CHAPTER 1

AN EXPLORATORY ANALYSIS OF TSS FIRMS: INSIGHTS FROM THE ITALIAN NANOTECH INDUSTRY

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Private service firms have largely diffused in the last years as external sources of technology that are accessed by innovative companies for supporting their innovation process. This paper in particular focuses on Technical and Scientific Service (TSS) firms that basically sell technical and scientific knowledge. Examples of TSS are contract Research and Development, laboratory testing, technology consulting and product development. The purpose is to offer a preliminary insight into the business models adopted by TSS firms and analyze the resulting strategic, managerial and organizational choices. This investigation is based upon the results of an empirical study on Italian nanotech companies.

1. Introduction

In the last years, technological innovation has become increasingly complex and expensive, whereas markets have turned out to be dramatically fast-changing. For innovating successfully, firms need a wide set of competencies and resources they can hardly develop by themselves. As a result, they have been increasingly relying on other companies, universities, research institutes, start ups, with the aim of creating "networks" of relationships through which knowledge and technological assets are exchanged (Amidon Rogers, 1996). Among the possible actors of these "creation nets" (Brown and Hagel III, 2006), private service firms have largely diffused. These companies develop

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and sell technology-intensive services to clients that use them for improving their innovation process. Examples of these Technical and Scientific Services (or TSS) are: (i) product design, engineering, testing, rapid and virtual prototyping; (ii) Contract Research & Development (CRO); (iii) software instruments supporting the R&D process; (iv) technological consulting, brokering and training. The market for TSS is rapidly growing and offers great opportunities for the future (Arora *et al.*, 2001; Howells, 1999). Literature on TSS has addressed the following major issues: the form of the relationships between the TSS organization and its clients, e.g. R&D contracts (Haour, 1992), partnering (Bruce *et al.*, 1995; Millson *et al.*, 1996); the role of TSS firms as partners in technological collaborations (Chatterji and Manuel, 1993; Chesbrough and Teece, 1996); the role that TSS play in different phases of the innovation process (Bruce *et al.*, 1995; Millson *et al.*, 1996; Turpin and Garret, 1996); the impact of TSS on national or local economies (Windrum and Tomlinson, 1999; Mansfield and Lee, 1996). What is almost totally missing is the attempt to study the phenomenon from the perspective of the company that develops and sells the TSS, in order to understand the peculiar strategic, organizational and managerial problems it is called to face. In order to make a step further in this direction, this paper focuses on a specific cluster of TSS companies (i.e., those operating in the nanotechnology industry), with the purpose of describing the business models they apply. Many authors have provided definitions for the term "business model" (e.g., Chesbrough and Rosenbloom, 2002), although a largely accepted one has not emerged yet (Shafer *et al.*, 2005); here we define "business model" as the set of answers to the following questions: What does the company offer to its customers? How is that offer conveyed to them? Specifically, how does the TSS firm structure its marketing approach and manage the interaction with its clients? The choice of the nanotechnology industry as the scope of the investigation was suggested by the growing attention paid, in the last seven to eight years, to nanotechnology, both in academic and industrial environments. The expectations that have surrounded nanotechnology are witnessed by the growth of public funds devoted to research into the field; in 2004 they raised the amount of

4.6 billion US Dollars worldwide, with an increase of about 700% with respect to 1997 (www.luxresearchinc.com, 2004). However, the novelty of the nanotech market and the pervasiveness of the underlying technology, together with a lack of common definitions, make it very difficult to clearly distinguish between nanotech and non-nanotech firms. This is why it was necessary to develop an empirical framework that would serve as an instrument for identifying the players of the nanotech market and supporting the investigation of their business models.

2. Research Objectives and Methodology

The first objective of this paper is to develop an empirical framework that clearly defines the boundaries of the nanotech market and help identify its players. All the Italian companies (together with the most important European ones) that are currently labeled by scholars and practitioners as "nanotech", were extensively surveyed. They were interviewed in order to understand the nanotechnology domain(s) and the applications they have developed or applied. This investigation suggested the basic classification criteria to be used for clustering nanotech companies; they represent the dimensions of the empirical framework. Moreover, the empirical analysis served the purpose of identifying those Italian nanotech companies that actually offer technology-intensive services (TSS firms) to be studied in the second step of the research. The second objective of the paper is to offer preliminary insights into the business models of nanotech TSS companies. To this aim, a multiple case study on five Italian nanotech TSS firms was undertaken. The selected companies were homogeneously distributed in the empirical framework, so that a certain degree of theoretical replication is allowed.

