



Nina Granqvist

NANOTECHNOLOGY AND NANOLABELING  
– ESSAYS ON THE EMERGENCE OF NEW  
TECHNOLOGICAL FIELDS

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HELSINKI SCHOOL OF ECONOMICS

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## ABSTRACT

The aim of this doctoral research is to explore the individual and organizational level activities that lead to the emergence of new technological fields mainly from the institutional entrepreneurship perspective. These issues are addressed from four differing viewpoints in the essays that form the main body of the research output. Essay I investigates the initial shaping of the boundaries of a field through framing of meaning and mobilization of resources by institutional entrepreneurs, bringing together the institutional entrepreneurship and social movements literatures. Essay II develops the institutional entrepreneurship approach by investigating empirically how actors, drawing from their formal status and relational embeddedness, bridge cognitive, organizational and spatial gaps present in embryonic fields. Essay III addresses the role of institutional entrepreneurs as the translators of globally disseminating discourses into a suitable form to a local institutional context, and deepens the micro level understandings of the cross-scalar processes in field emergence. Essay IV draws on the literatures of organizational forms and image and identity to study the strategies of business managers to become associated with novel fields and to gain access to the resources offered by them, as well as the outcomes of such activity for the emergence of new organizational forms. The principal technological field which is the focus of the research is that of nanotechnology. Essays I and IV focus solely on the context of nanotechnology, whereas Essays II and III draw on a comparative case study of nanotechnology and functional foods, where the processes of emergence are contrasted across the two fields in different stages of emergence.

Previously, a multitude of studies in the new institutional theory have investigated agency in the emergence of novel fields from different perspectives. However, this research identifies three important gaps in this literature, and contributes to creating new knowledge in these areas. Firstly, incorporating agency in the new institutional tradition also generates novel connections to other literatures, a link which remains largely unexplored. The current research complements the institutional entrepreneurship literature by drawing on social movements, relational approaches, socio-economic approaches to technology, institutionalization of discourses, and literature on identity and image. These provide important contributions to extend the understandings of agency in the institutionalist approaches. Secondly, the theory on skills, roles, activities and positions of institutional entrepreneurs as enablers and mediators of various processes of institutional emergence is still under development. The multidisciplinary approach, comparative case studies and extensive empirical data reported in the essays contribute to further strengthen the theory on institutional agency in the emergence of new fields. Drawing from this, the research develops a model of the capacity to act of an institutional entrepreneur. Finally, the entire literature on the institutionalization of discourses is still inconclusive, especially in terms of the empirical evidence on how various discursive processes contribute to field emergence. The empirical case of nanotechnology provides a unique research context, and is especially powerful in casting light on various processes through which discourses, and opportunistic agents tapping on them, sediment the emerging fields.

**Keywords:** institutional entrepreneurship, field emergence, nanotechnology



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Retrospectively, writing a PhD thesis has been a wonderful example of emergence, the principal phenomenon this study investigates. This particular emergence had its origins in a decision of doing a PhD in 2002. The ideas that I held at the time about the process were very distant from the unfolding reality, as were my original conceptions on the focus of my research. The process was characterized by recurrent cycles of confusion and frustration, then illumination and accomplishment. Yet, retrospectively all the trouble makes a great deal of sense – all was as it should have been, and these were the ups and downs that formed part of this particular flow of events. What a beautiful journey during which I had a privilege to meet, work with and befriend many great individuals!

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Helsinki, October 2007

*Nina Granqvist*

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# **PART I**





# 1 INTRODUCTION

## 1.1 Background

This doctoral research is driven by the quest to understand the micro-level processes which set in motion and contribute to the emergence of new industries. An industry, according to Scott (2001: 83), refers to “a population of organizations operating in the same domain as indicated by the similarity of their services or products”. The notion of field extends beyond such a population to include also other organizations that critically influence their performance (Scott, 2001). The latter part of the 20<sup>th</sup> century is marked by the rise of various fields and industries, both science and technology driven. Common examples of these are information and communication technology, biotechnology, and most recently, nanotechnology. There is a wide body of literature investigating the evolutionary and institutional dynamics of industry development from a macro perspective (e.g. Abernathy & Utterback, 1978; Hannan & Freeman, 1989; Anderson & Tushman, 1990; Strang & Meyer, 1993; Scott, 2003; Morrill, 2007). However, arguably the origins of each domain of activity can be traced back to the actions of a few individuals in a few organizations. Due to their focus, ecological and institutional studies have not been able to grasp the micro-level processes that contribute to their very emergence. Despite the crucial role these processes play in the emergence of new and in the renewal of existing markets, they have received altogether far less academic attention than the dynamics of established industries.

In addition to science and technology driven domains, the past century is also characterized by the surfacing of many social issue driven fields. These include movements such as environmentalism, civil and human rights, consumer awareness, and anti-war campaigns. A closer look into the spread and mobilization of ideas in both types of domains of activity reveal that their early emergence is largely driven by same types of processes. What especially characterizes technological emergence of the late 20th century are the strong movements and *hypes* that surround them. Such hypes have significantly contributed to field formation by increasing awareness and legitimacy, and mobilizing actors to jump on the

bandwagon. From the point of view of the current study, hypes may be conceptualized as a process of strong institutionalization of mutually supportive macro-cultural discourses (Berger & Luckmann, 1966; Lawrence & Phillips, 2004), which amplifies the activity within an emerging field, and gives rise to action and adoption, resulting in a further institutionalization of the technology or issue in question. Such movements are often driven by knowledgeable individuals, who aim to create coalitions around the issues they promote by employing various discursive and political strategies. Consequently, technology emergence is a result of the interaction of various agents, such as researchers, public policy makers, technology and management consultancies, i.e. technology and policy ‘evangelists’, who promote the positive discourse around the technology and participate in the institution building activities. These processes of technology emergence make them very similar to social movements.

However, the presence of strong discourses is a sign of a relatively high level of institutionalization of a field, and a multitude of processes contributing to emergence precede such institutionalization. During recent years, researchers within the new institutionalist tradition have begun to grant increasing attention to the role of individual and organizational agency in the birth of new fields, the institutional entrepreneurship approach providing an outlet for this research. According to Lawrence and Phillips (2004: 690), “understanding how institutional fields emerge is an important next step in the development of institutional theory”. Indeed, all activity in society is dependent on its individual members, who are embedded in their social, organizational and institutional contexts. Changes in their actions and the collective adoption of these changed behaviors, turning them into more widely disseminating practices, form the roots of any institutional level changes. For this reason, developing approaches that cast light on the early emergence processes is crucial for creating further understanding on how new fields come into being.

