successfully used in large enterprises and in governments, there has been little research focusing specifically on its application in SMEs, either as promoters or as participants in a shared construction in a strategic reference context (Arshed et al., 2012). The authors recognize that the research is primarily aimed at large companies and implicitly neglects small and medium-sized ones. According to Caetano and Amaral, 2011, research on roadmapping methods has been developed to suit the context of large companies that have large internal structures for research and product development. The larger firms are more easily treated because they tend to have long-term research contracts and are guided by long-term planning, unlike the majority of SMEs, whose needs require a market-oriented roadmapping process.

The lack of attention to SMEs in the existing literature, both as partners alongside large organizations or as promoters, is partly because, in practice, SMEs are often excluded from the roadmapping process. This exclusion may be due for example to a number of reasons (Arshed et al., 2012). First, many of the large organizations, which tend to be the typical adopters of roadmapping methods, do not want to engage SMEs or any other outside organization that could be a potential competitor (Lichtenthaler, 2008a, Lichtenthaler, 2008b). They possess all the expertise and see little value in involvement with small and medium-sized enterprises. Second, knowledge sharing can encourage opportunistic behavior when there are asymmetries of knowledge and can influence businesses to rely less on the behavioral level if adverse effects occur too early, or occur in negative sharing experiences (Petrick and Echols, 2004). Third, typical technology roadmaps have been realized in practice to hold information for strategic use, rather than operational use (Savioz and Blum, 2002). These strategic approaches are often not useful for most small businesses because of the short time horizons SMEs reference and the prevalence of operational objectives. Finally, small and medium-sized enterprises have difficulties in implementing and supporting roadmapping due to a number of factors – time, cost and effort – associated with the maintenance of what can be considered a complex process (Yoon et al., 2008).

In the literature, it is however possible to find some studies of roadmapping applied to SMEs.

Some papers examine the involvement of SMEs in the process of roadmapping. For example, Holmes and Ferrill (2005) applied the technique to help SMEs in Singapore to identify and select emerging technologies. The introduction of SMEs in the manufacturing sector in Singapore increased the horizon perspective of these businesses from the traditional 4–6 months to an average of 3–5 years, allowing them to think about and to plan future developments. From the point of view of SMEs, the initiative has been successful, and SMEs were satisfied with undertaking the process, particularly when it involved the initial stages of development of new products or services in a given period. However, research showed that the technology strategic planning process and the traditional business strategy process overlap in SMEs, resulting in an integrated approach to roadmapping.
Some papers are applicative, such as Strand et al., who applied roadmapping to SMEs in the specific sector of photonics. They developed three roadmaps for specific groups of SMEs (high tech developers, producers and users) and integrated them in a specific industry.

Some papers are based on a specific methodology such as T-plan, for example (Holmes and Ferrill, 2005). The paper initially reviews the application of roadmapping in small companies, and then highlights the various areas in which the companies have applied the roadmapping technique.
Other papers are focused on policy programmes such as Jun et al., who measured the outcomes of a Korean roadmapping support programme designed to reinforce the capabilities of SMEs.

An initial attempt to fill the gap in detailed guidance on how to start the technique was made with the development of the "T-Plan" method to support the rapid start of roadmapping (Phaal et al., 2001). This guide comprises three phases: the planning phase, the roadmapping phase and the roll-out phase. Subsequently, Holmes and Ferrill (2005) introduced a modified version of the T-Plan process that comprises five core modules in an organization to create the first technology roadmap. These processes are useful, but the standard T-Plan specializes in product planning and also is specifically company-centric (Lee et al., 2007). In addition, T-Plan was developed for SMEs with several hundred employees (Phaal et al., 2001). Moreover, there are differences in the process of composing the roadmaps. The T-Plan programme focused on a few facilitated meetings, making the programme accessible for a relatively low cost but creating only a simplified output of priorities and rankings. By contrast, our proposal relies centrally on the figures of the intermediary and on analyses of specialists and technology and market research, and the core outcomes included the provision of in-depth information to describe the roadmap itself.
Addressing SMEs' need for focused TRM is important because small and medium-sized enterprises are often considered the engine of economic growth. In addition to an essential source of labor, they generate entrepreneurship spirit and innovation and are therefore crucial for fostering competitiveness and employment. The highly dynamic environment that characterizes today's environment requires flexibility and responsiveness typical of SMEs, combined with the advantages of relationships and efficiency of large enterprises.

SMEs have the need to develop quick but also resource-efficient methods. SMEs need strategic roadmaps to study their product portfolio technological evolution, to support the integration of technology into their business and to communicate their strategy internally and to stakeholders (key partners, customers, suppliers and investors). Holmes and Ferrill (2005) note that "this is becoming increasingly important, as smaller companies move up the value chain, seeking to increase revenues and growth".

2.3. Role of the intermediary

Innovation intermediaries have been defined as: "An organization or body that acts an agent or broker in any aspect of the innovation process between two or more parties. In general, the role of innovation intermediaries to support the innovation process involves a number of different

activities: technology transfer and diffusion; innovation management; systems and network. Such intermediary activities include: helping to provide information about potential collaborators; brokering a transaction between two or more parties; acting as a mediator, or go-between, bodies or organizations that are already collaborating; and helping find advice, funding and support for the innovation outcomes of such collaborations" (Howells, 2006:720). In this context, the intermediary performs two main functions, both of which might be associated with the front-end of innovation (Lynn et al., 1996, Wolpert, 2002): the information scanning and gathering function and the communication function. This broad stage is equivalent to what Seaton and Cordey-Hayes (1993) term as the "scan and recognise" and "communication and assimilate" phases and what Hargadon and Sutton (1997) identify as the "access" and "acquisition" phases. Many studies see the primary role of intermediaries as providing information scanning and exchange functions (Howells, 2006) but few studies jusaxpose the role of the intermediary with the difficulties of SMEs in doing technology intelligence and specifically technology roadmapping.
A roadmap can be seen as a collaborative foresight process that produces a broad set of plans and strategies to reach a future goal. Roadmaps include simple forecasts, scenarios, strategy, and plans, but go beyond such tools in three ways: (1) they emerge in a collaboration network of multidisciplinary and competing experts, (2) they emphasize uncertainties and challenges as much as probable and preferred futures, and (3) they have long-term time horizons (commonly 5–15 years is common) by comparison to traditional forecasts and plans.

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Some papers focus on relationships or collaboration for TRM. Some papers discuss about collaborations between SMEs and large enterprises: in this case, larger firms initiate the TRM process and SMEs collaborate as consultants in developing the roadmaps either as partners or suppliers. Dixon (2000) highlights roadmapping as an integrated process to promoting the participation of the problem owner, solution provider, customer and other stakeholders (Lee et al., 2012). However, no study explicitly indicates or enables SMEs to join this process.

2.4. Literature gap

The literature analysis showed a lack of attention to describing a methodology for analytical and systematic roadmapping (Farrukh et al., 2003, Lee et al., 2009). Although some studies (Phaal et al., 2001, Phaal et al., 2004, Geum et al., 2011, Geum et al., 2013) propose processes and tools that can be helpful in building a roadmap, it remains difficult for analysts to create roadmaps using the methods suggested in these studies. The majority of previous contributions on roadmapping simply describe the general procedure of roadmapping (Vojak and Chambers, 2004) or report the results of adoption of roadmapping (Barker and Smith, 1995, Kappel, 2001). These contributions offer little practical help to those who adopt roadmapping for the first time (Lee et al., 2007) because there remains a lack of a detailed guide on how to start and apply the methodology (Phaal et al., 2004).

Thus, further work is needed to study methods to increase effectively the applicability of roadmapping so that it can be used more widely in the future.
The majority of studies on roadmapping have been realized as corporate processes in large companies; many others refer to inter-organizational processes involving large trade associations or large industry associations, but very few studies have been aimed specifically at small and medium enterprises (Caetano and Amaral, 2011, Arshed et al., 2012). Whereas TRM has been successfully used in large businesses and at the government level, there has been little or no research focusing specifically on its application in SMEs, either as promoters or as participants in a shared construction of the strategic context of reference. The lack of attention to SMEs in the existing literature is partly because SMEs have more difficulties in the application of roadmapping because the methodology was not designed for such organizations; thus, it must be customized for them (Van de Vrande et al., 2009). In fact, although the technology roadmap is a useful and flexible approach, the potential benefit cannot be fully exploited if there is difficulty in personalizing the technique to meet specific needs or to adapt to particular circumstances. Some studies attempted to identify customizable factors for the roadmapping process in terms of planning, architecture and process; but, again, the existing research does not provide a direct answer to the question of how to customize the roadmapping approach – and organizations do not have concrete principles for customization (Lee and Park, 2005). In particular, as Savioz (2004) suggested, in the literature there are two gaps concerning technology roadmapping in SMEs:

- in the SMEs literature, there is a gap of systematic approaches for technology intelligence;
- in the technology intelligence literature, there is a gap of systematic approaches for SMEs.

