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# Technology roadmapping for SMEs: an action research in Area Science Park

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# TECHNOLOGY ROADMAPPING FOR SMES: AN ACTION-RESEARCH IN AREA SCIENCE PARK

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**Abstract**

*Innovation requires an interdisciplinary approach, knowledge processing, diversity and openness to collaboration that in general SMEs struggle to access. SMEs are disadvantaged because they experience cultural, knowledge, capabilities and financial access barriers. For their strategic and innovation activities, SMEs need to access to selected knowledge focused and connected to their technology, product, market and resources. For SMEs, the problem is that they lack specific and tailored technology-intelligence and foresight (TIF) systems that are normally thought and fitted for big large companies. The paper contributes to enriching the research field of foresight and technology management, proposing a methodology to implement technological roadmapping tailored for SMEs. The research strategy is an action research in a S&T park, Area Science Park.*

**Keywords**

Technology roadmap, SMEs, technology transfer, foresight, innovation

## 1. INTRODUCTION

The decrease of the useful lifespan and the obsolescence of knowledge and capabilities are becoming the norm in complex and dynamic competitive environments. In this context, technology-intelligence and foresight (TIF) systems sit at the heart of organizations' ability to: (1) succeed in detecting threats and perceiving opportunities, (2) enhance their resilience and (3) achieve successful and repeated innovation (Rohrbeck, 2010).

SMEs are disadvantaged because they experience cultural, knowledge, capabilities and financial access barriers (Lange *et al*., 2000). Therefore, they tend to adopt an unplanned, informal, crisis-driven approach to strategy and R&D, perceiving it purely as a means of solving immediate rather than future problems (Lawless *et al*., 2000).

For their strategic and innovation activities, SMEs need to access to diversity and openness to collaboration and to obtain selected knowledge (Lichtenthaler, 2008; van de Vrande *et al*., 2009) – focused and connected to their technology, product, market and resources. For SMEs, the problem is that they lack specific and tailored TIF systems that are normally thought and fitted for large companies. The problems for SMEs are three: knowledge, competences and resources. In this context the role of innovation intermediaries to support the innovation process involve a number of different activities (Howells, 2006): technology transfer and diffusion; innovation management; systems and network.

The paper proposes a technology intelligence methodology for Technology Roadmapping (TRM) tailored for SMEs. The specific context is a Science and Technology Park in Italy, Area Science Park (AREA). As an innovation intermediary it had a specific need of supporting its activities of SMEs' technology transfer services with a theoretical methodology for TRM. The researchers followed a methodology of Action Research, with two cycles: the first in an association of high-tech companies in Belluno (Italy) that derived in the building of an Opportunity Profile methodology and the second in the Coffee Cluster in Trieste that derived in the building of an Extended Map methodology. This paper would then like to:

1. Study the roadmapping as an instrument to support Technology Transfer and Technology Management in a context of Open Innovation;
2. Study the role of the innovation intermediaries for the use of roadmapping;
3. Comprehend the tools/ methodologies for SMEs for Technology Roadmapping.

## 2. LITERATURE REVIEW

### 2.1 Roadmapping

The systematic application of TIF systems into the decision-making process of companies and their products development is seen as a fundamental support to strategy and innovation (Becker, 2002; Will, 2008). More in detail, an instrument of TIF that can support technology management, helping in facing a changing environment and enabling the technology transfer process, is the *Technology Roadmap* (TR) (Kostoff and Schaller, 2001; Phaal *et al*., 2004).

Technology Roadmapping (TRM) is a process for managing the future of technology. It identifies alternative technological and market "roads" in terms of dynamic linkages among resources, organizational objectives and the changing environment (Garcia and Bray, 1997; Rinne, 2004).

TRM is more than just about technology; it should set out a landscape, the status and direction of an opportunity, an application and the associated technologies. TR must outline products and services, within the opportunity, that businesses or consumers would actually buy:

- It relates products and services to functional requirements and/or technologies;
- It describes key business considerations that help decide about the more opportune strategic path.

TRs are particularly tailored for large companies or in contests of availability of financial resources and knowledge.