3. A Framework for Nanotechnology Firms Classification

The objective of this section is to illustrate the classification framework that can be used for bringing order into the "world" of nanotech applications; it has been elaborated on the basis of the information

collected through the semi-structured interviews with the Italian nanotech firms and some non-Italian ones, and the available public and private documents and reports. It was finally tested through a panel study that involved experts in nanotechnologies. A list of the studied companies is reported in Table 1.

Table 1. List of studied companies.

Italian Firms	**Non-Italian Firms**	
A.P.E. Research	Ntera Ltd	Bayer AG
Crf	Carbo Microelectronics Corp.	Sony Corporation
Csm	Mitsui & Co. Ltd	Motorola Inc
Geal	DuPont	DSM
Kedrion	Xerox Corporation Ltd	Basf
Microcoat	Intel Corporation	Toshiba Corporation
Moma	Elan Corporation	Toyota Motor Corporation
Olivetti I-jet	Aveka Group	ABB Group
Organic Spintronics	Lucent Technologies	ExxonMobil Corporation
Prometon	BAE Systems	Canon Inc
Saes Getters	Fujitsu Group	General Motor
Siad	Infineon Technologies AG	Agfa-Gevaert N.V.
Sorin Biomedica Cardio	NEC Corporation	Schering AG

The analysis has shown the possibility to classify nanotech companies on three levels, connected in a hierarchical structure. At the **first level**, nanotech firms are classified into "**nanotechnology categories**", i.e. the macro-areas through which a company can access the market for nanotech applications. Each category aggregates applications that are homogeneous in terms of the type of use they are destined to. Obviously, it is possible for a firm to access contemporarily more than a single macro-area (e.g., IBM, NEC, General Electric, and Intel). There are four main categories at this level:

1. Nanomaterials. The properties of a solid material depend upon its microstructure, i.e. the atomic structure, the shape and dimension of the material itself in one, two or three dimensions. Conventional materials have grains with a dimension that can vary between a few

microns and a few millimeters, while the nanostructured materials are made of grains with dimensions of 1-100 nanometers. The simple material has a structure that is repeated homogeneously along one, two or three axis (characteristic that a nanomaterial may not have), and therefore shows homogeneous features in terms of chemical, physical and mechanical properties. This dramatically limits the possible applications of a traditional material, with respect to a nanostructured one.

2. Nanostructures. These complex systems are composed of different parts (inorganic or organic) assembled together; at least one of them has dimensions of 1-100 nanometers, and they are typically made of nanostructured materials. They are assembled and made interacting in order to create structures with macro-dimensions. They normally show innovative chemical, electrical, mechanical and optical properties and are capable of autonomously functioning.
3. Nanotools. This nanotechnology category contains: (i) instruments capable of operating with an atomic precision in order to manipulate and measure materials on a nanometric scale; and, (ii) interface software that are capable of 3D modeling materials at the atomic scale and of conducting very accurate simulations on the behavior of nanomaterials and nanostructures.
4. Nanoprocesses. Within this category are mainly included synthesis methods for obtaining nanomaterials and nanostructures.

At the **second level**, categories are divided into "**nanotechnology sub-categories**", each aggregating nanotech applications homogeneous in terms of the scientific or technological domain they belong to. Finally, the **third level** of the model includes the "**nanotechnology applications**" that are available on the market or are actually being developed. For instance, major nanotech applications in the sub-category of "nanotubes" are field emission displays, optic biosensors, nanoneedles, nanotubes antennas, probes for scanning tunneling microscopes, electron guns.

The nanotechnology categories and the sub-categories they are composed of are represented in Figures 1, 2, 3, 4.