While there have been other studies that have investigated the micro-level activity, the current research identifies gaps in this literature and develops these views further. Firstly, incorporating agency in the new institutional theory generates novel connections to other literatures. These links still largely remain unexplored. Secondly, the theory on the skills, roles, activities and positions of institutional entrepreneurs as enablers and mediators of various processes of institutional emergence is still under development. Finally, the entire

literature investigating the role of hypes and discourses in the emergence of novel fields is still incomplete and calls for further empirical studies. Consequently, the aim of this doctoral research is to investigate the micro-level dynamics of the early stages of field emergence by focusing on the role institutional entrepreneurs, i.e. entrepreneurial individuals and organizations, play in the process. Hence, this doctoral research contributes to the new institutionalist approaches of field emergence. To widen the understandings of agency in this context, the research draws on a multitude of literatures, which include institutional entrepreneurship, social movements, discourses and institutionalization, and spatial scales. A socio-economic approach to technology emergence is also included as the means to extend the 'black-boxed' views present in the institutionalist approaches to technology (Munir, 2004) so as to build further understanding on the emergence of, particularly, science-based and technological fields.

While the research focuses on investigating the role of entrepreneurial individuals and organizations, it portrays these actors as the initial identifiers and mobilizers of ideas which may, or may not, become adopted by a collective of actors. When an idea becomes collectively adopted, it evolves out of the control of any single individual or organization and a multitude of interpretations come about. Thus, the research aims not to parade the actions of "heroic lone riders". Rather, it aims to investigate how certain individuals and groups of individuals have contributed to the creation of a novel concept; have bridged across various relational and institutional gaps for local emergence of a field; crafted a local interpretation of a globally shared issue; or opportunistically exploited emerging labels for the benefit of their businesses. These issues are discussed respectively in the four essays that form the main body of this research. Indeed, according to Meyer and Rowan (1977: 345), "the building blocks for organizations come to be littered around the societal landscape; it takes only a little entrepreneurial energy to assemble them into a structure". From the perspective of this research, institutional entrepreneurs are such individuals and organizations who are capable of identifying these potential building blocks and begin to disseminate them, driven by an opportunity or an intrinsic motivation. However, it is together with others that they construct these building blocks into a novel structure, be it an ideology, practice, technology, or issue, which may, or more typically, may not, form an embryo of a novel field. Furthermore, while there is a myriad of issues, ideas and technologies with potential to initiate a novel field, and there are many people who grab

those ideas and turn them into issues, only very few individuals or organizations come to do it successfully on a very few ideas. The research argues that this depends on the capacity to act of an institutional entrepreneur, and thus, develops a model, which presents the different components of this capacity.

The research provides important contributions to the above identified research issues in the context of an especially interesting and potentially very influential emerging field, that of nanotechnology. Despite all the excitement regarding its enormous potential, nanotechnology still largely remains developed in basic and applied research, though some early business activity has emerged. The very emergence of the concept or category of nanotechnology has been a cultural and political process. Scientific developments combined with the agency of certain key individuals (who, interestingly, during the early emergence represent as much popular culture as science and policy) in creating and promoting the concept have resulted in the surfacing of a novel domain of activity, where the smallest common denominator for the actors is the very concept of 'nanotechnology'. Nanotechnology holds broad understandings of what kind of activities are included in the field, and similar definitions are not necessarily shared across a variety of communities involved. Around 2000, nanotechnology was acknowledged at the highest governmental levels and it was made a focus area of research almost simultaneously in the EU, US and Japan. This gave rise to an 'armaments race' in the public investments in nanotechnology, which resulted in a surge of funding and a massive hype around the concept, mostly orchestrated by various intermediating bodies such as venture capitalists and business research organizations, but also by researchers themselves.

In order to investigate the role of individual and organizational agency in the emergence of the nanotechnology field, some conceptual and methodological choices were necessary. Firstly, although contributing mostly to the new institutionalist theory, and especially to the institutional entrepreneurship approach, I have acknowledged the requirement for a somewhat multi-paradigmatic approach to study the topic. According to Lewis and Grimes (1999: 672), "multiparadigm approaches aid exploration of particularly complex and paradoxical phenomena by helping theorists employ disparate theoretical perspectives". Paradigmatic boundaries are often fuzzy and to a certain extent permeable (Willmott, 1993; Lewis & Grimes, 1999). This research, including the essays, draws mainly from approaches

that are compatible with ‘subjectivist’ (Burrell & Morgan, 1979) paradigms in their orientation, and all of them have aspects that are compatible with the new institutional theory. An effort was made to explore and illustrate the connections between different literatures that are applicable for investigating field emergence. Application of such meta-triangulation (Gioia & Pitre, 1990) helped to uncover the processes contributing to field emergence, and was necessary to address such a complex, multi-level phenomenon.

Secondly, this research draws on data and investigator triangulation (Denzin, 1978). The data on nanotechnology are complemented and compared with the data on functional foods collected by a colleague, Tiina Ritvala. Comparative data on two emerging fields at differing stages of development and logics of action helped to critically examine the emergence processes in each case. In addition, such an approach contributed to identifying their field specific and other, potentially more generalizable, features. Hence, contrasting nanotechnology with functional foods also helped to reveal the issues that are unique and interesting in the nanotechnology case, and vice versa. The comparison of the emergence of two institutional fields was an extremely challenging task and required such a contested approach between different views and interpretations. A ‘stereo view’ was helpful in conceptual and empirical work also with my other co-author, Professor Juha Laurila.

Thirdly, a multi-level approach (Rousseau, 1985; Klein et al., 1994) is adopted in the current research. According to Scott (2001: 196), for investigations of various institutional processes “the most informative studies are those that identify and trace the effects of salient and influential processes across two or more levels”. In studies with multiple levels of analysis an essential question is the level of theory that the study aims to depict and explain, and also to which the generalizations are made (Klein et al., 1994). As already discussed, the research aims to contribute to the understanding of field (macro) level emergence of nanotechnology, but to do this it is necessary to investigate the individual (micro) and organizational (meso) level processes that contribute to this emergence. However, it is acknowledged that distinguishing between different levels of action may be very difficult and even irrelevant, particularly because individual and organizational action tends to be intertwined.