The majority of the works on Technology roadmapping are concentrated on the process of TRM applied in different contexts and sectors (Bruce and Fine, 2004, Gerdsi, 2009, Lee and Park, 2005, Cosner et al., 2007).

### 2.2 TIF in SMEs and barriers to Roadmapping for SMEs

Although TIF practices are not new in management literature, there is poor empirical evidence of how foresight is implemented in small and medium businesses. In fact, compared to larger companies, foresight is clearly an even more difficult challenge for SMEs (Alsan, 2008), due to scarcity of time, money and human resources. They are disadvantaged by nature when it comes to accessing new ideas: the lack of resources and the need to invest them in a prompter way "filling the order book" pushes small and medium businesses to orient to short-term needs and to concentrate to more "pragmatic" businesses, to forget about the need to innovate and to stop from looking beyond their own horizons. Moreover, from an organisational point of view, lack of organisational slack conducts in difficulties both as regards an internal systemic approach and both an external difficulty in connecting with the outside of the company.

Innovative and successful enterprises use systematic TIF methodologies more often than less innovative and successful enterprises (Z-Punkt, 2008). But taking innovation and especially foresight (Rohrbeck and Gemuenden, 2011; von der Gracht *et al*., 2010) into SMEs is hard. 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) showed anyhow that some SMEs are developing TIF in their companies, but with important barriers such as organizational silos and policies restrict dialogue, limited attention of internal stakeholders and lack of resources.

Recent explorative papers examined the clusters of foresight practices in thirty SMEs in biotech industry (Mietzner and Reger, 2009), described how foresight can be integrated in SMEs (Major and Cordey-Hayes, 2000) or illustrated the results of a foresight exercise in a SME (Will, 2008). These researches are first steps toward an approach on CF to be adopted in small and medium businesses, but still present some gaps:

- previous studies seem to lack of "actionability": they do not explain how the SMEs really implement the foresight in their businesses;
- they have an interpretation of CF only as a set of methods or as a process, while the very recent literature gives a holistic interpretation as a set of strategic, organizational and managerial features or as a capability of "future orientation" (Rohrbeck, 2010).

Finally, some papers tried to build theoretical frameworks for knowledge management and foresight in SMEs (Pozdnakova, 2008), but lack of real cases examples.

In particular, as Savioz (2004) suggested, there are two gaps as regards the 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.

Moreover, there is an action gap because of limited human resources and financial resources and limited knowledge and competences: SMEs have difficulties in applying technology roadmapping tools and methodologies. In fact, as reported by literature, SMEs lack:

A) resources

- Lack of financial resources (Kim and Park, 2010; Nerula, 2004);
- Few possibilities to hire specialised human resources (Vossen, 1998, Rothwell and Dodgson, 1991; Van de Vrande et al., 2009);
- Limited resources to have internal R&D (Hausman, 2005; Lee et al., 2008; Van de Vrande et al., 2009);
- Low access to external sources of technology (Narula, 2004).

B) knowledge and competences

- Limited internal R&D and technological assets (McAdam and McCovery, 2004; Hausman, 2005);
- "cultural deficit" (Souitaris, 2001; Frishammar and Horte, 2005);
- Low technological resources to exchange (Nerula, 2004).

### 2.3 Role of intermediary

In this context the role of innovation intermediaries to support the innovation process involve a number of different activities (Howells, 2006): technology transfer and diffusion; innovation management; systems and network.

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. 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).

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.

## 3. RESEARCH STRATEGY

### 3.1 Research question

As a "small business is not a little big business" (Welsh and White, 1980), foresight cannot be implemented in SMEs as in big companies merely: it is necessary to find proper organisational and managerial systems. The paper contributes to enriching the research field of foresight and technology management, proposing a methodology to implement TRM for SMEs. The paper aims to:

1. Understanding the process of Technology Roadmapping to support Technology Intelligence;
2. Building a methodology of Technology Roadmapping for SMEs.

Specifically, the present work is propelled by the following research question:

- *How can a methodology of Technology Roadmapping be structured to be fitted to SMEs' needs?*
    - *How can a small-medium enterprise do foresight and technology-intelligence?*
    - *How can the innovation intermediary support the SMEs in the technology-intelligence processes?*

### 3.2 Context

The Trieste AREA Science Park Consortium is a top MIUR (Ministry for Education, University and Research) national research body and manages Italy's foremost multi-sector Science and Technology Park, which houses public and private institutions with an active role in scientific research, technological development and industrial innovation.

