POMS

Production and Operations Management Society

23RD ANNUAL CONFERENCE

SOCIALLY RESPONSIBLE OPERATIONS

Toward a methodology of technology roadmapping for SMEs: an action-research in Area Science Park

Battistella C. (University of Udine)
De Toni A. F. (University of Udine)
Pillon R. (AREA Science Park Consortium)

20th-23rd April 2012
Chicago, Illinois (USA)

TOWARD A METHODOLOGY OF TECHNOLOGY ROADMAPPING FOR SMES: AN ACTION-RESEARCH IN AREA SCIENCE PARK

Cinzia Battistella [a], Alberto F. De Toni [a], Roberto Pillon [a, b]

[a] University of Udine, Department of Electrical Engineering, Management and Mechanical Engineering, Udine, Italy
[b] AREA Science Park Consortium, Padriciano 99, Trieste, Italy

Abstract

Innovation requires an interdisciplinary approach, knowledge processing, diversity and openness to collaboration that in general SMEs struggle to access. The paper contributes to foresight and technology management, proposing a methodology to implement technological roadmapping 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 big companies. The problems for SMEs are three: knowledge, competences and resources.

The paper proposes a methodology for Technology Roadmapping (TRM) tailored for SMEs. The specific context is a Science and Technology Park in Italy, Area Science Park (AREA). It had a specific need of supporting its activities of SMEs' 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 the Opportunity Profile methodology and the second in the Coffee Cluster in Trieste that derived in the building of the 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 big companies or in contests of availability of financial resources and knowledge.

2.2 Barriers to Roadmapping for SMEs

As Van der Vrande et al. (2009) 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 Roadmapping
- In the Technology Roadmapping literature (and in general 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 specilised human resources (Vossen 1998, Rothwell and Dodgson 1991, Van de Vrande et al. 2009, Kimble, Li & Barlow 2000)
- 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 (Kim and Park 2010, Nerula 2004)

B) knowledge and competences

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

3. RESEARCH STRATEGY

3.1 Research question

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 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.

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 do 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 • AR to comprehend - as a group member – how and why implemnted actions and procedures impact on the system/process functioning • 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.

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 big 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. no public financing).

After a pilot-case in a big 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.

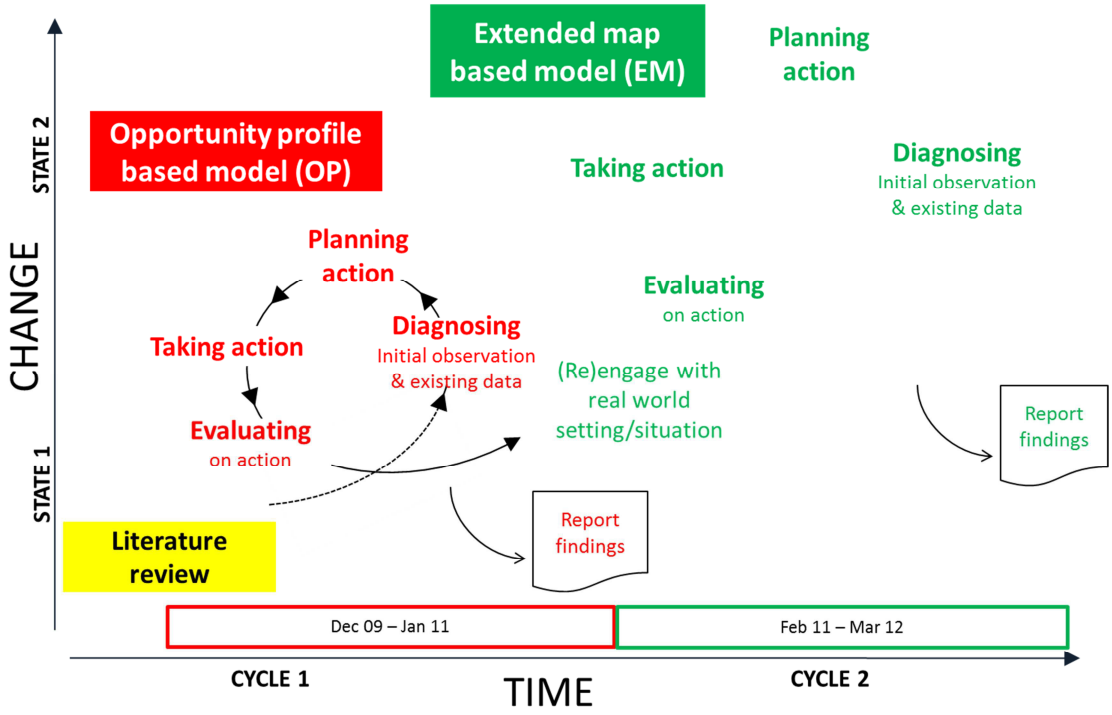

Figure 1 – Cycles of action research for technology roadmapping for SMEs

4. FINDINGS

For the cycles, we followed the steps as suggested by Coughlan and Rinne (2004): 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	• Opportunity profiles development