Concerning particularly the TRM, in the literature, the phases of the process are quite solid and shared; however, sub-phases and specific activities to be undertaken are only mentioned, and there often is only higher-level guidance for implementation. Organizational roles are identified in the literature, but they are described in a general sense and their association to the specific activities and tasks in the different phases is partial. Support tools in our opinion are well presented in the literature. The architecture is well described, particularly in terms of layout (layer, template and format). The work of Phaal in particular provides useful information for customization, with respect to different possible targets (planning, foresight and strategy) without considering the organizational peculiarities.

Moreover, there is an action gap due to difficulties in the practical application of TRM tools and methodologies by SMEs. In fact, as reported by studies focused on innovation and technology intelligence processes for SMEs, SMEs lack the following:

- knowledge and competences: limited internal R&D and technological assets (McAdam and McConvery, 2004, Hausman, 2005); “cultural deficit” (Souitaris, 2001, Frishammar and Horte, 2005); and low technological resources to exchange (Narula, 2004);
- resources: lack of financial resources (Narula, 2004, Kim and Park, 2010); few possibilities to hire specialized human resources (Rothwell and Dodgson, 1994, Vossen, 1998, Van de Vrande et al., 2009); too limited resources to have internal R&D (Hausman, 2005, Lee et al., 2009, Van de Vrande et al., 2009); low access to external sources of technology (Narula, 2004).

3. RESEARCH STRATEGY

Because a "small business is not a little big business" (Welsh and White, 1980), technology intelligence cannot simply be implemented in SMEs as in large companies; it is necessary to find proper organizational and managerial systems. Because of the scarcity or lack of previous practical applications of roadmapping and possible case studies or examples of references related to small and medium-sized enterprises, this research had the purpose of realizing a direct experimental activity aimed at structuring, implementing and evaluating a methodology of roadmapping specifically for SMEs. The paper contributes to enriching the research field of technology intelligence, proposing a methodology to implement TRM for SMEs. The paper aims to

1. understand how an innovation intermediary could support the process of technology roadmapping to support technology intelligence activities in SMEs;

2. build a methodology of technology roadmapping for SMEs (in a context of an innovation intermediary).

3.1. Choice of action research

The Action Research strategy followed the approach suggested by Coughlan and Coghlan (2002) and Coghlan and Brannick (2010).
The objective of the research is to create a basis for a methodology of roadmapping applicable to the context of SMEs. The research project is tied to a *specific* situation. The experimental context outlined is more related to "theory building" than to "theory testing", and action research is characterized by generating *emergent* theory, which is built through reflection of practical implementations. The path of theoretical development, as a result of the research, will be *incremental*, and therefore starts from the particular and moves in small steps toward the general (Coughlan and Coghlan, 2009).
The research context is the "Consortium for the AREA of scientific and technological research" of Trieste, a national research body at the first level of the MIUR (Ministry of Education, University and Research). The purpose of AREA on this issue is to develop a methodology for providing to SMEs value-added services for technology intelligence that is accessible with limited resources (i.e., not through public financing) to increase the competitiveness of the small and medium enterprises supported. This project was created as an open project with the establishment of an internal working group aiming to investigate the problem, identify and devise solutions, and then to experience the first services starting from the basis of expertise present in the intermediary and the services of Business and Technology Intelligence already available. This allowed us to actively participate in the project of AREA Science Park, while aiming at the development of this experimental tool (the service of roadmapping to support SMEs in the processes of technology intelligence). The activity allowed us to confront the working group on how to structure and customize an instrument of roadmapping specific to SMEs, adapting it to the context, intervening in characterizing elements (process, roles, tools, architecture) and integrating into the system the presence of the intermediary.

A pilot case was conducted in a large company in 2009 (Electrolux), which was instrumental in gaining mastery of the general technology roadmapping methodology. Following the pilot, the cycles of action research were twofold: a cycle for the design, development, test and evaluation of an *Opportunity Profile methodology* roadmap (OP) in a business association (Assindustria Belluno, the association of industrialists of Belluno province in Italy) in 2010–2011 and a cycle of an *Extended Map methodology* (EM) in a specific cluster of companies (Trieste Coffee Cluster) in 2011–2012. See Fig. 1 for an overview of the two cycles. Currently, the project is concluded because the experimental phase is over. AREA believes the methodology is developed, shared and

consolidated and the roadmapping service for the SMEs ready. Overall, the project lasted 46 months.

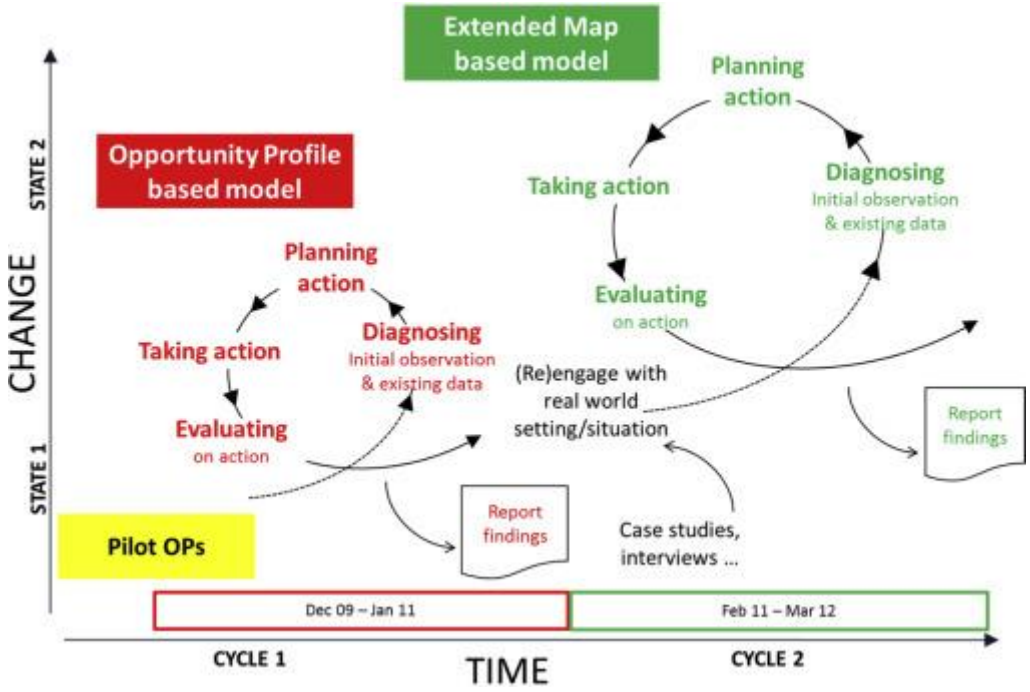

Fig. 1. Cycles of action research for technology roadmapping for SMEs.

3.2. Cycles of action research

For cycles, we followed the steps as suggested by the literature (Coughlan and Coghlan, 2002): diagnosing, planning action, taking action and evaluating action.

3.2.1. Diagnosing

The diagnosis (definition of context and purpose) for OP methodology began in February 2009 with the kick-off meeting and the presentation of the project objectives, the rationale and the issues involved. The project was launched with the creation of an internal working group aiming to investigate the problem, identify and devise solutions, and then experience the first services starting from the basis of internal expertise and from the services of business and technology intelligence that already were available. Internal stakeholders were involved to share issues to be addressed and the competences and basis to plan and then perform the actions. The working group met on several occasions to discuss issues such as roles, skills and available tools. The phase of diagnosis for EM was performed in mid-2011, bringing the internal working group back to the initial objectives of the project to review the needs to which the services were addressed and to identify additional needed resources and actionable expertise.

3.2.2. Planning action

For the intermediary, the problem is to ascertain how to appropriately support the processes of intelligence of companies, particularly in the case of SMEs in which the activity normally is not (or rarely) performed or is unstructured. In this case, it is essentially a problem of planning and positioning (role) the specific service to be provided. An internal reflection, an analysis of available tools (e.g., Explorer® and Business Insights®), and a comparison to share limitations and potentialities were conducted. To acquire mastery of the methods and tools of intelligence, as a preliminary phase, we tested the roadmapping in a project for a large company (Electrolux). This experience showed the potential of the method and offered ideas on how to customize it to meet the

needs of SMEs. At the same time, it revealed that the skills needed to perform the activities and use the tools are actually important and not easily accessible to SMEs. These reflections led the intermediary to set up its “heavy” role in the planning stage.