The AREA Consortium was created to manage this science and technology park and promote its growth. It subsequently developed distinctive skills in the organisation of technology transfer activities, the management of training initiatives and the implementation of scientific and technology networks, at both national and international level.

Thanks to these distinctive skills, the Consortium is nowadays able to offer services to help the surrounding environment, to participate to the international network and to organize high-level training activities.

### 3.3 Design/methodology/approach

The research strategy is an action research, as suggested by Coughlan and Coghlan (2002). See Table 1 and Figure 1 for the explanation of why we chose the action research methodology and for the overview of the two cycles.

The context is a Science & Technology park in Trieste (Italy): Area Science Park. Its Technology Transfer service comprises business intelligence tools (such as SCAN$^{TM}$ and Explorer) and TRM tools (for large companies). The aim of this intermediary of innovation is to increase the competitiveness of the SMEs of its territory, supplying value-added TIF services but with limited resources (i.e. not through public financing).

After a pilot-case in a large company in 2009, the action research cycles have been two: a cycle of an "opportunity profile based model" roadmap (OPmodel) in an association of SMEs in 2010 and a cycle of a "extended map based model" roadmap (EMmodel) in a specific cluster of SMEs (coffee cluster) in 2011.

Table 1 – Explanation of the choice of action research basing on questions from Coughlan and Coghlan (2002)

| | RATIONAL | EXPLANATION |
|---|---|---|
| **Rational for Action** | *1. Action project* | The project is promoted from AREA Science Park. |
| | *2. Forces driving the need for action* | Internal and external stakeholders. |
| | *3. Commitment and collaborative relations* | Direct collaboration with the responsible of the Technology Transfer service and creation of a project steering committee. |
| **Rational for Research** | *1. Why this this action project is worth studying?* | Literature does not presents TRM methodologies for SMEs and do not presents practical applications in the SMEs context. |
| | *2. How action research (AR) is an appropriate methodology to adopt?* | • AR to describe a series of events that are happening inside an organization<br>• AR to comprehend - as a group member – how and why implemnted actions and procedures impact on the system/process functioning<br>• AR to comprehend the changes in order to learn from them |
| | *3. What contribution of knowledge it is expected to make?* | Creating a theoretical basis for a TRM methodology for SMEs as a synthesis of a solution for a practical problem. |