This brief introduction outlined the background, aims and context of the study. In the remainder of this chapter I present firstly, the fundamental concepts for the research, and secondly, the structure of the entire PhD thesis, consisting of two parts.

## 1.2 Some fundamental concepts in field emergence

When investigating field emergence, it becomes important to understand and make visible the basic assumptions of how a new domain of social action may emerge. In this research, there is a particular focus on how focal actors shape their environment, and how that results in the emergence of a field. Consequently, in this section I discuss some views on *agency* and *structures* and how they generate the possibility for something new to emerge. I also define the concepts of *field* and *technological field*, and discuss their relationship to the notions of *industry* and *form* which are widely referred to in the relevant literature. Although the main concept that I employ is field all through the research, also form and industry are used to signal the level of analysis, or the original wording used by an author.

### 1.2.1 Agency and structures

One of the main underlying questions of this research is *to what extent are the individuals and organizations constrained by their environments, and how much room for action they have to change that environment?* Here a researcher can move on an axiom, where pure voluntarism is at one end and structural determinism at the other. Voluntarism refers to “the doctrine that will is the basic factor, both in the universe and in human conduct” (Durant, 1926: 401). However, an argument presented by many authors is that all actors and activity are embedded in the social context or structures, where an actor and action are situated (Giddens, 1984; Granovetter, 1985; Bourdieu, 1990; Garud & Karnoe, 2003; Leca & Naccache, 2006). This dramatically restricts the employment of free will. According to these views, individuals are bound to their environment through many ties, and the availability of choices that they see and perceive possible is inherently a consequence of their social contexts. On the other hand, Giddens (1976: 96) in his critique of Parsons’ later work (especially Parsons, 1951) argues that in a wholly deterministic system “there is no room [...] for the creative capacity of the subject on the level of the actor, so there is a major source of difficulty in explaining

the origins of institutionalized value-standards themselves”. As a response to the failing of functionalism and structuralism in addressing the constitution of social life as the production of active subjects, Giddens presents the notion of structuration. With structuration he means that “social structures are both constituted *by* human agency, and yet at the same time are the very *medium* of that constitution” (Giddens, 1976: 121 - see also Section 4.5 of Part I). Such a dialectical view provides some reconciliation between action and structures, and deterministic and voluntaristic approaches by stressing the role of knowledgeable subjects in changing and constructing their environments.

Also Bourdieu and Wacquant (1992: 107) regard individuals as agents, who are “socially constituted as active and acting in the field under consideration by the fact that they possess the necessary properties to be effective, to produce effects”. Bourdieu’s (1990) notions of habitus and field give implications on how such actions and constitutions may be organized in the society. Habitus, according to Mutch et al. (2006: 617), refers to “a set of durable dispositions to act that are transposable across contexts”. Such dispositions can be considered parallel to the outcomes of the structuration in the Giddensian sense, though such statement risks overly simplifying the assumptions of these fairly complex theories on social action and structures<sup>1</sup>. Despite habitus being a representation of “identical histories”, imposed by “the practices of the members of the same group or [...] the same class” (Bourdieu, 1990: 59), the difference between individual habitus originates from the “singularity of [individuals’] social trajectories, to which there correspond a series of chronologically ordered determinations that are mutually irreducible to one another” (Bourdieu, 1990: 60). In other words, each individual has their singular past experiences and contexts that determine their possibilities to act. Such differences in the individual trajectories can be argued as the drivers of lowest level, and most fundamental, parameters of change in any institutionalized system.

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1 It is acknowledged that Giddens is constructionist in his perspectives on agency and structures (Blaikie 2003), whereas the views of Bourdieu have been characterized to be “compatible with a broadly realist ontology” (Mutch et al. 2006: 610).



## 1.2.2 Organizational and technological fields

Bourdieu (1984) has addressed field as a setting in which agents and their social positions become materialized as a result of interaction between the specific rules of the field agent's habitus, and the agent's social, economic and cultural capital. Bourdieu's (1984) notion of the field, however, refers to a social arena which is impregnated by the battles of agents in struggling to access social resources, rather than to an organizational field with shared meanings, identities and activities. This research draws from and contributes to the latter understandings of fields, but acknowledges the value of Bourdieu's notion of field in understanding their dynamics. Consequently, the research adopts the new institutionalist approach to fields, which is elaborated below. This choice is also in harmony with the literature and gaps in knowledge addressed in the research.

According to DiMaggio and Powell (1983: 143), organization field is formed by "those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products". For example, the field of nanotechnology consists of governmental level actors in funding and regulation, researchers in public and private institutions, and business actors. Further, according to Scott (1994: 207-208; 2001: 84), "the notion of field connotes the existence of a community of organizations that partakes of a common meaning system and whose participants interact more faithfully with one another than with the actors outside of the field". It may be argued that each organization belongs to more than one field. The larger the organization and more multiplex the tasks in which it engages, the more likely it is to be associated in a multitude of fields. Regulatory organizations are but one case in point here. Similarly, in the case of nanotechnology, involved organizations engage in their respective industries, and in addition to that are associated with nanotechnology. This refers to nanotechnology as being too young and not yet established and definite enough as a field, to function as the only reference base for most of the organizations that are associated with nanotechnology<sup>2</sup>. Hence, rather than the requirement for the participants of the field to interact more faithfully with the members of the field than with the outsiders, like Scott suggests, I argue

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<sup>2</sup> The nature of nanotechnology as a domain of action will be discussed in more detail in Section 3.

that it is enough that they interact regularly and act as a point of reference to each other in the issues that are related to the field. Finally, in technological fields the focus of organizational activity is on a shared set of technologies or technological visions. Consequently, the definition of a technological field employed in this research is as follows:

*Technological field refers to those organizations that, in the aggregate, are engaged in development, use, regulation or exploitation of a technology or set of technologies, share a common meaning system, and are in regular interaction with one another.*

### **1.2.3 Organizational form**

Scott (2001) defines organizational form as a subcategory for an organizational field. Hence, an organizational field may consist of many organizational forms, and the institutional construction takes place on the organizational population i.e. form level. The result of this is that by being a part of an organizational form (for example by being a nanotechnology company), an organization also forms part of an organizational field (the field of nanotechnology). The emergence of a subcategory also induces the emergence of a field. In a similar vein, the emergence of other subpopulations in the field, or emergence of more general field level resources (such as public funding to nanotechnology, or demand for a nanotechnology label) also induce the emergence of novel forms. For example, the emergence of nanoscience induces the emergence of nanobusiness, and their respective development contributes to the emergence of the field of nanotechnology. The concept of form in its subpopulation meaning is used extensively in Essay I.