	Business Intelligence Explorer tool, with further information taken from other sources for integrating, validating and presenting the contents of an OP.	for the coffee sector, based on secondary research, interviews with sector leaders and case studies. • Building of a strategic technological map that identifies opportunities for new products and servicces, functionalities and required technologies, business considerations.
Results	6 Opportunity Profile: •5 derived in R&D projects •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. The idea was to simplify the roadmap by taking in consideration – already from the beginning - only one path, starting from a possible market opportunity (technical or of business).

Planning and taking action. The opportunity profiles were developed in 6 companies. The themes of the OPs have been specific technological, for example RFID technology or OLED technology.

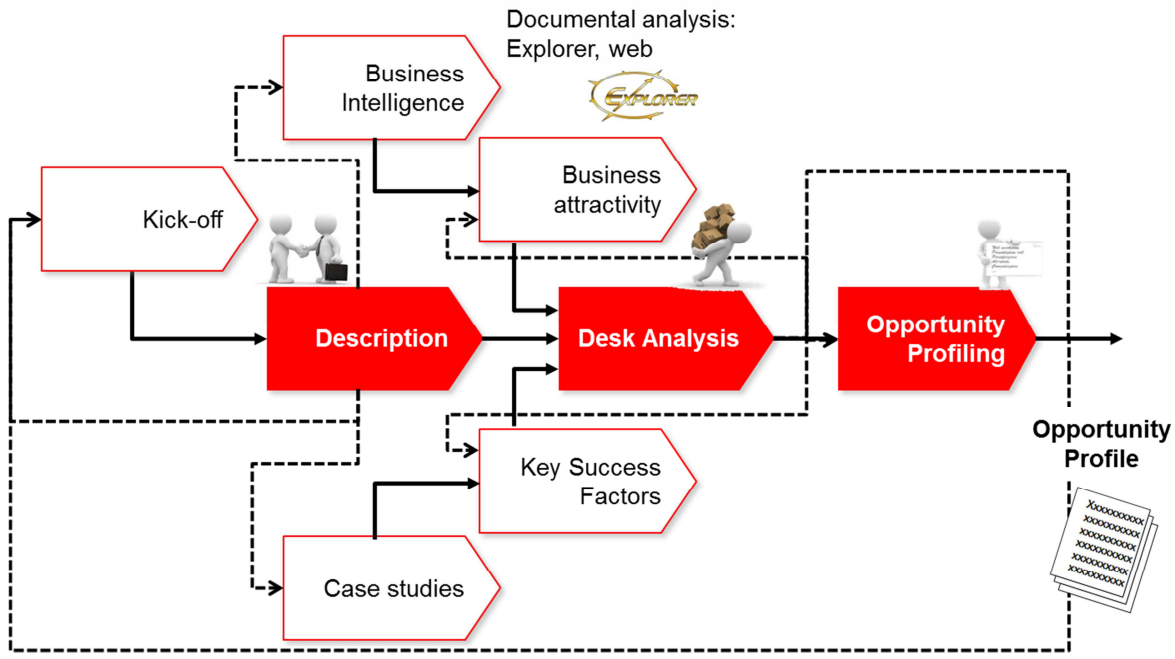

Figure 2 – Opportunity profile roadmapping methodology

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. 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.

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.

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).

Cycle 2

Diagnosing. In this second case the idea is to subdivide the process in different steps, involving different smes within the same industry (or involved by the same technology) and doing as first a collaborative step (industry specific) and then a single step (company-specific one).

Planning and taking action. As in Figure 3, the main steps of the methodology have been three: the first step, opportunity profiling, is the same of the cycle 1. Then many opportunity profiles are put together in order to compose a complete industry roadmap. Finally, there are specific paths for specific companies in order to identify in the industry roadmap the strategic options for the implementation plan for that specific company.