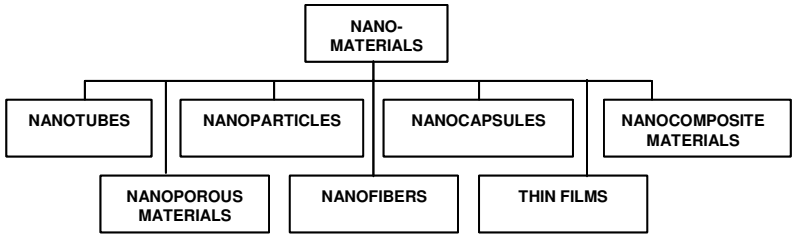

Figure 1. The articulation of "nanomaterials" category into sub-categories.

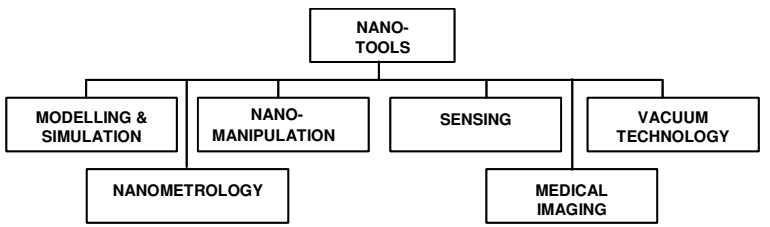

Figure 2. The articulation of "nanotools" category into sub-categories.

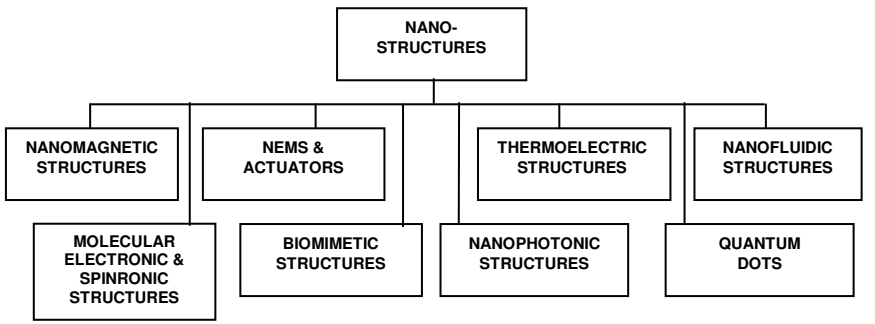

Figure 3. The articulation of "nanostructures" category into sub-categories.

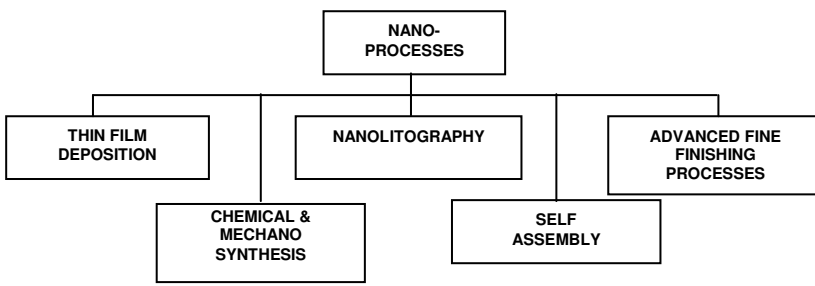

Figure 4. The articulation of "nanoprocesses" category into sub-categories.

This framework has been tested through a panel study involving experts in physics and, especially, nanotechnologies, and the analysis has confirmed its completeness. Therefore it is possible to state that the model has a general validity and can be effectively used for classifying every type of nanotech firm. Moreover, it can be applied for supporting macroeconomic investigations into nanotech markets that represent a fundamental starting point for the definition of public funding projects or other types of governmental initiatives. Similarly, it represents an important basis for technology forecasting activities that have a great relevance because of the novelty of the nanotech environment. The generality of the framework makes it possible to apply it as a reference model for discriminating between nanotech and non-nanotech companies. We label as "nanotech" a company that develops, sells or incorporates in its production processes one or more nanotech applications that can be included at least in one of the sub-categories encompassed by the model.

4. Emerging Business Models among Nanotech TSS Companies

Companies listed in Table 1 adopted two different types of business models: (i) the "**A-type**" business model, i.e. the one pursued by those nanotech companies offering a service (a process, a tool, an intermediate finding that needs to be further developed and included into an innovative product) through which their scientific competencies in a particular nanotechnology category(ies) are transferred to the client firm, and (ii) the "**B-type**" business model, i.e. the one adopted by those nanotech companies internally developing, acquiring or licensing in from other companies nanotechnological processes, tools, or intermediate findings to be used for innovating their processes or products.