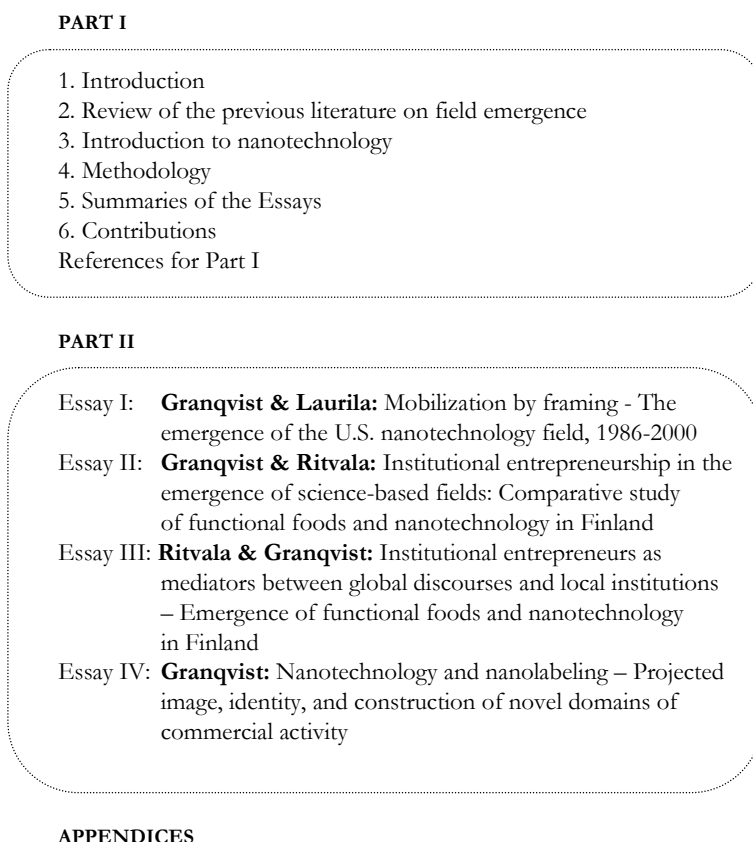
### **1.2.4 Industry**

An industry, according to Scott (2001: 83), refers to “a population of organizations operating in the same domain as indicated by the similarity of their services or products”. As discussed above, the notion of field extends beyond such population to other organizations that critically influence their performance (Scott, 2001). Nanotechnology is a field rather than an industry, because the products and services of nanotechnology are very different from each other, and there is no specific market, where ‘nanotechnology products or services’ would compete with one another. For the current research, nanotechnology is

conceptualized as a field of activity, where a variety of organizations from different industries engage in. The smallest common denominator for these organizations covering a broad set of industries is the concept of nanotechnology. It remains to be seen whether nanotechnology will become a focal domain of activity for more organizations so that it could attain the status of industry.

### 1.3 Structure of the research

The research is reported in two parts: Part I gives an overview of the research and Part II presents the essays in their entirety. The structure of the research is exhibited in Figure 1.1.



*Figure 1.1: Structure of the research*

The remainder of Part I is organized as follows. Chapter 2 discusses the contributions and gaps in the previous literature by presenting the approaches of field emergence present in the new institutionalist literature. This literature is followed by the review of socio-technical approaches to technology in order to complement the weak understanding of technology from an institutionalist perspective. I end the literature review by exhibiting the commonalities of reviewed approaches and by presenting a conceptual framework for field emergence. Following the literature review, Chapter 3 presents nanotechnology, the empirical context of the research. This section discusses some antecedents and consequences of its emergence as a field of activity in more detail. Chapter 4 casts light on the methodological choices of the research, including the data collection and analysis methods, assessment of reliability and validity of the research as well as presenting some ontological and epistemological assumptions that underlie the research. Chapter 5 presents the summaries and contributions of the four essays that form the body of the research. Chapter 6 discusses the ways in which the current research casts light on the field emergence processes from the point of view of a focal actor, and presents the conceptual and practical implications of the doctoral thesis as well as some directions for future studies.



## **2 INSTITUTIONAL ENTREPRENEURSHIP AND EMERGENCE OF NEW TECHNOLOGICAL FIELDS**

The emergence of new fields, forms or industries is a relatively new domain of research activity in management and organization studies. Ecological and evolutionary approaches have studied the evolution of forms and industries by drawing directly from biological evolutionary models, and use the evolution of species as a metaphor for the process. This body of literature is wide and established (e.g. Schumpeter, 1939, 1942; Nelson & Winter, 1982; Tushman & Anderson, 1986; Hannan & Freeman, 1989). However, these macro-level approaches tend to give few implications for understanding those micro-level processes which induced the emergence of new organizational fields and forms in the first place. More specifically, these approaches neglect the social and organizational interactions and their role in field formation and evolution (also Romanelli, 1991). Rao (1998) further criticizes these approaches of failing to incorporate norms, values and beliefs as significant components in understanding how emergence and evolution unfold.

The new institutional theory, on the other hand, is able to tackle each of these issues. Traditionally it adopts a macro-level or top-down approach for investigating institutional persistence and change. However, some recent developments in this theory provide implications for institutional emergence also from a micro or bottom-up perspective. These approaches form the conceptual foundations and the literature to which the contribution of the current research is made. Hence, I start by discussing the basic assumptions of the new institutional theory, and more specifically, discuss the views on how the emergence of new institutions may unfold within an existing institutional context. For this purpose I review the literatures on institutional entrepreneurship, social movements and discursive approaches to institutional emergence. After this I discuss the socio-technical approach to technology, which casts light on the social processes in the emergence of new technologies. This approach complements the scarce implications for technology emergence of the institutionalist approaches. At the end of this section I present the conceptual framework of the research, which aims to build a synthesis of the reviewed approaches.