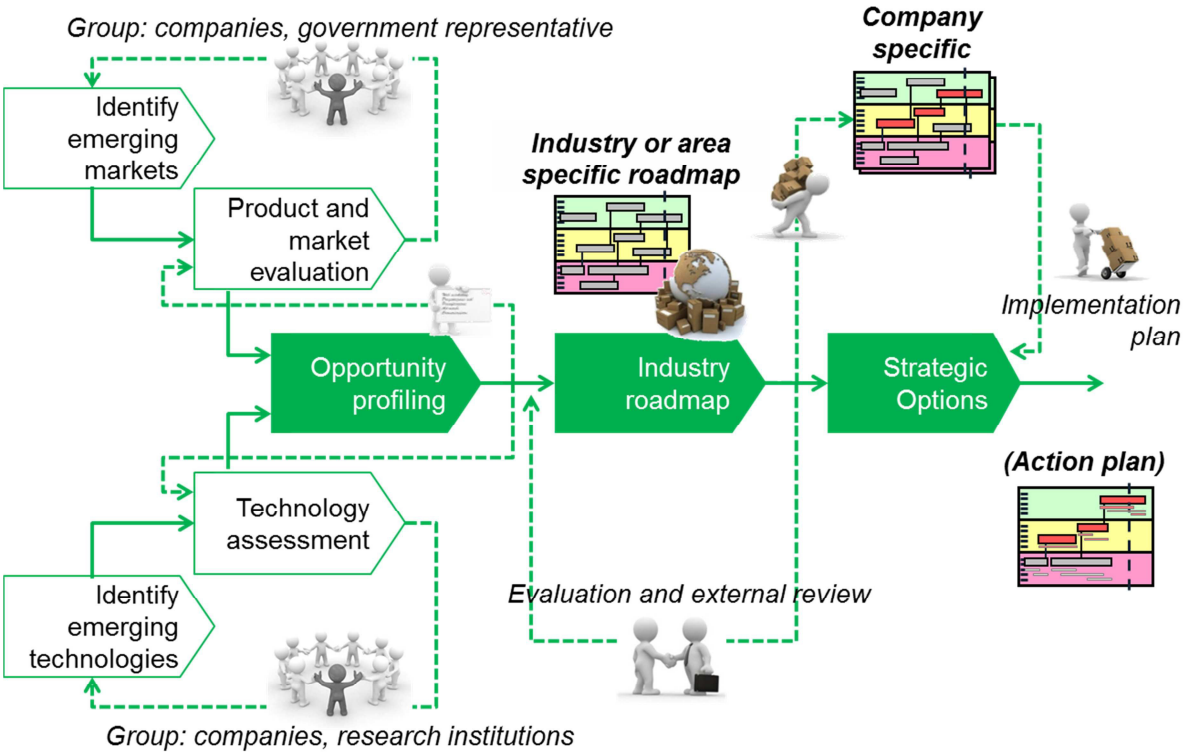

Figure 3 – Extended map roadmapping methodology

Evaluating action. The role of the intermediary seem to be effective in a SMEs context. Morever, acollaborative action seem 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 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.

5. DISCUSSION

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. The process has been subdivided into a collaborative process for common activities for the same sector or technology (e.g. technologies, markets, norms and standards) and an individual process for specific activities for the specific company (e.g. products and services, resources and competences). The role of the intermediary and of the cluster of companies become fundamental in order to: define the objectives; be responsible of maintaining the interest; traduce the information in R&D projects and strategic decisions.

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

1) The definition and development of a TRM system is a partecipative and collaborative process, that requires:
    - experts in technology fields and experts in the specific market
    - a «company champion»
    - 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; be responsible of maintaining the interest; traduce the information in R&D projects and strategic decisions.

2) The TRM system can be subdivided into four main steps:
    1. Opportunity profile
    2. Industry level roadmap
    3. Company specific roadmap
    4. Action roadmap

In order to capitalize knowledge and financial resources, the idea is 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 for the same sector or technology (e.g. technologies, markets, norms and standards) and an individual process for

specific activities for the specific company (e.g. products and services, resources and competences).

6. CONCLUSIONS

Contribution

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 interrelated 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;
- actionability of TIF;
- the problem of the resources can be overcome also for these kind of knowledge intensive activities with a mixed collaborative and individual process;
- importance of the role of innovation intermediary;
- link of technological aspects with socio-economical ones;
- focus on specific technology or specific sector;
- ecosystem point of view.

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.

Practical implications

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.

REFERENCES

Chesbrough, H., 2003. *The era of open innovation*. MIT Sloan Management Review 44 (3), 35-41.

Cohen, W.M., Levinthal, D.A., 1990. *Absorptive Capacity: A New Perspective on Learning and Innovation.* In: Administrative Science Quarterly 35 (1), 128-152.

Danneels, E., 2002. *The dynamics of product innovation and firm competencies*. Strategic Management Journal 23, 1095-1121.

Davenport, T.H., Prusak, L., 1998. *Working Knowledge: how organizations manage what they know*. Harvard Business School Press, Boston.

Dodgson, M., Rothwell, R., 1991. *Technology Strategies in Small Firms*. In: Journal of General Management 17 (1), 45-55.