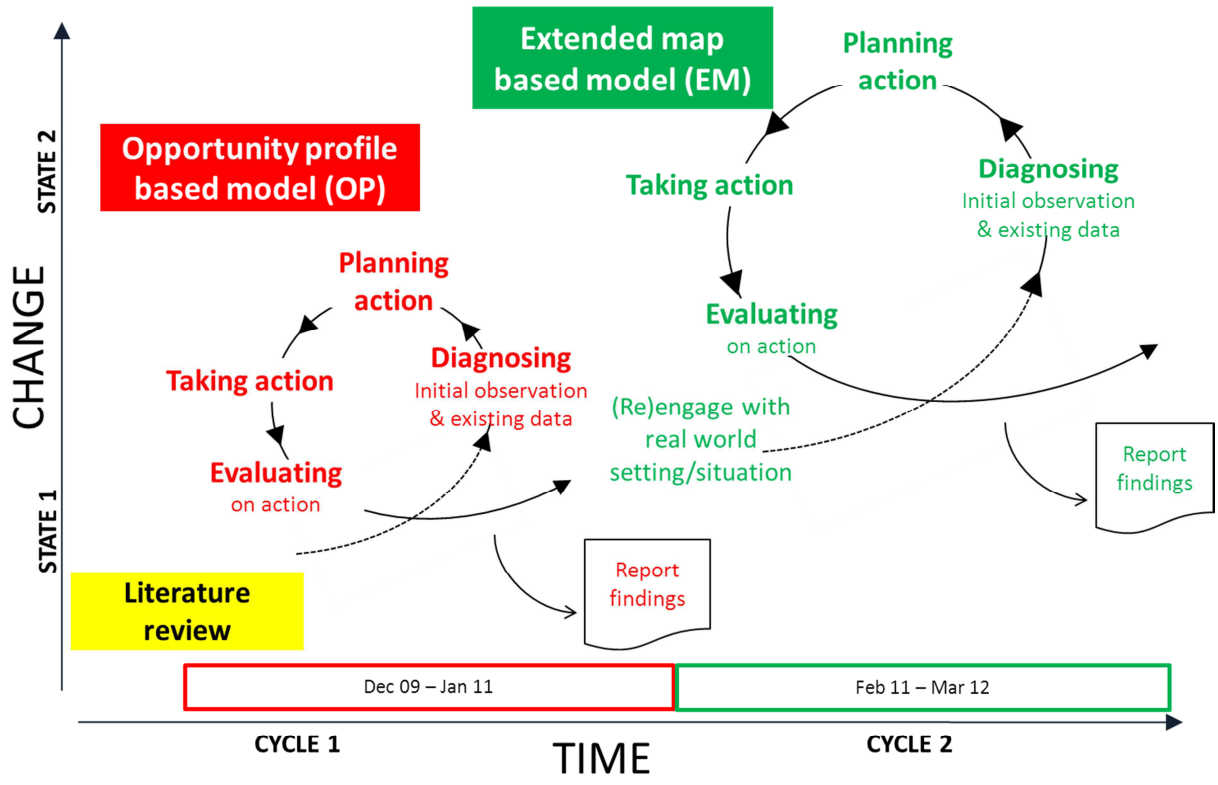


Figure 1 – Cycles of action research for technology roadmapping for SMEs

## 4. FINDINGS

For the cycles, we followed the steps as suggested by Coughlan and Coghlan (2002): context and purpose, diagnosing, planning action, taking action and evaluating action. The first cycle has been done in an association of high-tech companies (Assindustria Belluno) and derived in the Opportunity Model roadmapping methodology while the second cycle has been done in the Trieste Coffee Cluster and derived in the Extended map roadmapping methodology.

Table 2 – Overview of the two cycle of Action Research

| | ASSINDUSTRIA BELLUNO | TRIESTE COFFEE CLUSTER |
|---|---|---|
| Companies | 6 | 9 (7 small and 2 medium size) |
| Period | February 10 – December 10 | February 11 - March 12 |
| Object | Preparation of 6 Opportunity Profiles for 6 companies of an association of companies in Belluno (Italy). In the Opportunity Profiles there are information on opportunity/possibility – technical and of business – connected to technological / commercial questions related to future developments. | Trieste Coffee Cluster needs to have information and knowledge about the possible research and business direcion of the coffee sector. AREA develops a strategic technological map focused on the industry sector of coffee (international level). The map will cover a time period for the next 5-7 years and will map the global context. The specific themes have been: products, services, supply chain, technologies, business parameters. |
| Methodology | Desk Analysis connected to the Business Intelligence Explorer tool, with further information taken from other sources for integrating, validating and presenting the contents of an OP. | • Opportunity profiles development for the coffee sector, based on secondary research, interviews with sector leaders and case studies.<br>• Building of a strategic technological map that identifies opportunities for new products and services, functionalities and required technologies, business considerations. |
| Results | 6 Opportunity Profile:<br>• 5 derived in R&D projects<br>• 1 derived in a creation of a start-up (business plan) | R&D direction for the companies of the cluster and identification of 6 possible new products/services |

**Cycle 1**

*Diagnosing.* For SMEs, the problem is that they lack specific and tailored TIF systems that are normally thought and fitted for large companies. The problems for SMEs are three:

knowledge, competences and resources. The idea was to simplify the roadmap concept by taking in consideration – already from the beginning - individual paths, starting from a possible market opportunity (technical or of business). Creating a technology OP requires industry research to describe the opportunity: What is market need 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?

In the OPmodel approach the intermediary support a SME in the development of an opportunity profile based on secondary research and interviews with industry leaders and case studies. In this way, the intermediary supplies the tools and the technology intelligence competences (documents and relationships). The approach focused on a specific opportunity allows to restrict the area of intelligence research and the needed resources to execute the study.