3.2.3. Taking action

The OP methodology was implemented six times to support the activities of six SMEs belonging to the industrial association “Assindustria Belluno”. The companies were individually involved. In contrast, the EM methodology was implemented 1 time in support of the activities of companies belonging to Trieste Coffee Cluster. The involvement of companies (collectively involved in this cycle) was necessary in the process of taking action. In the case of EM, the OPs constitute an *intermediate result* that then was integrated into an overall map. In particular, in the Trieste Coffee Cluster project, we executed six OPs then integrated into a single EM.
For OP, this phase of the project lasted approximately 2 months from kick-off to project closure, with a commitment of intelligence activities of 10–12 days. For EM, this phase of the project lasted much longer for two reasons. First, the preliminary phase of the activity launch required a great effort (primarily for administrative procedures) and, second, the operational execution of the activities requires more work and project timing (the service implementation was estimated at approximately 6 months from the kick-off and 150 man-days total, however it has actually required 9 months).

Table 1 shows a summary of the activities, the companies involved and the 6 OP and 1 EM performed. The researchers were professionally involved; they participated in activities as contact person for the project (management of activities with the senior project manager) and as responsible for the methodology. For OP, concerning the application of the methodology to support SMEs, on three occasions there was a direct (professional) involvement of the researchers and participation in the activities, whereas in the remaining SMEs, the involvement was indirect (participant observation). For EM, concerning the technical and scientific activities of research, analysis and processing, the researchers played the role of supervision and methodological support for analysts. Analysts were selected for their specific competencies in scientific and technical disciplines (Table 2).

Table 1. Executed studies.

	Company	Typology	Period	Opportunity profile	Roadmap
A1	Company 1	SME	December 09	Combine RFID technology with temperature sensors	None
A2	Company 2	SME	February 10	CPV cylindrical focusing systems	None
A3	Company 3	SME	March 10	WPC: applications, technologies, players	None
A4	Company 4	SME	March 11	Integrated supermarket HVAC and refrigeration systems	None
A5	Company 5	SME	April 11	OLED lighting – commercial development parameters	None
A6	Company 6	SME	July 11	Nanomaterials applications in automotive sector: paints and coatings	None
B1	Trieste Coffee Cluster	Cluster of small and medium companies	June 12– September 12	Genetics (biodiversity, security of the genetics of the coffee) and global warming	Coffee cluster Extended Map
B2				Traceability of the supply	
B3				Shelf-life and packaging	
B4				Sensorial branding, social networks, social media and customer co-creation – coffee customization	
B5				Pharmacology	
B6				Nutraceutics (functional food and new products)	

Table 2. Synthesis of activities for OP and EM methodologies.

	Opportunity profile	**Extended roadmap**
	Assindustria belluno	**Trieste coffee cluster**
Companies	6	9 (7 small and 2 medium size)
Period	February 10 – December 10	February 11 – March 12

	Opportunity profile	**Extended roadmap**
	Assindustria belluno	**Trieste coffee cluster**
Objectives	Preparation of 6 OPs for 6 companies of an association of companies in Belluno (Italy) • Information on technical and business opportunities (possibilities) • Connected to technological or commercial questions related to future developments	Preparation of a strategic technological map focused on the industry sector of coffee for the Trieste Coffee Cluster (Italy) • The map covers a time period for the next 5–7 years • International level • Specific themes: products, services, supply chain, technologies and business parameters
Methodology	• Desk analysis connected to the business intelligence explorer tool • Additional information collected from other sources to integrate/validate content	• OPs based on • secondary research • interviews with sector leaders • case studies • Strategic technological map • identifies the opportunities for new products and services, functionalities and technologies, business considerations • permits to Trieste Coffee Cluster and to its companies to formulate their strategic choices
Activities description	• 1 kick-off with companies • Desk analysis • explorer tool • other sources of information • Organization of information in 1 OP for each company • Presentation of the OPs • Final meeting for feedback	• Kick-off and orienteering • aims, themes, material, sources of information, planning of activities and meetings, planning of project times and TCC teamwork • External research and opportunity profiles • description of opportunity, of products and services, market attractiveness and critical success factors, case studies on reference actors • Industry sector technological map • main factors and business requirements, innovative products/services, functionalities and technologies, potential indicators, elements to monitor, society, market and technology • Final presentation and discussion of the project results • presentation of the main results of the opportunity profiles • presentation of the industry sector technological map • discussion on how to use the roadmap ad tool for supporting the decisional process for the Trieste Coffee Cluster companies • discussion of how to build single specific paths to define development plans of products and business

	Opportunity profile	Extended roadmap
	Assindustria belluno	**Trieste coffee cluster**
Money	x = 1 (1 OP)	x = 10 (6 OPs)
Results	6 OPs: • 5 derived in R&D projects • 1 derived in a business plan for a possible creation of start-up	• R&D direction for the companies of the cluster Industrial map with: • 3 mapped macroareas • 6 selected opportunity profiles and 4 not selected • 82 new possible products considered in development in next 5–7 years

3.2.4. Evaluating action

For the evaluation phase of Ops, we organized a meeting with the association. For EM, a meeting was organized with the Trieste Coffee Cluster with the aim of obtaining feedback for the OP/EM revisions. The cluster evaluated the work positively because it adhered to its common objectives.

We also organized a meeting of the AREA internal group to analyze the process and the methodology used. This comparison was used to draw conclusions from the experience, assessing strengths and limitations. The meeting was also open to other colleagues from outside the working group who could add educational value. The organization's goal is indeed to consolidate acquired skills and broaden the working group.

In addition, the researchers conducted formal internal interviews with key figures involved in the activities, specifically, the manager of technology transfer, the senior project manager, and an expert in the techniques and processes of intelligence. The purpose of the interviews was to deepen and critically evaluate the experience, to bring out explicitly all the considerations made during the course of activities, reflect on these and finally draw conclusions. Finally, the researcher performed a final analysis of all the documents produced (to align the results of all direct and indirect activities) for a better understanding of the process, the method, and the methodological framework, trying to make an effort to generalize and formalize the processes.

3.3. Research sources and participants

In our research, the main method of data gathering has been observant participation because one of the three researchers was active and present during the operations in AREA. This method has some advantages, i.e., direct access to events, perception of reality from an internal point of view, the possibility to manage some processes such as events and meetings.

Naturally, in accordance with Yin (2003), this active role also presents some shortcomings. There is little possibility to work as an external observer and a major possibility of being influenced by the working group. The participative role can become dominant over the observer role. Coghlan and Brannick (2010) note that the actions of the researcher focused on data collection should not be considered neutral. In fact, interviewing people, confronting them, or even observing them at work not only collects but also generates data, knowledge and learning for both researcher and partcipants. Participation in the activities of the project, meetings and events has been, however, the main source of data generation. According to Coughlan and Coghlan (2002) for the action researcher, the generation of data collection is the active involvement in the daily organizational

processes related to the project of Action Research. The data are obtained not only through for example the observation of teamwork, problem-solving, and decision making but also through direct intervention and participation in the activities of the project. The observation and investigation of how they work the systemic relationships between individuals, groups, and organizations is critical to the solution of problems or the implementation of change (Coghlan and Rashford, 2006). To try to overcome these criticalities, the solution we adopted is to having an integration of the academic group (in the university) with the project group (in AREA). In other words, one researcher has been only external, and two have been both internal and external (only one with a defined role in AREA). For example, the second researcher has been involved in meetings of the steering group and in planning and evaluation meetings. This participation contributed to making the process more objective. In fact, the second researcher has been recognized by AREA as an external observer. Finally, to add objectivity, the last researcher has been involved for evaluation but only in meetings with restricted group.
In the initial phase of the project, relevant documentation available in the organization was studied (e.g., from similar projects previously performed or available tools). The aim was twofold. On the one hand, this study was necessary and functional to understand the reference system and the tools available to design the service to be provided; on the other hand, the study contributed to the collection of data useful for research. This process benefited from the possibility of the researcher gaining secondary access to confidential documentation (reports, reports and documents, contracts).