## **2.1 Approaches to emergence of novel fields in the new institutionalist tradition**

### **2.1.1 Basic assumptions of the new institutional theory – how things stay the same**

New institutional theory is concerned with institutions as social systems that regularize social interactions, and provides a holistic, cross-level framework (DiMaggio & Powell, 1983; Welch & Wilkinson, 2004) within which to investigate field emergence. New institutional theory mostly focuses on investigating how institutional environments affect organizations by imposing on them socially created beliefs and myths. Such myths define the norms and expectations of the field, and conformity to them leads to social acceptance within an institutional context (Meyer & Rowan, 1977; DiMaggio & Powell, 1983; Zucker, 1983). Conformity is conceptualized in this approach as institutional isomorphism, which leads to the homogenization of an organizational field over time (DiMaggio & Powell, 1983), and promotes the success and survival of organizations (Meyer & Rowan, 1977) within a given institutional context. New institutional theory is powerful in explaining the forces through which such homogenization takes place. DiMaggio and Powell (1983) define institutions as those entities that induce the members of a field to encounter similar reputational and regulatory pressures. Scott (2001) identified three ‘pillars’ that form institutions: regulative, normative and cultural-cognitive. The regulative pillar bases on laws and sanctions, the normative pillar bases on what is regarded as morally appropriate, and the cultural-cognitive pillar draws from what is taken for granted, shared as beliefs and supported culturally (Scott, 2001). Consequently, new institutional theory essentially defines the elements “from the conscious to the unconscious, from the legally enforced to the taken for granted” (Hoffman, 1997: 36 in Scott 2001: 51) that maintain the status quo.

### **2.1.2 Incorporating change into the new institutional theory**

The strength of the new institutional theory to explain how things become persistent is also its weakness. The new institutional theory has been criticized for its limited means to address change (Scott, 2001; Dacin et al., 2002) and incorporate agency into the approach (DiMaggio, 1988). Institutional change has gained a lot of academic attention due to the need to understand the creation of new institutional forms and fields (Scott, 2001). Owing

to the increased focus on change of institutions, there is a wide body of research on institutional change (Hoffman, 1999; Scott, 2001; Dacin et al., 2002; Greenwood et al., 2002;), institutionalization (Zucker, 1977; Galaskiewicz, 1991; Jepperson, 1991; Tolbert & Zucker, 1996; Barley & Tolbert, 1997) and deinstitutionalization (Oliver, 1992). Scott (2001) presents a number of external factors that trigger institutional change, including the introduction of new and most notably “competence-destroying” technologies; major changes in policies and regulation; social movements; economic crises or dislocations; and changing cultural beliefs and practices. Institutional change necessarily involves an aspect of deinstitutionalization, where the legitimacy of an established or institutionalized practice or procedure erodes or discontinues (Oliver, 1992). However, this research tends to concentrate on the macro-level diffusion of the existing practices and the changes diffusion causes in relatively stable institutional environments rather than on investigating the origins of novel practices (Leblebici et al., 1991; Lounsbury & Crumley, 2007). Further, the changes eroding the existing institutional practices have their origins in micro (Vaara et al., 2006) and meso (Laurila & Lilja, 2002) levels of activity, which also calls for further studies.

Van de Ven and Hargrave (2004: 264-291) identify four perspectives or models of institutional change in their comprehensive and elaborate review of the literature, which is summarized in the following. *Institutional design* model focuses on the agency of individual entrepreneurs engaged in the creation of new or change of existing institutional order in the pursuit of personal goals. In this view, institutions are products of intentional decisions and actions and the purposeful strategic action of individual actors. *Institutional adaptation* model draws from organizational sociology and examines how organizations become alike when facing similar institutional environments. The authors consider institutional environmental pressures as the mechanisms that serve to conform the structure and actions of organizational actors through coercive, normative and mimetic isomorphism. *Institutional diffusion* model borrows from ecological approaches and investigates how institutional arrangements diffuse among actors in a population as a function of density and competitive selection of certain institutional forms. Mechanism of change is, hence, competition for scarce resources. *Collective action* model focuses on the construction of novel institutions as an outcome of political behaviors of multiple actors with diverse roles. These studies focus mainly on how new institutional arrangements emerge from the interaction among the



partisan actors. Hence, the change mechanism underlying this approach is a dialectical process between competing frames of action.

Further, Van de Ven and Hargrave (2004) identify institutional design and collective action as the modes of change where the construction of novelty takes place, whereas the institutional diffusion and adaptation models tend to describe reproduction of existing institutions. Hence, institutional design and collective action models have most relevance for the emergence of novel institutions.

### **2.1.3 Later developments in the new institutional theory – three approaches with implications for institutional emergence**

As discussed, new institutional theory has lacked the tools to investigate the emergence rather than the mere diffusion of new practices (Leblebici et al., 1991; Munir, 2005). Lawrence and Phillips (2004: 690) argue that “understanding how institutional fields emerge is an important next step in the development of institutional theory”. Research has emerged to tackle this gap, and three institutionalist perspectives with implications to field emergence are introduced in the following. Two of them are categorized following Van de Ven and Hargrave (2004), however, adopting somewhat different labels and literature for each category: institutional design is *institutional entrepreneurship*, and collective action is *social movements and institutions*. While conducting this research I have come across with one further perspective on institutional change which Van de Ven and Hargrave (2004) have not addressed: *institutionalization of discourses*. This approach is concerned with how new discourses become institutionalized, and how they shape the actors’ underlying frameworks for reason and belief and, consequently, change the existing institutions’ and institutional logics. These three approaches are reviewed next.