*Planning and taking action.* The opportunity profiles were developed in 6 companies. Figure 2 shows the OPmodel roadmapping methodology. The overall process follows the standard TRM process approach that includes three main phases (preliminary activities, roadmap development and follow up activities) and three main layers (Customer/Market, Products/Services and Technologies/Resources layers) (Bruce and Fine, 2004, Garcia and Bray, 1997, Gerdsi et al, 2009, Strauss, 1998, Phaal, 2004). Preliminary activities are implemented during the kick-off meeting where intermediary and the company share the project terms, goals and company's intelligence needs. Once preliminary activities have been defined, the parties enter into the roadmap development phase. This phase includes opportunity definition (step 1), analysis (step 2) and profiling (step 3). Step 1 identifies a possible opportunity to be further examined preliminary defining its framework components (markets, value chain, products/services, key technologies, etc.); Intermediary is in charge of the Step 2 and Step 3 activities. Step 2 consists in detailed opportunity examination and its analysis in terms of business attractiveness and key success factors. Step 3 synthesizes the intelligence research in a document including business considerations (customers and markets), products/services characteristics and functionalities, technical parameters (related technologies and other relevant resources). Once the Step 3 is concluded it is up to the company to utilize intelligence opportunity profiled by the intermediary and eventually develop an appropriate company activity plan (follow up activities).

*Evaluating action.* For evaluating action, we followed the questions by Coughlan and Coghlan (2002). The first question asks if 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. The second and third questions ask about the correctness of action and if it overcome the initial problems. Opportunity Profile Based Model permits to obtain only partially the objectives: the output is too focused, and does not guarantee a sufficient contextualization. The first cycle (OPmodel) has begun to overcome the problems of knowledge and competences because the intermediary guarantees the access to knowledge sources and TI tools.

But the model did not overcome at all the problem of resources. The themes of the OPs have been specific technological (for example RFID technology or OLED technology) and the 'profile' characterized the following aspects: applications, key technologies, markets, customer needs, benefit/disadvantages, value chain and competition, key success factors, enablers, regulatory requirements, future developments, business attractiveness, entry barriers, issues, risk. Moreover, the depth of analysis remains not so high and to do an in-depth examination with an adequate level requires more resources.

The further cycle will take from this first one the OP model process, as a part of a more complex process, and the supporting tools (integrated with other tools).