Gerybadze, A., 1994. *Technology Forecasting as a Process of Organisational Intelligence*. In: R&D Management 24 (2), 131-140.

Gilbert, M. e Cordey-Hayes, M., 1996. Understanding *the process of knowledge transfer to achieve successful technological innovation*. Technovation 16, 301-312.

Horton, A.M., 1999. *A simple guide to successful Foresight*. Foresight 1 (1), 5-9.

Howells, J., 1996. *Tacit knowledge, innovation and technology transfer*. Technology Analysis & Strategic Management 8, 91-106.

Howells, J., 2006. *Intermediation and the role of intermediaries in innovation*. Research Policy 35, 715-728.

Huston, L., Sakkab, N., 2006. *Connect and develop: inside Procter & Gamble's new model for innovation*. Harvard Business Review 48, 58-66.

Kogut, B., Zander, U., 1992. *Knowledge of the firm, combinative capabilities, and the replication of technology*. Organization Science 3, 383-397.

Lane, P.J., Koka, B., Pathak, S., 2006. *The reification of absorptive capacity: a critical review and rejuvenation of the construct.* Academy of Management Review 31, 863-883.

Lane, P.J., Lubatkin, M., 1998. *Relative absorptive capacity and interorganizational learning*. Strategic Management Journal 19, 461-477.

Lee, C., 2008. *Strategic alliances influence on small and medium firm performance*. Journal of Business Research 60, 731-741.

Leonard-Barton, D.L., 1995. *Wellsprings of Knowledge: Building and Sustaining the Sources of Innovation*. Harvard Business School Press, Boston. MA.

Lichtenthaler, E., 2000. *Organisation der Technology Intelligence: eine empirische Untersuchung in technologieintensiven, international tätigen Grossunternehemen*. Zürich, Dissertation ETH no. 13787.

Lichtenthaler, U., 2008. *Knowledge exploitation in innovation networks: the perspective of the knowledge source*. International Journal of Foresight and Innovation Policy 4 (3/4), 265-286.

Lichtenthaler, U., Ernst, H., 2007. *External technology commercialization in large firms: results of a quantitative benchmarking study*. R&D Management 37, 383–397.

Lichtenthaler, U., Ernst, H., 2008. *Innovation intermediaries: why internet marketplaces for technology have not yet met the expectations*. Creativity and Innovation Management 17 (1), 14-25.

Nonaka, I., 1994. *A dynamic theory of organizational knowledge creation*. Organization Science 5, 14-37.

Nonaka, I., Takeuchi, H., 1995. *The Knowledge- Creating Company*. Oxford University Press, New York.

Norris, W.C., 1983. *How to expand R&D co-operation*. Business Week, April, 11-21.

OCSE/ Organizzazione per la Cooperazione e lo Sviluppo Economico, Giugno

Phaal R., Farrukh C.J.P. e Probert D.R., 2001. *Characterization of Technology Roadmaps: Purpose and Format*. Proceedings of the PICMET‟97, Portland.

Phaal, R. e Muller, G., 2009. *An architectural framework for roadmapping: towards visual strategy*. Technological Forecasting & Social Change 76, 39-49.

Phaal, R., Farrukh, C.J.P. e Probert, D.R., 2004. *A framework for supporting the management of technological knowledge*. International Journal of Technology Management 27, 1-15.

Phaal, R., Farrukh, C.J.P. e Probert, D.R., 2001. *A framework for supporting the management of technological innovation*. Proceedings of ECIS Conference, The Future of Innovation Studies, 20-23 September, Eindhoven.

Rothwell, R., Dodgson, M., 1994. *Innovation and size of firm*. In: Dodgson, M. (Eds.), Handbook of Industrial Innovation. Edward Elgar Publishing Limited. Aldershot, 310-324.

Rothwell, R., 1991. *External networking and innovation in small and medium-sized manufacturing firms in Europe*. Technovation 11 (2), 93-112.

Sanchez, R., Heene, A., Thomas, H., 1996. *Dynamics of competence-based Competition: Theory and Practice in the New Strategic Management*. Oxford, New York.

Savioz, P., 2004. Technology intelligence: Concept Design and Implementation in Technology-based SMEs. Palgrave

Tidd, J., Bressant, J., Pavitt, K., 2001. *Managing innovation. Integrating technological*. Market and Organizational Change, John Wiley & Sons, New York.
Van de Vrande, V., de Jong, J.P.J., Vanhaverbeke, W., de Rochemont, M., 2009. *Open Innovation in SMEs: trends, motives and management challenges*. Technovation 29, 423-437.
Van de Vrande, V., Lemmens, C., Vanhaverbeke, W., 2006. *Choosing governance modes for external technology sourcing*. R&D Management 36, 347-363.