An additional data collection tool was the interview. To avoid interfering excessively in the system during the course of the activities (generating possibly inappropriate effects such as questions, clarifications, suspicion, or enthusiasm), most of the interviews during the project had an informal nature. Semi-structured formal interviews were instead performed in the final phase of the project to support the final evaluation of the activities.

3.4. Issues considered in the development of the methodology

We consider a methodology a systematic procedure to produce a certain result. It is usually structured in methodological steps that constitute a *process* within which specific activities and tasks are performed by the people involved, who occupy a certain position – *role* – within an organizational *structure*. The result produced is a representation of the test system that is expressed by a representation model, or *architecture*. The methodological *tools* include instead the tools that are used in the methodology for data collection, analysis, evaluation, representation.
In the following, we explore the steps that have characterized the evolution of the methodology during the action research project, from the initial base provided by the literature through the first experimental version (OP methodology) and the second and last version (EM methodology). To develop and formalize a methodology of roadmapping applicable in the context of small and medium-sized enterprises, it was decided to proceed by analysing and then defining the elements that characterize a methodology: that is, the process, organizational roles, support tools and architecture.

4. OPPORTUNITY PROFILE METHODOLOGY

4.1. The OP idea

To achieve the aim of structuring a methodology adapted for the SMEs context, the idea of OP was to simplify the roadmap concept by considering – already in process from the beginning – individual paths, pre-identified from a possible market opportunity (technological opportunity or business opportunity). The process is about building specific pathways of interest (linking technology, product and market) useful to deepen the elements and characterize the opportunity of development that the opportunity profile defines.

Creating an OP requires deepening technologies and industry research to describe the opportunity: what are the market needs and the likely evolution of products and services? What are the enabling technologies, and how might they evolve? What are the critical success factors and other business considerations? What are the key uncertainties?

This approach differs from the traditional methods of roadmapping implemented in large companies and present in the literature because of the simplification of the concept of roadmapping that narrows the focus of the analysis only to one specific "path".

The OP methodology had the objective of simplifying the process of roadmapping, so it was decided to intervene, maintaining the general structure suggested by the literature (Strauss et al., 1998) by simplifying the activities and reducing the scope of the project. The roadmap development activities have been based on the philosophy of opportunity profiling, which *focuses on a specific opportunity* (differing from the standard methodology) and then an activity of data collection, analysis and synthesis.
The overall process follows the standard approach of mapping that involves three main phases (preparatory, roadmap development and follow-up activities) and considers three main layers (market/customers, products/services and technologies/resources). Preliminary work is performed during a kick-off meeting at which the intermediary and the company agree on the terms of the project, its objectives and the requirements of business intelligence. Once the preliminary activities have been defined, the parties enter into the development phase of the roadmap. This phase includes the definition of the opportunity (Step 1), the analysis of the opportunity (Step 2) and final opportunity profiling (Step 3). The follow-up requires the enterprise to use the obtained information to support business decision making.

4.2. Lesson learned from the OP

Following the questions that Coughlan and Coghlan (2002) suggest using to evaluate the results of a cycle of action research (Table 3), the first question to ask is whether the initial diagnosis was correct. The initial thoughts were confirmed; the initial audit with several SMEs confirmed their difficulty in performing a structured activity of intelligence (for lack of knowledge, skills and resources as expected but also for other factors such as cultural ones). Therefore, the role of the intermediary appears to be effective for technology intelligence in a SME context. Support tools are useful, but not always sufficient. The second and third questions refer to the correctness of the action and whether it might have consequences worse than the initial problems might have been. *The OP methodology approach allowed reaching the objectives only partially; the output is too concentrated and does not guarantee an adequate contextualization. This issue began to overcome the problems of knowledge and skills because the intermediary provides access to sources of knowledge and to technology intelligence tools.*

Table 3. Evaluation of OP methodology.

Question	Answer
1. The original diagnosis was correct?	• Initial considerations were confirmed: the intermediary role seem to be effective in a SMEs context • The support tools are useful but not always sufficient
2. The action taken was correct?	Opportunity Profile Based methodology permits to obtain only partially the objectives: • the output is too focused • it does not guarantee a sufficient contextualization
3. The action taken overcome the initial problems?	• It has begun to overcome the problems of knowledge and competences. These studies can be done also beyond the boundaries of companies: here one of the possible solutions is the role of the intermediary of innovation. • But the model did not overcome at all the problem of resources. • Moreover, the depth of analysis remains not so high and there is not a guarantee of a sufficient contextualization.
4. What feed into the next cycle?	• The Opportunity profile process as a part of a more complex process • The supporting tools (integrated with other tools) • A more active role for intermediary

However, the model has not completely overcome the problem of resources. The themes of the OPs are very focused on technologies (e.g., RFID or OLED technology). The opportunity "profile" characterized different aspects (applications, key technologies, markets, customer needs, advantages/disadvantages, value chain and competition, key success factors, enabling factors, regulatory requirements, future developments, commercial attractiveness, entry barriers, problems and risks). *However, the analysis was comparatively shallow; a thorough examination with an appropriate level of contextualization requires more resources. Equally, widening the scope to more products, technologies and markets, although maintaining the same depth, requires more resources.* Finally, there were no solutions to the initial question, but there was the impression that the shared methodological basis was positive. *The next cycle will begin from this first attempt,*

- taking in the concept of opportunity profiling as part of a more complex process;
- allocating a broader role of the intermediary;
- carrying forward the support tools (integrated with other instruments).

5. EXTENDED MAP METHODOLOGY

5.1. The EM concept

Considering the positive results of Cycle 1 (for example, how to manage such trade-off parameters as breadth and depth of investigation) and again the barriers to roadmapping for SMEs (resources,

knowledge and skills), we decided to explore the possibility of increasing the value of output produced in terms of breadth and depth of information. Thus, we expanded the scope and intelligence activities, although minimizing necessary resource requirements for single companies. To do this, we adopted an ecosystemic approach (Iansiti and Levien, 2004, Battistella et al., 2013, Battistella and Nonino, 2012a, Battistella and Nonino, 2012b, Battistella and Nonino, 2012c) for roadmapping:

- introduced a more active role for the intermediary; in addition to the expertise of intelligence, we took advantage of the mediation and access to knowledge network expertise (Howells, 2006);
- developed a roadmapping process based on a collaborative approach that involves a group of companies that

- share a common interest in the issues of the study (knowledge economies);

- share the resources of the project (economies of scale);

considered the barriers to a collaborative approach by defining an individual process for the follow-up phase specific to each company (Bruce and Fine, 2004; Chesbrough and Crowther, 2006).

The EM methodology aims to create a strategic technology roadmap *at the industry level* that contains pre-competitive information (Bruce and Fine, 2004) of *collective interest* on the opportunities for development of new products and services that require functionalities/innovative technologies and consider the main business parameters. The map is intended as a tool to *support the group*, and it provides each company structured information to support decision making and a basis for strategic choices. Therefore, *in the case of EM, the OPs constitute an intermediate result that then is integrated into an overall map.* Fig. 2 illustrates how the OP methodology fits conceptually into a wider and more complete model. In particular, in the Trieste Coffee Cluster project, we executed 6 Ops and then integrated them into a single EM map.

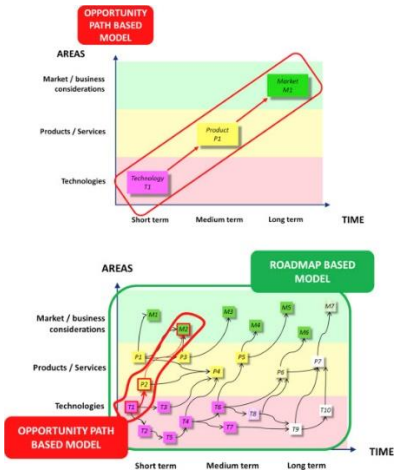

Fig. 2. OP as an intermediary result for EM.

The idea is to subdivide the process into different steps, involving a group of several SMEs within the same industry sector or interested in the same technology or scientific area for the development of a *collaborative industry-level roadmap*. Then, leave to single companies the decision of whether to eventually develop their subsequent business paths.

- The first step plans an involvement of the whole group; companies engage in a collaborative project to conduct a thorough examination of a topic of common interest that allows collecting data and knowledge, defining and analysing key issues and realizing several industry paths.

- The second step plans that each company leverages the group work on topics of general interest to continue the study and individual development on a topic of special interest, creating specific business paths.

The roadmap at the industry level shows the possible paths in which individual organizations (as well as their products, services and technologies) could participate in the development of the opportunities by defining specific possible innovation paths. In this case, the scope is much broader, and there is not necessarily a specific need to identify opportunities at the start. In fact, the approach thus defined is not limited to deepening a single opportunity but allows creating a complete thematic map.