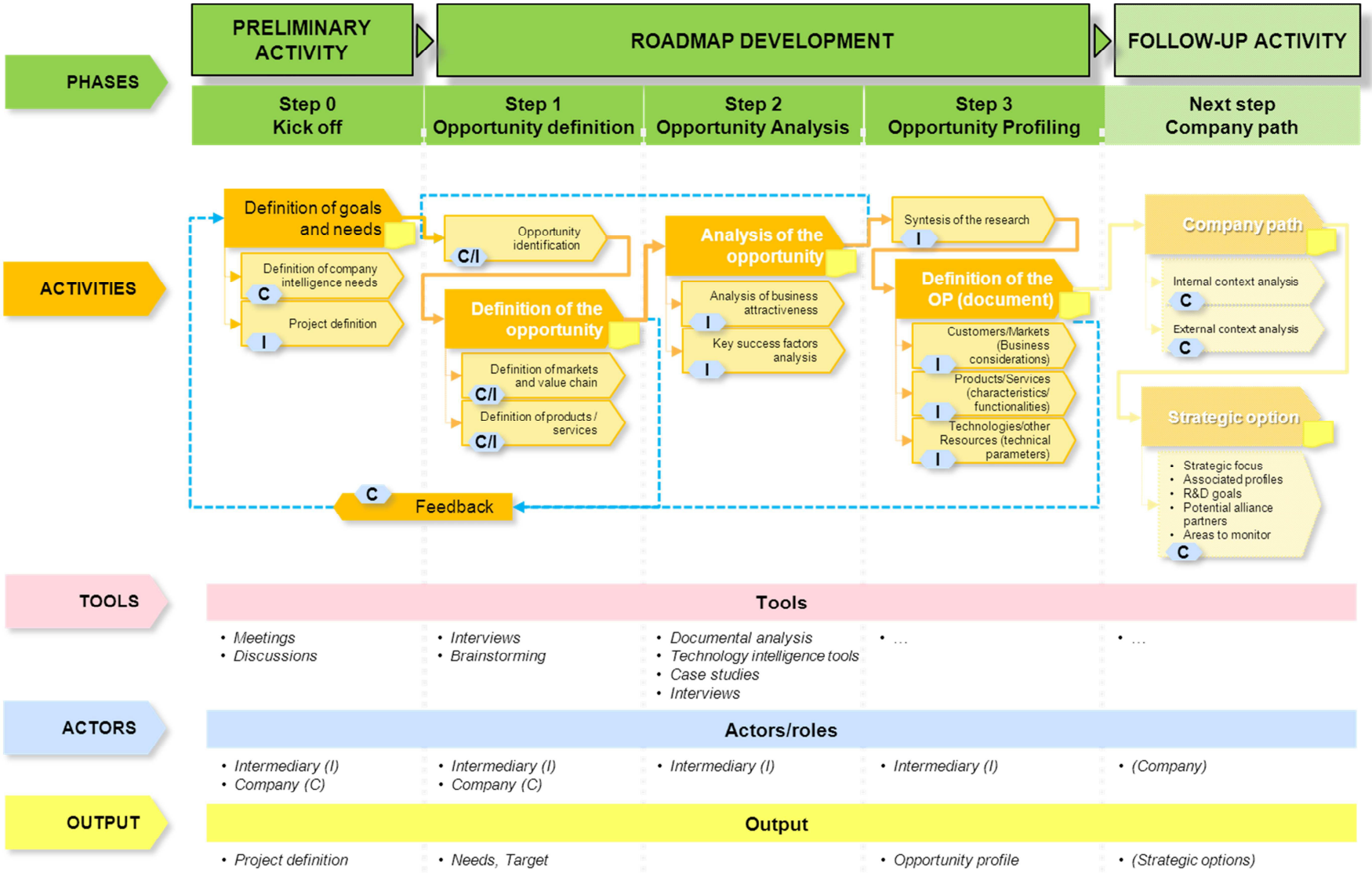


Figure 2 – Opportunity profile roadmapping methodology

**Cycle 2**

*Diagnosing.* In this second case the idea is to subdivide the process in different steps, involving a group of different SMEs within the same industry or interested in the same technology or science area for a collaborative industry specific roadmap development and then a single company specific path development.

The first step schedules an involvement of all the group: the companies start a project in collaboration to carry out an in-depth examination on a thematic of common interest that permits to gather data and knowledge, define and analyse the thematic and realise industry pathways.

The second step schedules that every company exploits the work done in group on the thematic of general interest to continue the in-depth path and of individual development on a thematic of specific interest, realising the specific company pathways.

The EMmodel approach aims to create an industry-level strategic technology roadmap for product and service opportunities, required functionalities/technologies and business considerations, that will allow the group of organizations to begin to make strategic choices. The industry-level roadmap shows the possible paths that individual organizations (as well as their products, services and technologies) might take in developing the highlighted opportunities defining specific company pathways.

The intermediary supplies the tools and the TI competences, facilitates the access to knowledge sources (documental and relational), does the project management and the coordination of the companies group and the open innovation and collaboration activities. The extended approach involves a higher number of SMEs interested in a common thematic permits scale economies and therefore in containing the needed resources to execute the study.

*Planning and taking action.* Figure 3 shows the EMmodel roadmapping methodology. The overall process follows the same standard TRM process approach including the three main phases (preliminary activities, roadmap development and follow up activities) and three main layers (Customer/Market, Products/Services and Technologies/Resources layers). Preliminary activities are implemented during the initial meetings where intermediary and the group of companies define project terms (deadlines, costs and activities), relevant thematics for the research and appoint a team of project champions overseeing the development of the study providing suggestions and feedback. Once preliminary activities have been defined, the parties enter into the roadmap development phase. This phase includes external research (Step