Companies belonging to the first group can be labeled as TSS firms. The aim of this section of the paper is to study the cases of five of these firms in order to analyze in greater detail the business model they apply. This will give the opportunity to point out the major characteristics of the business models of TSS firms operating in different nanotechnology categories, and enlighten the managerial and organizational choices the five considered firms have made. The five companies that have been

analyzed in this way are: Saes Getters, Pometon, A.P.E. Research, Olivetti I-jet, Sorin Biomedica Cardio.

4.1. *The empirical results*

Table 2 shows the classification of the five analyzed TSS companies in the framework presented in Section 3.

Table 2. The framework classification of studied companies.

	Nanotechnology Category	Nanotechnology Sub-category	Applications
Saes Getters	Nanoprocesses	Thin film deposition	Sputtering
	Nanomaterials	Thin film	Absorbers
Pometon	Nanomaterials	Nanoparticles	Nanopowders
A.P.E. Research	Nanotools	Nanomanipulation	Scanning probe microscope
		Modelling & simulation	Software for real time imaging
Olivetti I-jet	Nanostructures	MEMS & actuators	Ink jet technology
	Nanoprocesses	Thin film deposition	Sputtering
Sorin Biomedica Cardio	Nanostructures	Biomimetic structures	Implantable devices

If the activities undertaken by the companies are carefully considered, it clearly emerges that the business models of three companies (Saes Getters, Pometon and A.P.E. Research) are wholly focused on the sale of TSS ("A-type" nanotech companies). On the other hand, Olivetti I-jet and Sorin Biomedica Cardio are mainly "B-type" nanotech firms that expanded their business model in order to include, even if as a marginal activity, the development and sale of TSS.

The empirical evidence on nanotech companies adopting an "A-type" business model, i.e. developing and selling, at least as a marginal part of their activities, TSS, suggests the possibility of classifying them into three main categories:

A1. Nanotech TSS firms developing intermediate findings (e.g., nanopowders or nanotubes) to be sold, licensed out or partnered with the client company, that carries out the remaining tasks of the development process and includes them into its innovative products. This type of TSS can be labeled as "Work In Progress (WIP)

Innovation", and is typical of firms operating in the nanotechnology category called "nanomaterials". An example of this type of nanotech TSS firm is Pometon.

A2. Nanotech TSS companies carrying out, for the client firm, a particular process (e.g., magnetic abrasive finishing or thin film deposition) that requires excellent competencies in a specific scientific domain. It is possible to call this kind of TSS "Process Activity", which is common among firms operating in the "nanoprocesses" category. Examples of firms offering this kind of service are Saes Getters, Olivetti I-jet and Sorin Biomedica Cardio.

A3. Nanotech TSS firms developing and selling instrumentation operating at the nanoscale (e.g., machinery for nanolithography, Scanning Probe Microscopes or software for real-time imaging) that is used by the client firm for supporting its innovation processes (typically, its basic and applied research activities). This type of TSS can be referred to as "Technologies to develop technology" and is offered mainly by firms operating in the nanotechnology category called "nanotools" (e.g., A.P.E. Research).

Olivetti I-jet and Sorin Biomedica Cardio possess exclusive competencies in nanostructures. However, these skills are not exploited in order to offer a TSS, but to innovate their products. The TSS sales activity of these companies leverages competencies in the "nanoprocesses" category. The emerged empirical evidence stands therefore for a lower diffusion of nanotech TSS firms working in nanostructures.

The managerial and organizational decisions of the studied companies are summarized in Table 3.

First, it is possible to point out that all companies adopt a structured marketing approach, based upon a direct contact with clients, the participation at professional fairs and the use of the Web site as a window on the firm's projects and services. The only case of non-structured marketing approach is that of Sorin Biomedica Cardio, but it can be explained taking into consideration that the adoption of an "A-type" business model by this firm is still at an embryonic stage. In fact, the interviewees have recognized the importance of developing a

Table 3. Schematic description of the analyzed business model's variables.