5.2. Methodology: process

The assessments performed for the OP methodology requested review of the methodological approach, also in terms of process. The decision to simplify the process was abandoned because it led to a not entirely satisfactory result. We moved toward realizing collective and collaborative activities (involving a cluster of companies). In the activities of development of the roadmap, the objective is to produce an Extended Map of the industry sector requiring expansion of the scope of data collection, analysis and summary while maintaining the canonical structure of the process.

Fig. 3 shows the comparison among the processes of traditional roadmapping methodology, OP methodology and EM methodology.

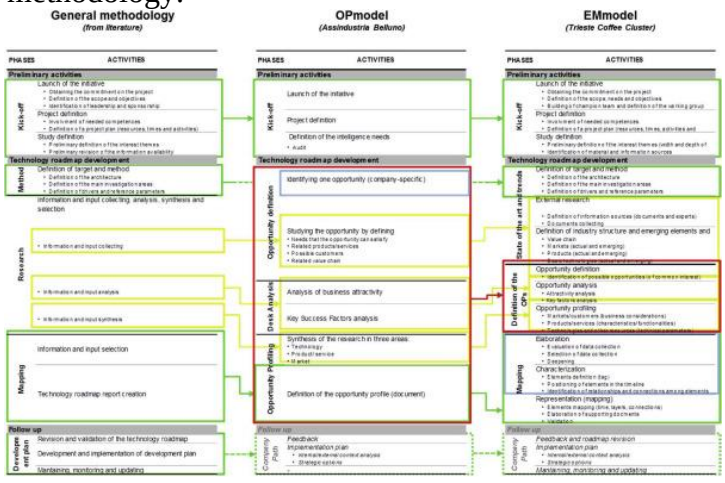

Fig. 3. Evolution of the methodology.

In contrast with the general approach proposed in the literature, we considered it useful to keep the philosophy of opportunity profiling. For intermediary-SMEs, it was functional in facilitating the focus, communication, and confrontation at the collective level in an important phase of the process in which it is necessary to switch from a divergent to a convergent phase of the study. The red box in Fig. 3 shows one of the main elements of novelty in the EM methodology (compared with the traditional one): the insertion of the opportunity profiles as a step of the methodology itself.
The mapping phase was better defined and structured than in the literature (which does not define in detail the activities to be performed). Experience showed for example that for the creation of the technology roadmap report, before proceeding to the graphical representation, important activities are processing and characterization of the information. These activities are quite complex, but generally are left implicit. In an inter-organizational context, it is important to formalize this stage because alignment and sharing among participants are required. For a generalization of the methodology to a general case intermediary-SME, it is appropriate to maintain the structure already proposed in the literature, integrating the activities of processing and characterization of the elements of the map into the development phase of the roadmap.

The phases of the process are as follows:

1. *Kick-off:* the kick-off is the launch of the initiative, the project definition and the study definition.
2. *State of the art and trends.* The first step explores the themes initially defined and identifies the state of the art and current industry trends (e.g., markets, value chain, products/services, and key technologies) within the scope of interest.
3. *Definition of OPs*. The study leads to the second step: the identification and definition of possible favorable opportunities that could be further examined. Once approved by the responsible of the team of champions, every opportunity identified and found interesting will be examined and analyzed using the same approach described in the OP methodology. The resulting profiles of opportunities are further examined and evaluated before being assembled to compose a complete roadmap for the industry sector.
4. *Mapping*. Step 3 consists in elaboration (evaluation, selection and further study), characterization (definition, time positioning and linkages of elements of the map) and graphic visualization (elaboration of map graphics, processing of documents) of all the information collected and analyzed.
5. *Follow-up.* The follow-up requires an enterprise to use the information obtained to support business decision making. This information, of a strategic nature, can enable the implementation of a subsequent new product development plan or a technology transfer process.

The intermediary is responsible for steps 2 and 3 and conducts operational intelligence necessary to perform analyses and studies. There are also recurring workshop meetings with the participating companies and frequent interactions with the “champions” team, who intervene to specify the interests, evaluate the data and information collected, guide the choices and define the programme and execution. In particular, see Table 4 for details on the process, with sub-activities, deliverables and employed resources. The activities of the companies in the coffee cluster refer to importing and trading, logistics, commerce of green coffee and coffee, roasting, decaffeination, packaging, systems and machines for espresso. To understand in particular the themes of sustainability, new products and services, customer changes and competition changes, the companies decided to focus the collaborative map on the following:
•a temporal horizon of 5–7 years;

- green coffee, roasted coffee (e.g., pods or capsules) and new possible products;
- the activities of production of roasted coffee, export/import of green coffee and logistics;

- the technologies of green coffee processing, chemical analysis and post-harvesting coffee management.

Table 4. Activities, deliverables and teams for the EM process.

Phase	Activity	Deliverable	Teams
Kick-off	Preparation	• Preparation and submission of questionnaire to cluster companies to focus themes and aims • Planning of project times • Planning of activities and meetings	Intermediary
	Meeting	• Comparison on questionnaire results • Definition of working team • Definition of interest themes • Definition of objectives • Identification of available material and informative sources	Intermediary Cluster of companies
State of the art and trends	Elaboration	• Elaboration of indications from cluster companies	Intermediary
	Sources identification	• Definition of sources of information • Documents collection	Intermediary
	Definition of the industry sector structure	• Value chain • Markets • Products • Basic technologies	Intermediary Cluster of companies
	Experts identification	• Experts identification, contact and interview • Sharing of results • Feedbacks	Intermediary Experts Cluster of companies
Definition of OPs	Definition of emerging elements and themes	• Definition of emerging elements and themes: • New markets • New products • New technologies • Attractivity analysis • Revenues, profitability, competition, regolamentation, entry barriers, R&D requirements, risks, etc. • Critical factors analysis • Business model, partner, service level, distribution channels, production, marketing, etc.	Intermediary Experts
	Case studies	• Case studies analysis: market strategy, technology strategy, best practices, alliances, business models, etc.	Intermediary Experts

Phase	Activity	Deliverable	Teams
Mapping	Synthesis of the information	• Presentation of opportunity profiles	Intermediary
	Feedback	• Feedbacks from cluster companies	Intermediary Cluster of companies
	Information evaluation and selection	• Definition of the industry map with considerations on business, commercial opportunities, products and services to be offered in the market, functionalities and technologies • Information on: • Business considerations • Products/services • Technologies • Indicators/areas to monitor	Intermediary Experts Cluster of companies
	Information synthesis in the map	• Map realization • Positioning of the elements in a timeline	Intermediary
	Experts revision	• Map validation	Intermediary Experts
	Feedback	• Feedbacks from cluster companies	Intermediary Cluster of companies
Follow-up	Preparation	• Final meeting preparation	Intermediary
	Meeting	• Presentation of project results: • Main results from Ops • Industrial technological map • Discussion on how to use the roadmap as a tool for decision making in the companies • Discussion on how to structure specific paths for define development plans of products and businesses	Intermediary
	Feedback	• Feedbacks from cluster companies	Intermediary Cluster of companies

The activities, deliverables and teams involved of each phase of the process are presented in Table 4.

The result is an industry map containing several different paths, which can be specifically interpreted by single companies to identify individually the strategic options in the roadmap of the industry sector. It is up to each company to use the map as a tool for intelligence and, finally, develop an appropriate plan of business operations (follow-up). The business paths describe the

path of the organization, and, to be useful, they must lead to action plans. The AREA manager argues that “to define, select and implement the following action steps will be more demanding of having a path mapped out, but in the end that is where you find the value for the enterprise.” Unlike the previous OP methodology approach, this one provides greater availability of information and lower rigidity, and in particular allows for more creativity that leads to identify unexpected (outside the usual knowledge domain) opportunities.

5.3. Methodology: tools

Fig. 4 highlights the support tools used in the different versions of the proposed methodology. The starting point was the set of tools discussed in the literature and systematized following Popper's framework. Popper (2008) classifies the tools according to nature (qualitative or quantitative) and capability (ability to gather or process information based on evidence, interaction, creativity, and expertise). These tools function to support operators in data collection, analysis, evaluation and representation. Typically, they are selected based on accessibility and functionality criteria with respect to the specific needs and specific goals of intelligence. Therefore, in the initial diagnosis, they were not considered an appropriate basis for customization in the case of SMEs. Despite that choice, at the beginning of the methodology design, we were aware that for SMEs in particular, we could detect issues of accessibility in terms of availability (for example, in regard to information databases and modeling tools) or skills needed to use the tools. This also is why the proposed methodological approach exploits the intervention of an intermediary providing tools and skills in support of SMEs to overcome the problems highlighted.