1) and mapping (Step 2). Intermediary is in charge of the Step 1 that identifies the state of the art and current sectorial trends (markets, value chain, products/services, key technologies, etc.) leading to the identification and definition of possible favourable opportunities that could be further examined. Once approved by the project team champions each opportunity will be examined and analysed following the same approach described in the OP Model. The resulting opportunity profiles are put together in order to compose a complete industry roadmap. This leads to the Step 2 (the mapping) that consists in the elaboration (evaluation, selection and further in-depth examination), characterization (definition, time positioning and interrelation of map elements) and graphical visualization (elaboration of the graphical map, elaboration of supporting documents) of the information included in the opportunity profiles. Once the Roadmap development is concluded there are specific paths for specific companies in order to identify the strategic options in the industry roadmap. It is up to each company to utilize the map as an intelligence tool and eventually develop an appropriate company activity plan (follow up activities). Company pathways describe the organization's path; to be useful they must lead to action. Describing, selecting and carrying out the action steps is more challenging than charting a path, but ultimately that is where the value lies.

*Evaluating action.* The role of the intermediary seems to be effective in a SMEs context. Moreover, a collaborative action seems to reduce the needed resources and seem to favour learning and networking processes. In the second cycle (EMmodel), the first process (OPmodel) became a part of a more complex process and the specific tools have been integrated with further ones. This cycle contributes to reduce also the problem of resources. In order to capitalize knowledge and financial resources, the idea is to have a collaborative process involving several SMEs interested in the same industry or science/technology area, and an important role of the innovation intermediary for the project coordination, methodological support, provision of TI tools, the access to information sources.