	Marketing Approach	Degree of Standardization	Commercial Relationship Management Model	Phase(s) of Interaction
Saes Getters	• Structured; • Direct approach; Professional fairs; Web site	Customized output	• Structured; • Checkpoints; Regular meetings; Reference person	R&D
Pometon	• Structured; • Direct approach; Professional fairs; Web site	Mainly standardized output	•Not structured; • Reference person	Service delivery
A.P.E. Research	• Structured; • Direct approach; Professional fairs; Web site	Highly customized output	• Structured; • Checkpoints; Regular meetings; Reference person	R&D; Service delivery
Olivetti I-jet	• Structured; • Direct approach; Professional fairs; Web site	Customized output	• Very structured; • Checkpoints with reports; Regular meetings; Reference person; Co-development teams	R&D; Service delivery
Sorin Biomedica Cardio	• Not structured; • Professional fairs	Standardized output	•Not structured; • Reference person	Service delivery

structured marketing approach for the future. The contact of new potential clients seems therefore to be a critical aspect for the analyzed firms, and this is a typical attribute of TSS companies (Chiesa *et al.*, 2004).

Considering the other three perspectives from which the five companies have been analyzed, two alternative models seem to be applied by Italian nanotech TSS firms in the management of the service sale. First, the offering of a **standardized output** through a non-structured commercial relationship management model in which the interaction with the client company is merely limited to the phase of service delivery and, second, the offering of a **customized output** which, on the other hand, requires an intense interaction since the early stages of the service development and a sort of co-design with the client company. This second case entails a greater complexity in the management of commercial relationships that have also a longer duration. All the companies offering a customized output, indeed, have to implement formal and structured approaches consisting in: (i) the definition of

checkpoints with the client where it is informed, through different types of reports, about the project advancement; (ii) the establishment of regular meetings with the client; and, (iii) the identification of internal and client's reference persons in charge of managing the commercial relationships.

The empirical evidence has therefore allowed classifying the business models of TSS players operating in nanotechnology into six different typologies. They are summarized in Table 4.

Table 4. The taxonomy of nanotech TSS companies' business models.

		Degree of Standardization	
		Standardized output	Customized output
Type of Output	WIP innovation (A1)		
	Process activity (A2)		
	Technologies to develop technology (A3)		

This matrix seems to be a viable instrument for further analyzing nanotech TSS companies from a managerial perspective. Of course, some of the quadrants of the matrix will be less likely populated than others. For example, a firm adopting an "A1-type" business model is expected to offer a standardized output while a firm adopting an "A2-type" or an "A3-type" business model is likely to offer an output characterized by a high degree of customization. This is reasonable considering that in the latter cases the type of output provided has to be strictly modified to function with the client's needs and requirements.

5. Conclusions

In the last seven to eight years, interest in nanotechnology has steadily grown, both in academic and industrial environments, and it has proved to be an emerging and rapidly-growing field for the diffusion of TSS. The paper offered a preliminary insight into the business models adopted by TSS firms operating in nanotechnology. First, an empirical framework that is useful for identifying the players of the nanotech market and supporting the investigation of the business models they apply was developed. The analysis of the companies studied in order to

create the aforementioned framework made it possible to identify two basic types of business model: (i) the sale of a Technical and Scientific Service (TSS) that supports the innovation process of the client company ("A-type" business model), and (ii) the use of nanotechnologies, internally developed or externally acquired, for innovating the offered products, processes or services ("B-type" business model). The second part of the paper focused exclusively on Italian nanotech TSS companies, i.e. those adopting an "A-type" business model. It reported the results of the multiple case study conducted on five of the previously identified nanotech TSS firms, and provided an insight into the managerial and organizational choices related to their business models. Finally, a taxonomy matrix of nanotech TSS companies' business models was developed. It can support further analyses of nanotech TSS firms from a managerial perspective. The research described here had an exploratory dimension as well. It has suggested some possible directions for deepening the knowledge of the business models adopted by nanotech TSS players. Further aspects that could be investigated are: (i) the organizational structures, i.e. the way the nanotech TSS company organizes its resources (mainly human) in order to develop and provide the services; (ii) the mechanisms implemented to protect the nanotech TSS company's intellectual capital; (iii) the applied managerial techniques, like the performance evaluation and reward systems, or the management control system; and (iv) the technical and scientific service's pricing model, that would require to identify the methodologies used to evaluate the intangible assets and the R&D activities of the company.

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