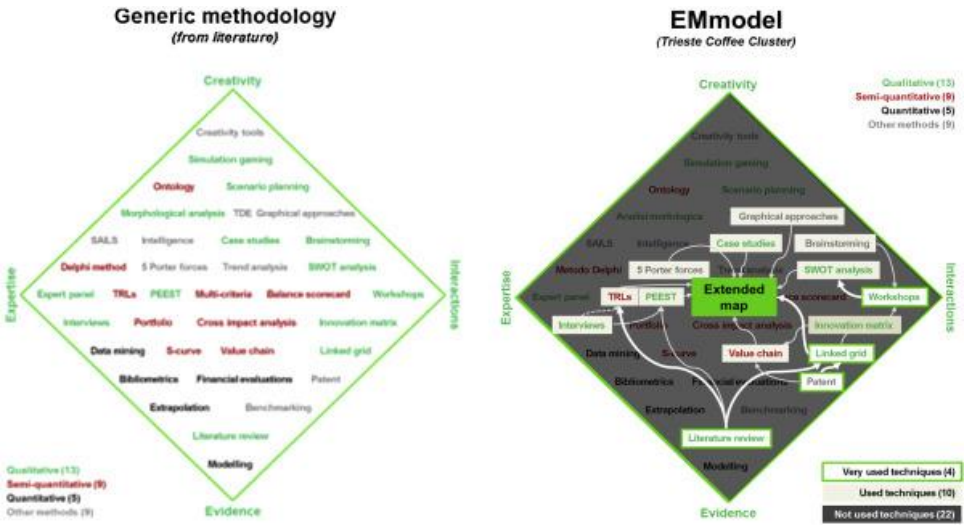

Fig. 4. Comparison of tools used in the traditional methodology and in the SMEs context (Foresight diamond, Popper, 2008).

In the EM methodology, for the collection of information, we again used the literature review but enhanced the use of patent analysis. Other methods were case study analysis and interviews with experts. The analysis required a greater commitment and adding additional tools such as Porter's 5 forces (1979) and the analysis of PEEST factors (Political, Economic, Ecologic, Sociologic and Technologic factors – which were particularly useful given the industry sectoral focus of the study). The evaluation activities involved group activities. The key tool used was the workshop (integrated with previous analyses). For the preparation and characterization of the information, the aid of a technique (similar to the so-called "linked grid") was fundamental. For the final representation of information, we used graphic approaches.

In both cases (OP methodology and EM methodology), use of qualitative and semi-qualitative methods was prevalent (most likely for their easier accessibility). Concerning how to collect or process information, the tools used are largely based on evidence, expertise and interaction, and less on creativity (most likely because of the need to show greater discipline in a context in which the intermediary acts as a third party formally providing services). In the implementation of the EM methodology (based on a collaborative approach), the number of techniques used based on interaction was higher.

5.4. Methodology: roles

Fig. 5 highlights the different definitions of roles in the different methodologies proposed. The left column reports the definitions of roles that are typically involved in the activities of the traditional roadmapping methodology, summarizing the contributions identified by the literature (Garcia and Bray, 1997, Gerdsri et al., 2009, Savioz, 2004, Phaal et al., 2010). The TRM leading figures of reference are the leader and the analyst (roles typically found inside the company), the facilitator, the consultant specialist on the method and the external expert (typically external roles).

Fig. 5. Evolution of roles in the roadmapping methodology.

In relation to the specificity of the context of roadmapping customization – SMEs – from the beginning, we believed that the activation of specific organizational structures and interpersonal relationships was the most important methodological aspect on which to base our approach.

This is also justified by recalling the considerations that led to the introduction of a new actor in the system – the intermediary. It is clear that the effect of this choice rests largely on dynamics that characterize the roles. The initial question was precisely to understand what role the intermediary could take to support SMEs in the adoption of an instrument of roadmapping. In the literature, reference is made to the intervention of external figures in support of companies in implementing the process, particularly with respect to the contribution that an external consultant can make in facilitating group activities and adopting the method for the first time (Albright and Kappel, 2003, Savioz, 2004, Phaal et al., 2010).
Knowledge, skills and resources are typically provided by the organization itself, which may make use of external specialists identified in its network. *Identifying these elements as limitations of SMEs, we decided to establish a much stronger role for the intermediary that, in addition to assuming the duties of facilitation and consulting on method, directly supports the companies by managing the process and performing activities of intelligence.*
In testing the EM methodology, AREA was servicing a cluster of companies (Trieste Coffee Cluster). In particular, during the preliminary phase, it was essential to obtain the consent and commitment of the group of companies that participated in the project. To acquire it, it is necessary to let emerge awareness of a shared problem or need that can be solved through the development of a process of technology roadmapping. Thus, the identified problems and needs should not be specific to a single company but rather must cover the entire industry in which all the companies belong or a topic of common interest. Additionally, there is the possibility of particularization of the results in the specific context of the single company. Therefore, the intermediary acquired the functions of analyst (collection, analysis, and synthesis of data) to ease the commitment of resources and expertise for single companies in the intelligence activities.

Other functions assigned to the intermediary in the previous approach have been confirmed, but there was a need to enhance further its role and tasks (as indicated in Fig. 5 in the green area in the right column). In particular, because the process was occurring in a collaborative manner and many companies were involved, the facilitating role was enhanced by recalling the mediation skills of the intermediary. In the preliminary activities, the facilitation was performed to support the buy-in of the initiative, to illustrate the potentialities and limitations of the intelligence tool (which was unknown or little known), to support the company in better understanding its context and to clarify the possible path of evolution.
In group activities, interpersonal relationships were managed, encouraging collaboration and supporting a *shared definition of the purpose and boundaries of the roadmap*. Even in this case, the consulting on the method performed by the intermediary was made primarily to support the internal analysts in performing activities. However, because the EM methodology process was more articulated, it had a greater methodological complexity; therefore, the consulting role had a more significant valence. Furthermore, considering the group activities that were held during the workshops and group meetings, it was necessary to align the representatives of the participating SMEs on the methodological bases followed in the conduct of the process. This was performed through *formal and informal training activities*.
The role of the team of champions (made up of leading figures or representatives of single companies) is of fundamental importance. It remained central to the process and replaced the similar role of roadmapping leader. It is the same profile (the reference point between the single firm and the intermediary). The difference is that the team member is a participant and responsible for the activities that occur, with collective goals that are shared with the group with the evaluations and choices, which often were the result of compromise.

Compared with the role of analyst, in contrast to what is needed in the OP methodology implementation, strong interdisciplinary skills were also necessary because the border arguments were very different from one another. The “border” disciplines cannot always be foreseen in the initial stage but emerge in the course of the investigation, such as when you discover unexpected connections. It is thus confirmed that the skills of the team should not be intended as limited to the disciplines that relate exclusively to the area of investigation but should also include disciplines and neighboring areas that could provide considerations that are not discounted for new paradigms or innovations. Moreover, experience has shown that in addition to being necessary multidisciplinary skills, these must have together a certain degree of integration or overlap to allow all participants to share a common ground on which to base comparison and communication.

The role of external experts was still limited, and their support was used only when internal skills were insufficient. This choice was necessary to meet budget constraints.

Given the complexity of the project, one of the essential activities was that of *project management*, which has been formalized. The intermediary has actively assumed the role of project manager, with operational responsibility for activities, resources, timelines, and goals. The literature that studies the roadmapping, surprisingly, does not emphasize such a role. The function this role performs is undoubtedly necessary and becomes important in the most articulated projects. In our opinion, it deserves to be highlighted.

5.4.1. The role of the intermediary

The intermediary's roles are different from the simple traditional role of facilitating. It is responsible for project management, provides tools and skills of intelligence and facilitates access to knowledge resources (both documentary and relational ones). It needs also to have further mediation skills to coordinate the group of companies and activities to be performed in collaboration and enable access to knowledge networks (in particular, to provide an industry analysis of the boundary information within different sectors).

The extended approach requires involving a larger number of small and medium enterprises to build a group interested in a common theme, allowing economies of scale and thus to contain (by sharing) the resources necessary for the implementation of the study.