**Institutional entrepreneurship.** According to Lawrence and Phillips (2004, 692), “although pre-existing institutions constrain the potential range of activities and relationships that will make sense to other actors, they also provide the potential for innovative combinations and new practices”. Therefore, institutions are neither fixed nor determined, but subject to change induced by motivated actors (Lawrence & Phillips, 2004). DiMaggio (1988) presents the concept of institutional entrepreneurs as agents who

have an interest in certain institutional structures, and who have access and leverage over resources to either support the existing institutions or to engage in the creation of new institutions. According to him, institutional entrepreneurs play a role in socializing actors and mobilizing stakeholders in the organizational field to participate in the institutional change. Hence, the institutional entrepreneurship approach adopts a dynamic view and stresses the role of active agents, i.e. institutional entrepreneurs, in institutional change. Previous conceptual work on institutional entrepreneurs has suggested that social skills play a major role in their ability to motivate cooperation by providing common meanings and identities to the involved actors (Fligstein, 1997). Beckert (1999) discusses the role of strategic agency in institutional change, and argues that institutions are preconditions for strategic agency, which are then challenged by the strategic actors. Hence, institutional rules and strategic agency can be seen as destabilizing each other, but yet remaining interdependent (Beckert, 1999). More recent conceptual work by Hargrave and Van De Ven (2006) argue that institutional entrepreneurs construct networks of complementary players, and collectively they have a possibility to enact new institutional arrangements when they find the old ones too restricting. Further, Battilana (2006) investigates the role of an individual's social position in organizational networks and in organizational hierarchy as an enabler of agency, and concludes that individual positions play a major role in enabling institutional entrepreneurship. Such views build a bridge to both social movement and relational approaches. Social movement approaches to institutional emergence are presented later in this chapter. Relational approaches are not addressed in this literature review in greater detail, but they form part of the conceptual framework of Essay II. To conclude, the conceptual work on the institutional entrepreneurship approach stresses that the bottom-up processes for building legitimation are crucial and challenge the top-down adaptation to institutional isomorphism suggested by the new institutional theory.

Previous empirical research on institutional entrepreneurship has addressed a variety of issues related to the role, position and activities of institutional entrepreneurs. Garud et al. (2002) investigated the role of institutional entrepreneurs as the builders of legitimacy around their cause. An institutional entrepreneur, which in their study was Sun Microsystems, aimed to create new institutions such as standards and policies that were aligned with their aim to sponsor the Java programming language. The company faced inertia from the existing institutions, and was forced to employ various strategies to address

the resistance, such as persuading the opponents to join the coalition by creating a sense of shared identity and meaning. This, again, points out that agents benefit from good social skills. Further, maintaining the new collective also required political skills which help to enforce the achieved direction. Finally, Garud et al. (2002) identified the challenges of the role as an enforcing agent, in which they need balance between maintaining control and encouraging cooperation for the emergence of a new standard.

Maguire et al. (2004) in their study of HIV advocacy in Canada found that institutional entrepreneurs engage in three types of critical activities. Firstly, they occupy “subject positions” with wide legitimacy and possibilities to bridge between various stakeholders. Secondly, they engage in the theorization of new practices by employing a wide range of arguments that are translated to and aligned with the interests of various stakeholders, and employ political tactics in doing so. Thirdly, they institutionalize the practices by aligning them with the existing routines of stakeholders and hence, stabilize the field level relationships (Maguire et al., 2004). The study suggests that institutional entrepreneurs play an important role in the social construction of a novel field by creating meaning for new practices and identities as well as making them understandable to wider audiences. A further influential work by Lawrence and Phillips (2004) discusses the role of local actors and discourses in the emergence of a new institutional field. They argue that changing macro-cultural understandings of whales, from man-killers to sympathetic creatures with humanistic features, enabled the emergence of whale-watching as a commercial industry in North America. The role of individual institutional entrepreneurs was to identify and take advantage of the positive macro-cultural discourses and to establish local business around them (Lawrence & Phillips, 2004). According to these authors, the strategies of institutional entrepreneurs in emerging fields are highly tentative and emergent rather than intended. However, they found out that when successful, rapid imitation by others follows, which may lead to rapid institutionalization with relatively little conflict compared to the situation where more established fields are undergoing change. Lawrence and Phillips (2004) contribute also to the literature investigating the impact of discourses to institutionalization. This approach will be elaborated in more detail below.

*Gap in the literature.* The institutional entrepreneurship approach is present in all the essays that form the main body of this research. The main contribution of this research is to

broaden the understandings and application areas of the institutional entrepreneurship approach, as well as to build its interconnections to other, more established research traditions. For this reason, the research aims to identify some important gaps in this approach, and contributions of the thesis are related to creating knowledge to further found and develop the institutional entrepreneurship approach on the part of these gaps in our current understandings. According to Maguire et al. (2004), when incorporating agency to institutionalist approaches the researchers also need to be aware of other approaches such as those related to networks and inter-organizational collaboration. Not only the entrepreneurial individuals and organizations and their opportunistic motivations to induce change in an existing system is sufficient to cause the emergence of a new institution. Their positions in the existing institutionalized networks and their ability to mobilize human and material resources play a major role. The significance of these notions to institutional emergence has been established in conceptual papers, but hardly any empirical studies investigating the role of the actors' position have been published to date. Essay II maps empirically the role of formal status and relational embeddedness of actors in the local construction of an embryonic field. Further, the role of institutional entrepreneurs as translators of ideas and issues across national boundaries has been given very little attention in previous literature. Essay III investigates how institutional entrepreneurs mediate and translate the local emergence of what is to become a global field of activity in a later stage. Essay IV addresses the issue of how top management of business organizations take advantage of strong positive discourses on nanotechnology, and employ a variety of discursive and other strategies to align their activities with those discourses and newly available resources. The previous literature has not either attempted to bring together institutional entrepreneurship and social movements or aimed to synthesize some key points on how the approaches are interconnected, and how they, when applied together, could provide novel tools to address institutional emergence and change. These issues are addressed in Essay I, where cognitive framing and mobilization activities of individuals are portrayed and empirically investigated as the connecting links between social movements and institutional entrepreneurship approaches in field emergence.

**Social movements and emergence of new institutional fields.** According to Hargrave and Van de Ven (2006: 870), "it is widely recognized that shared meanings of institutional arrangements are socially constructed in the organizational field"; however, "less

appreciated is the idea that collective understandings emerge from battles over meaning and, indeed, are constantly under challenge”. As is discussed in the next section, discourse and language play a major role in shaping the beliefs and myths that create the foundations of institutional fields. Such beliefs and myths also underlie, and are shaped by, the battles over meaning. The social movements approach has discussed contested framing and meaning making processes fairly extensively, but only recently have these approaches been adopted in the new institutionalist approaches.