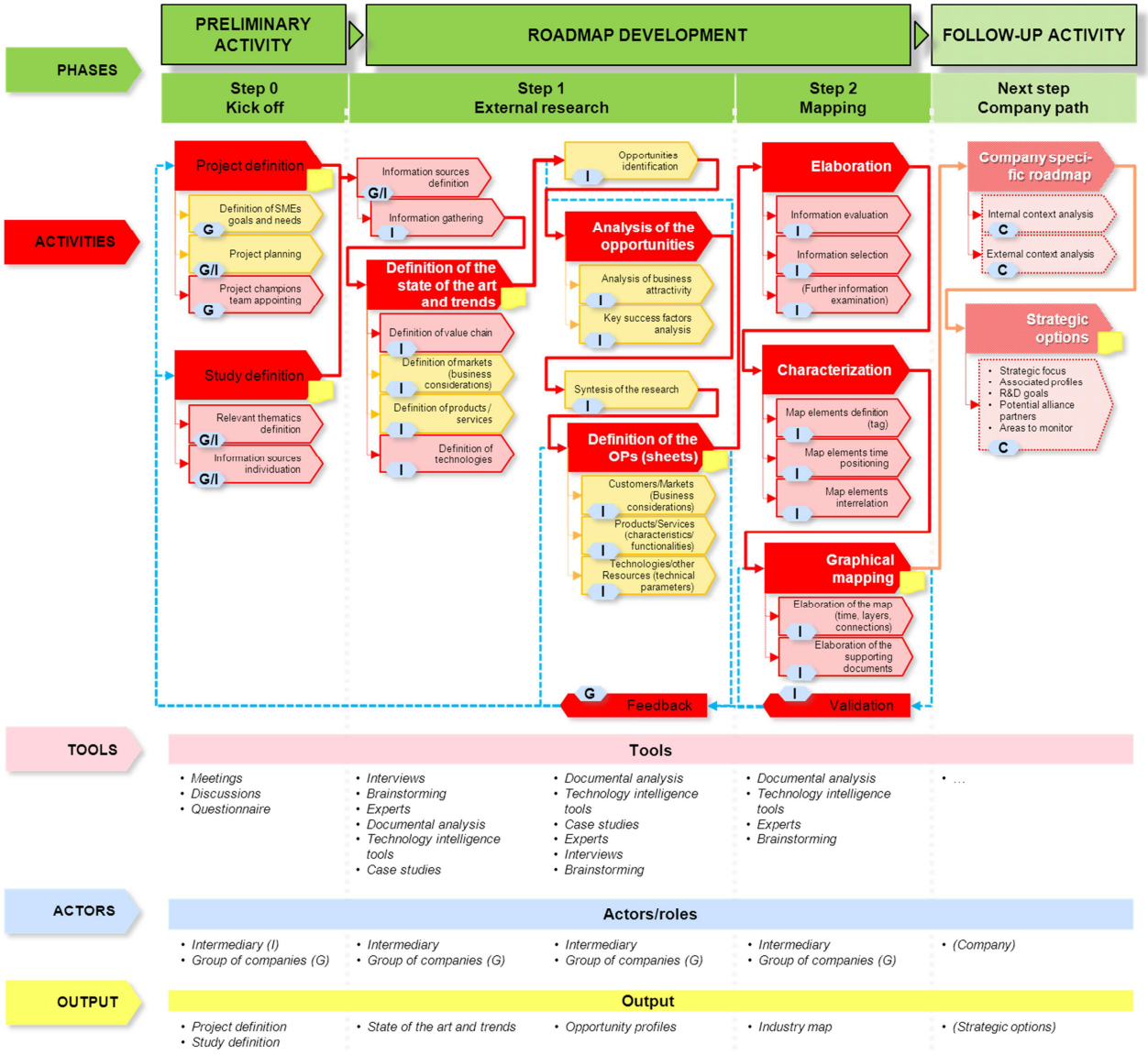


Figure 3 – Extended map roadmapping methodology

## 5. DISCUSSION

The present study presented two cycles of methodology, deriving in the proposal of the OPmodel (first cycle) and EMmodel (second cycle).

The first cycle (OPmodel) 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.

In the second cycle (EMmodel), the first process (OPmodel) became a part of a more complex process and 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 is to have a collaborative process and an important role of the innovation intermediary.

Specifically, some problems we encountered are:

- Specific of the SMEs context – competences – ex: difficulties in comprehending the methodological steps (e.g. difference between application and technology), difficulties in expectation of the companies for the intermediary and expectation of a company to the other  This has been partially solved with the role of facilitator and moderator, expert of the methodology and the coordination of the innovation intermediary;
- Specific of the SMEs context – resources – ex: at the beginning, one problem is to understand the width/depth of analysis and another problem has been that, especially for the coffee sector, the documental research found mainly information on the present. This has been partially solved with the role of the experts of the sectors and with specific tools of technology intelligence.

Therefore, the crucial elements to tailor TRM for SMEs are:

1) The definition and development of a TRM system is a participative and collaborative process, that requires:

- experts in technology fields and experts in the specific market;
- a «champions' team»;
- an expert in the methodology;
- a coordinated network;
- specific tools of technology intelligence.

In this sense, the role of intermediary can overcome the knowledge and competences barriers. It has the aims to define the objectives; supplies the tools and TI competences, enables the access to the knowledge sources (documental and relational).

2) The TRM system can be subdivided into three main steps:
    1. Opportunity profile
    2. Industry level roadmap
    3. Company pathways

In order to capitalize knowledge and financial resources, the idea is to have a collaborative process and an important role of the innovation intermediary. It is responsible of maintaining the interest; manages the project and coordinates the companies group and the open innovation and collaboration activities.

The process has been subdivided into a collaborative process for common activities for the same sector or technology (analysis and activities of intelligence on technologies, markets, norms and standards, etc.) and an individual process for specific activities for the specific company (strategic options definition, products and services development projects, definition of resources and competences).

## 6. CONCLUSIONS

This paper shows the development of a methodology for technological roadmapping – and specifically tailoring it for SMEs' needs and with the role of innovation intermediary – with the aim to produce Strategic Technology Roadmaps that can be used in the on-going making and communicating decisions on technology, business and strategy. 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 customised a methodology typically thought for large companies for the SMEs' context;
- actionability of TIF: the project has been implemented in two clusters by AREA and can be scalable and viable in other companies clusters;
- the problem of the resources can be overcome also for these kind 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 open innovation and collaboration activities.;
- ecosystem point of view: the philosophy of the methodology goes in the direction of business ecosystem because it supports the idea of interacting organizations and individuals that coevolve and share common resources.

Further work would like to implement the EMmodel also in other sectors in order to study contingency factors and better adapt the methodology to a larger extent.

From a practitioners' point of view, the collaborative approach at the basis of the methodology represents a promising potential solution to the major 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 would like to understand how to implement a TIF system in their enterprises and how to structure the "innovation engine" in order to give attention to the market of tomorrow.

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