The intermediary supports the group of SMEs in the development of an industry map, directly managing the process of mapping and providing skills of intelligence (foresight, scanning and information processing, generation, combination, gatekeeping and brokering, technology assessment and evaluation) for collection, analysis and evaluation of data and for the coordination of collective activities. The approach focused on an industry map permits broadening the scope of investigation and therefore requires a larger overall intelligence effort and resources necessary for the execution of the study.

5.4.2. Methodology: architecture

Literature presents different contributions that describe different possible layouts (layer – template – format) that can be used to structure the map and its components. There is no unique format, but it is possible to use different templates that allow customizing the map according to different objectives of planning, forecasting and strategy targeted by roadmapping activities. These customizations consider not the organizational characteristics but the experience made. There was no reason why they should not apply in a similar manner in the context of SMEs because they are related to the objectives and content (e.g., the need for the implementation of the EM methodology was to make an industry-level map and a layout suitable to capture a perspective such as the one

adopted). However, experience has shown that when working in the inter-organizational field, it is important to use *a clear, easily understandable and shared format*.
In the EM methodology implementation, given the breadth and width of the analysis, a graphic approach has been used to present a summary of information. Additionally, accompanying tables have been defined that develop in detail each element of the map describing their specific characteristics. To simplify the understanding of the map (which in its entirety is rather complex) and to characterize the different opportunities that compose and can be found in the map, a *textual descriptive approach* was used. In fact, because the map was built by identifying and investigating basic opportunities, these were then used to illustrate, in the final presentation, examples of reading the map. These examples are not the only possible ones because the various paths can intertwine with one another in an articulated manner by offering the chance to explore many paths, many of which are original and unexpected.

6. DISCUSSION

The analysis detected the hallmarks of SMEs compared with large companies and identified the main barriers to innovation and technology transfer that characterize the specificity of the context: resources, knowledge, skills.

Deepening the innovation intermediary role allowed us to identify how this actor can intervene in support of SMEs, providing expertise and specific services. In fact, in relation to the specificity of the context of roadmapping customization – SMEs – we believed that the activation of specific organizational structures and interpersonal relationships is the most important methodological aspect on which to base a new approach both from a practical and from a theoretical point of view. This led to the introduction of a new actor in the system – the intermediary.

6.1. Evaluation of EM

Again, following the questions by Coughlan and Coghlan (2002) (see Table 5), the answer to the first question is that the initial diagnosis was correct. To capitalize on knowledge and financial resources, the idea is to have a collaborative process that involves various SMEs interested in the same field or area of science and technology, and an important role of innovation intermediary for the coordination of the project, methodological support, provision of tools of intelligence, and access to sources of information. The initial thoughts were confirmed: the role of the intermediary appears to be effective in a SME context, not only in support of intelligence activities but also in the mediation and management of inter-organizational relationships. In addition, collaborative action allows us to share resources and seems to favor the processes of learning and networking. This cycle also helps to reduce the problem of resources. In the second cycle (EM methodology), the first process (OP methodology) has become part of a more complex process, and specific tools have been integrated with the first set.

Table 5. Evaluation of EM methodology.

Question	Answer
1. The original diagnosis was correct?	• The role of the intermediary seems to be effective in a SMEs context • A collaborative action seems to reduce the global needed resources and seem to favor learning and networking processes
2. The action taken was correct?	• In the second cycle (Extended Map) • the first process (Opportunity profile) became a part of a more complex process

Question	Answer
3. The action taken overcome the initial problems?	• the specific tools have been integrated with further ones • This cycle overcame also the problem of resources • in order to capitalize knowledge and financial resources, the idea has been to have a collaborative process and an important role of the innovation intermediary • The process has been subdivided into a collaborative process for common activities that focus on “pre-competitive” information for the same sector or area (e.g. technologies, markets, products and services, resources and competences, norms and standards) and an individual process for specific activities for the specific company (left to a later stages)

The second and third questions query the correctness of the action and if it overcomes the initial problems. The Extended Map methodology approach allowed achieving our objectives. It was possible to expand the scope of research and arrived at a richer and complete output, which provides a broad context. Considering the barriers to a collaborative approach, we expected problems from companies when proactively accepting group activities and sharing of information. Instead, this problem has not been relevant for two reasons: (1) the information processed was pre-competitive in nature and – by choice – addresses subjects in the boundaries of the knowledge base of the companies involved, touching adjacent scientific, intelligence and technological fields (e.g., genetics, pharmacology, electronics, social networks and social media). (2) Single companies contributed significantly in providing proprietary information – the research was performed by the intermediary – and were primarily involved in evaluation, choosing and directing the investigation. Instead of barriers to a collaborative approach, a critical point is that of a shared definition of the issues to be explored and the scale and depth of the analysis, choices that require reaching a compromise among different interests.

Compared with the OP, the EM model satisfies less precise and specific objectives and intelligence referring to single companies, although it offers a wider space of analysis, full of information and unexpected opportunities. Moreover, the EM allows companies not only to deepen a single pre-identified opportunity (and thus known) obtaining information for evaluation but also

- to offer more opportunities to be investigated, adding them to those proposed by others and those that emerge freely from the first divergent phase of research;
- to obtain a first analysis of all these opportunities;
- to make a choice shared with the community (which tends to discard those that the first study characterized as less interesting); and
- to investigate in depth a limited number of selected opportunities.

This greatly expands the range of choices for the single companies.

From the point of view of the companies, the EM methodology permitted obtaining an R&D direction for the companies of the cluster. Specifically, the result has been an industrial map with

- 3 mapped macro areas;
- 6 selected opportunity profiles and 4 not selected;
- 82 possible new products considered for development in the next 5–7 years.

Given the satisfactory achievement of the initial objectives, AREA was not interested in a further review of the procedure, but rather in further applying the same method to consolidate the experience. The roadmapping methodology developed by AREA for SMEs was then applied in

various experimental implementations and has finally been included in the catalog of services and competencies of the organization. The cycles of action research, then, end here.

6.2. Differences for SMEs between traditional methodology and EM methodology

For a generalization of the methodology to the case intermediary-SMEs, the proposal is to define a "heavy" role for the intermediary. The intermediary in fact can take the task of managing the project (project manager), provide methodological support (expert consultant/advisor of the method), provides intelligence services (analyst) and mediation within the inter-organizational collaboration context (facilitator). Concerning the process, this requires some specific adjustments of the general methodology to permit collaboration, facilitation and mediation during some steps. Concerning tools and architecture, for a generalization of the approach to the general intermediary-SMEs case, experience did not detect reasons for customization of the methodology relying on the tools. Therefore, we believe it is appropriate to maintain the structure proposed in the literature, which allows adapting the choice of techniques to support activities based on specific needs and capabilities, with the role of intermediary to ensure a sufficient level of accessibility.

Table 6 synthesizes for each element of the methodology (process, tools, roles and architecture) the comparison between traditional methodology in large companies and EM methodology.

Table 6. SMEs and roadmapping.

	Traditional roadmapping methodology large enterprises	**EM methodology (intermediary)-SMEs**
Resource Knowledge Skills	Knowledge, skills and resources are typically provided by the organization itself, which may possibly make use of external specialists identified in its network.	Single organizations typically fail to individually satisfy their needs for resources, knowledge and skills. A collaborative process is set up in order to capitalize knowledge and financial resources, while the important role of the innovation intermediary in providing intelligence, mediation and access to knowledge network expertise.
Process	The general structure of the TRM process obtained summarizing the contributions from literature is characterized by three main phases (Preliminary activities – Development of the technology roadmap – Follow-up) and a number of sub-phases.	The overall process follows again the standard approach of mapping that involves three main phases and a number of sub-phases, but we propose to set up collective and collaborative activities (involving a cluster of companies) and the presence of an intermediary.
Tools	As regards tools, for a generalization of the approach to a general case intermediary-SMEs, experience did not detect reasons for customization of the methodology relying on the tools, and therefore we believe it is appropriate to maintain the structure proposed in the literature, which allows to adapt the choice of techniques to support activities based on the specific needs and capabilities, with the role of intermediary to ensure a sufficient level of accessibility.	
Roles	The TRM leading figures of reference are: the leader and the analyst (roles typically inside the company), the facilitator, the consultant specialist of	In the context the leading figures of reference are: the team of champions (made up of leading figures of representatives of single companies) replace the TRM leader, the analyst (task mainly moved outside the