The literature on social movements is broad and established. Despite the social movement approach consisting of different schools with varying interests and focus areas, they all tend to be involved with the investigation of, firstly, *mobilizing structures*, i.e. the networks of actors, organizations and resources, which enable the actors to engage in collective action; secondly, *political opportunity structures*, which refer to the existing institutional and political arrangements working for or against the movement; and thirdly, *framing processes*, through which the actors and incumbents manifest the meanings that underlie the movement (McAdam et al., 1996, in Van de Ven & Hargrave, 2004). Traditionally researchers have explored resource mobilization and recruitment practices of political organizations with the aim of changing social structures and spreading new ideas and ideologies (e.g. Zald & Ash, 1966; McCarthy & Zald, 1977). In a later stage, the students of social movements incorporated culture into their inquiries with the attention on identity, meaning construction and framing processes (Benford & Snow, 2000; Zald, 2000). After such a ‘cultural turn’ (Zald, 2000; Lounsbury et al., 2003), which has taken place in social sciences overall since the late 1960s, movement leaders were conceptualized as the orchestrators and active participants in the creation of collective action frames (Snow et al., 1986; Benford & Snow, 2000), collective action frames being “action-oriented sets of beliefs and meanings that inspire and legitimate the activities and campaigns of a social movement organization” (Benford & Snow, 2000: 614). Such a cultural turn also brought the social movement approach into interaction with contemporary institutional theorists in sociology, who perceive social structures of resources and meaning, embedded in particular cultural rules and relationships, to affect practices and behavior (Lounsbury & Ventresca, 2002; Lounsbury et al., 2003). Actors within different communities have their own interpretations of what the field is about, and what kind of activities take place within the field. Hence, each community puts forward their views of what is going on or what should be going on,

i.e. their frames of action (Benford & Snow, 2000). From an institutionalist point of view, this competition and interaction between frames strongly shapes the nature and boundaries of emerging organizational fields.

There are relatively few conceptual or empirical studies, where the social movement approach has been explicitly applied to explain institutional emergence. According to Fligstein (1996), transformation of existing *market institutions* results from exogenous forces such as economic crises and political interventions. During the transformation, “invaders”, with which the author refers to individual and organizational actors with particular interests at stake, are likely to participate and take advantage of turbulence to create advantage for themselves. Fligstein (1996) argues that during the periods of turbulence change may resemble social movement, where the emergence of a common language helps to produce conceptions of control, i.e. shared cognitive structures within and across organizations. This has significant effects on how organizational design and competition take shape in new markets (Fligstein, 1996). In the study on the emergence of non-profit consumer watchdog organizations, Rao (1998) analyzed their institutional production. He focused on how institutional entrepreneurs draw from cultural resources to frame a form in which they have an interest and consider as necessary and valuable. During the consequent competition between different frames, those that enjoy political support at the highest level: from the state, professions and other organizations, become dominant. Those supporting the losing frame have various strategies that they can adopt, such as exit, migrate, or convert to the ascendant frame (Rao, 1998). Further, Lounsbury et al. (2003) examined the role of social movements and field frames in the emergence of US recycling industry. They introduced the concept of “field frame” to investigate how political struggles give rise to novel cultural meaning systems and socio-economic processes that may induce the emergence of new fields and industries. Social movements, in their view, construct and solidify new practices and de-institutionalize dominant field frames, and hence, facilitate this creation. In their empirical case the interactions between social movements, organizational and state actors formed a triad, which drove the social change (Lounsbury et al., 2003).

*Gap in the literature.* Lounsbury et al. (2003: 97) contend that “research approaches that integrate the sociological subfields of social movements, organizations and institutions will

prove to be particularly fruitful in the development of a richer and more comprehensive understanding of socio-economic change”. As discussed in the previous section, the interconnections between institutional entrepreneurship and social movements have not been addressed to any large extent, with the exception of Rao (1998). Conceptualizing movement leaders as the focal actors in cognitive framing processes and mobilization of actors brings us very close to the view that the task of institutional entrepreneurs is to theorize around issues and make them widely accepted and, hence, create momentum and following around them (Maguire et al., 2004). Essays I and III investigate the role of institutional entrepreneurs as the leaders of framing processes, and bridges this gap between social movements and institutional theory.

**Discourse and emergence of new institutions.** The inclusion of discourse (Lawrence & Phillips, 2004; Phillips et al., 2004; Hardy et al., 2005) and rhetoric (Green, 2004; Suddaby & Greenwood, 2005) to institutional accounts has provided further means to tackle change and emergence. These approaches discuss how new discourses become institutionalized, and how they change the existing institutions and institutional logics that shape the actors’ frameworks for reason and belief. In their seminal work, Meyer and Rowan (1977) point out that language creates and transmits the organizational myths that shape the individual action within an institutional context. Hence, changes in the language result in changes in the institutionalized behaviors and give rise to new collective identities (Hardy et al., 2005). Likewise, change in an institutionalized context shapes the myths and organizational rhetoric, which again has an influence on how the organizational actors perceive themselves in relation to the field, which contributes to the transformation of the field. According to Phillips et al. (2004), institutional theorists have tended to define the concept of institutions in terms of patterns of action. However, action per se does not travel over distance and shape the beliefs and attitudes of others, whereas texts and discourse do (Phillips et al., 2004; Vaara et al., 2006). They argue that “institutions can be understood as products of the discursive activity that influence actions” (Phillips et al., 2004, 635). Green (2004: 654) defines rhetoric as “a type of instrumental discourse used to persuade audiences, reach reliable judgments or decisions, and coordinate social action”, and argues that actors use rhetoric to “produce and assign meaning, constructing both their identities and the world”. Hence, the creation of rhetorical strategies and embedding rhetoric into

widely shared and circulating discourses presents yet another means to induce institutional change and emergence.

Berger and Luckmann (1966) provide important views on the role of discourse in their conceptualization of institutionalization, especially in their notion of *objectivation* of individual ‘realities’. Objectivation refers to the process through which the “externalized products of human activity attain the character of objectivity” (p. 60). This means that an individual takes things that pre-exist her and which seem as durable and given as the objective reality. However, a starting point of objectification is *externalization*, where an individual “projects his own meanings into reality” (Berger & Luckmann, 1966: 104), which become shared with a wider audience. In this process, discourses play a central role by transmitting the ideas and opinions of an individual actor to a broader community of actors. Externalization is followed by *internalization* “by which the objectivated social world is retrojected into consciousness in the course of socialization” (p. 61). In other words, the actors assimilate the discourses and adapt them to their past experiences. According to Maguire & Hardy (2006), during institution building, actors draw on different discourses in order to sediment understandings, shape interpretations, and justify practices in a way which helps them to drive their own interests.