	Traditional roadmapping methodology large enterprises	EM methodology (intermediary)-SMEs
	the method and the external expert (typically external roles).	company), the facilitator, the consultant specialist of the method and the external expert (maintained as external roles and played by the intermediary). The proposal is to define a "heavy" role for the intermediary that takes the task of managing the project (project manager), provides methodological support (expert consultant/advisor of the method), provides intelligence services (analyst) and mediation within the inter-organizational collaboration context (facilitator).
Architecture	Different possible layout (layer – template – format) that can be used to structure the map and its components. There is no unique format but it is possible to use different templates that allow customizing the map according to different objectives of planning, forecasting and strategy targeted by the roadmapping activities. These considerations do not consider the organizational characteristics but the experience made, there was no reason why they should not apply in a similar manner in the context of SMEs, since they are related to the objectives and contents	

The literature identifies critical factors for roadmapping, i.e., elements that affect roadmapping performance positively or negatively (success factors or barriers) (Phaal et al., 2000, Kostoff and Schaller, 2001, Bruce and Fine, 2004, Abe et al., 2009, Cosner et al., 2007, Gerdsri et al., 2010, Groenveld, 2007, Lee et al., 2007, McMillan, 2003, Phaal et al., 2004, Phaal and Muller, 2009, Yoon et al., 2008). We subdivided these factors into three categories (organization, intelligence capability and process management), and we analyzed in the case study whether they also present criticalities in the case of roadmapping for intermediary-SMEs (Table 7). The critical factors identified are

- Project times – difficulties in managing an inter-organizational collaborative process, for example, because multiple levels (company – cluster – intermediary – development team) can cause slowness in communication.

- Data and information sources and availability – the companies of the cluster had a deep knowledge about the specific and central themes of the coffee, which is why the team decided to analyze "border areas", e.g., sociological aspects in coffee consumption or differences of tastes by geographic area.

- Interdisciplinary competences needed – for a collaborative activity, not only is having multidisciplinary competences necessary; they also should be integrated. Experts on methods and experts on specific areas need to collaborate. Moreover, "border" disciplines cannot be always defined a priori, but emerge during the analysis, for example, when an unexpected link toward "far" markets or products emerges.

- Sector width and depth for investigation (scope and granularity) – the definition of this parameter is critical because it must support compromise among different interests, particularly in multi-organizations contexts; it determines subsequent activities such as data collection and evaluation; the two elements of depth and width of analysis are a trade-off.

- Format, criteria, languages – difficulties in having the same terminologies and concepts.

- Confrontation and communication – social aspects and interaction are important for roadmapping, particularly when different organizations are involved.

Table 7. Critical factors in the case intermediary- SMEs.

Category	**Critical factors in literature (for large companies)**	**Critical factors identified in the case intermediary-SMEs**
Organization	Presence of a business owner and involvement of stakeholders	Not critical
	Relevance for future actions	Not critical
	Senior management commitment	Not critical
	Clear definition of the objectives of the initiative	Not critical
	Definition of a precise focus	Not critical
	Integration with management tools and decision processes	Not critical
	Guaranteeing process continuity	Not critical
Intelligence	Project costs	Not critical
	Project times	Critical
	Data and information sources and availability	Critical
	Support tools	Not critical
	Interdisciplinary competences needed	Critical
	Facilitation/training	Not critical
Process management	Clear, robust and effective process	Not critical
	Roles definition	Not critical
	Sector width and depth for investigation (scope and granularity)	Critical
	Architecture definition (layer-timeframe)	Not critical
	Format, criteria, languages	Critical

Category	Critical factors in literature (for large companies)	Critical factors identified in the case intermediary-SMEs
	Condivision and communication	Critical

6.3. Effect of the intermediary

The role of AREA Science Park has been an intermediary in support of SMEs involved in the roadmapping, an activity performed as a preliminary assessment before the process of technology transfer. In this context, the mission of AREA has been to support SMEs in the assessment phase, in which the difficulty lies in recognizing transfer opportunities and acting on them. The phase also requires significant effort to define the characteristics of the transfer, outline the scope of activities, select the time, evaluate the costs and establish the mutual obligations of the participants before the transfer can be effected. This occurred through

- provision of services to fill the gaps caused by lack of competences of involved companies (technological capabilities, organizational skills, and organizational culture);
- assisting in selecting the appropriate transfer mechanisms, facilitating their adoption and use, and enabling transfer channels otherwise inaccessible;
- smoothing of critical factors due to the characteristics of the object (favoring the interpretation with respect to issues concerning codifiability, contextuality, complexity, rate of change, and uncertainty) and the environment (a notable risk factor);
- facilitation of interpersonal relationships: the role of mediation is essential to support innovation by providing the bridge (bridging) and mediation (brokering) between subjects and content. The broker in fact facilitated the connection between distant parts, coordinated collaboration between different organizations, and enabled the integration of new knowledge and technologies;
- creation of a climate of trust, strengthening the channels and mechanisms of connection, and shortening the ‘distance’ between the parties.

In the framework, intermediation is one of the possible mechanisms for the transfer because it constitutes a particular organizational asset that specifically provides for the inclusion of a third party in the relational context. Such a choice is optional. The introduction of AREA Science Park in this context led to bringing into full participation another actor who assumed the role of mediator to facilitate the relational context and set itself the goal of supporting the development of the process in its criticalities, acting on enablers or on limiting factors.

In other words, the involvement of an intermediary is justified by its intervention in one or more of the critical factors presented. More generally, we note the following intermediary effect on the critical factors of technology transfer, limited to the preliminary part of the technology transfer process enabled by roadmapping:

- the intermediary in the case of roadmapping can support the skills of the actors (organizational structure, motivations, resources) and helps to spread the culture of open innovation;

- the intermediary in the case of roadmapping can help to reduce the distance of the base of knowledge between actors;

- the intermediary in the case of roadmapping can help in choosing the appropriate transfer mechanisms, facilitating its adoption and use, and enables transfer channels otherwise inaccessible;

- the intermediary in the case of roadmapping can contribute to a greater awareness of the object of the transfer (improve codifiability object, define parameters and performance evaluation, understand contextual features and consider evolutionary dynamics);

- the intermediary in the case of roadmapping can help to clarify the context of reference (mitigates uncertain costs and risks, and makes more transparent the limits of possible developments).

7. CONCLUSIONS

This paper describes the development of a methodology for technological roadmapping specifically tailored for SMEs' needs and including the role of innovation intermediary with the aim of producing strategic technology roadmaps that can be used by SMEs to support their decision-making on technology, business and strategy.

In the EM methodology, the first process (OP methodology) became a part of a more complex process, and the specific tools have been integrated with additional ones, maintaining a "heavy" role of the intermediary of innovation. The result aims *to increase the value of output produced to expand the scope of intelligence activities (in terms of breadth and depth of information) and to minimize the necessary resources for single companies.* EM methodology defined and developed a TRM system as a participative and collaborative process *involving a group of companies* that *share a common interest in the issues of the study (knowledge economies) and share the resources of the project (economies of scale).* A collaborative process is set up to capitalize knowledge and financial resources, whereas the important role of the innovation intermediary in providing intelligence, mediation and access to knowledge network expertise allows overcoming knowledge and competences barriers. The presence of the intermediary aims to define the objectives, supplies the tools and technology intelligence competences, and enables access to knowledge sources (documental and relational). It is responsible of maintaining interest, manages the project and coordinates the companies' group and the collaboration activities.
The innovative character in relation to the state-of-the-art can be identified for a number of reasons:

- tailoring of the TRM process for SMEs: the methodology customizes in the SMEs' context a methodology typically thought for large companies;

- actionability of technology intelligence: the project has been implemented in two case studies and can be scalable and viable in other companies clusters;

- the problem of the resources also can be overcome for these types of knowledge-intensive activities with a mixed collaborative and individual process: the process has been subdivided into a collaborative process for common activities for the same sector or technology and an individual process for specific activities for the specific company;

- importance of the role of innovation intermediary: it has the aims to define the objectives; supplies the tools and TI competences, enables the access to the knowledge sources; manages the project and coordinates the companies group and the collaboration activities;

- ecosystem point of view: the philosophy of the methodology goes in the direction of business ecosystems because it supports the idea of interacting organizations and individuals who coevolve and share common resources.

From a practitioners' point of view, the collaborative approach at the basis of the methodology represents a promising potential solution to the following constraints of SMEs' innovation: access to learning and knowledge processing, to cognitive diversity and openness to collaboration. The methodology is a basis for SMEs who wish to understand how to implement a technology intelligence and foresight system in their enterprises to focus on the market of tomorrow. Further work will implement the EM methodology also in other sectors to study contingency factors and better adapt the methodology on a wider scale.