There are scarce empirical studies that investigate the interplay between discourses and institutions from the presented viewpoint. Maguire & Hardy (2006), in their study of the development of environmental regulation on persistent organic pollutants, investigate how a new discourse shapes the emergence of novel regulatory institutions. Their particular focus is on the roles of actors and the texts the actors produced during the institution-building process. They found that the new discourse provided both incentives and resources for institution building. Further, the actors promoting the discourse produced texts that aligned it with “legacy discourses”. The actors also drew on “authoritative texts”, either with the purpose of interpreting the meaning of a new discourse and establishing its status as superior to the legacy discourse; or with the aim of hampering the new discourse and subordinating it to the legacy discourse. In their view, “it is out of this discursive struggle that new institutions emerge” (Maguire & Hardy, 2006: 24). As discussed in the *Institutional entrepreneur* section in more detail, Lawrence and Phillips (2004) found that the emergence of a field is a consequence of the emergence of favorable and, hence, supportive



macro-cultural discourses, which is clearly in accordance with the views presented by Maguire and Hardy (2006).

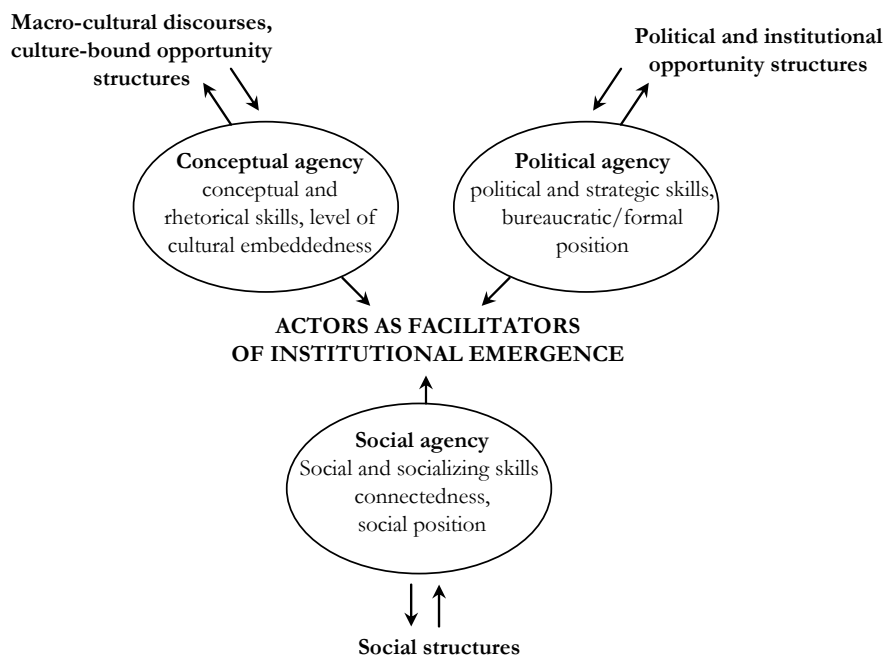
Selsky et al. (2003) study how actors mobilize and use discourses in an inter-organizational domain during the clash of business and union interests in a nationwide contention over stevedoring labor practices. They introduce the concept of *discursively ordered domain*, which suggests that an interorganizational domain of actors sharing a common issue is ordered by the complex ways in which the actors use discourses to make sense of the domain and to stimulate directed action in it. The outcome of such processes also strongly shapes the material conditions of the domain (Selsky et al., 2003). Selsky et al. (2003) found that different organizational networks in the domain mobilize and deploy differing discursive frameworks, and that they also employ complex mapping strategies for making sense of the domain. Such complex mapping in a discursively ordered domain may entail conflict over the meaning of objects and events. Finally, they found that material interests and discourses are embedded in the institutional context, which has an impact on power relationships and their evolution in the domain (Selsky et al., 2003).

*Gap in the literature.* As discussed above, there are only a few studies which empirically investigate the interplay between discourses and institutions. Overall, very little attention has been given to the role of macro-cultural discourses in the emergence of new technological fields, and to the role of the agents exploiting and participating in the creation of these discourses. Essay III investigates how local agents translate globally circulating discourses into local issues, which again have an influence to the globally institutionalized macro-cultural discourses. Essay IV addresses the question of how agents draw from discourses and strategically utilize and participate in their creation to their own benefit by investigating the nanolabeling activities of business managers. Further, the review of the literature on institutional entrepreneurship and social movements establishes that the task of institutional entrepreneurs is to participate in the meaning of work and framing, which refer to the creation of new understandings of issues, and their dissemination and interpretation to wider audiences. Such changed meanings transform the basic assumptions on which institutions are based. This links discursive approaches to social movements, because framing activity is very much to do with creating and managing new discourses (Benford & Snow, 2000), which then become institutionalized as cognitive

frames of action for the participants in the institutional change. The interconnections between discourse and framing in the institutionalist context have been given little attention. Essays I, III and IV provide some implications for this gap in our knowledge.

#### 2.1.4 Conclusions of the institutional approaches to agency in field emergence

A variety of relatively novel approaches in new institutional theory provides tools to address the problem of institutional change and emergence, which has previously been considered as a major shortcoming in this approach (e.g. Scott, 2001; Dacin et al., 2002). The presented literatures of institutional entrepreneurship, social movements and discourses and institutionalization discuss analytically interrelated issues by employing multitude of concepts with somewhat different foci (refer also to Table 2.1). Hence, these literatures cast light on varying aspects of the birth of new institutions, but they also have many connecting points and jointly create a broader picture on the underlying processes of field emergence. The common feature across the reviewed literature is agency, both in creating and managing meanings and in mobilizing actors and discourses.



**Figure 2.1:** *Institutional entrepreneurs and the components of their capacity to act as the facilitators of institutional emergence*

As discussed above, the institutional entrepreneurship literature serves as the main point of reference for this research. By synthesizing the three literatures, I conclude that the tasks, activities and capabilities of institutional entrepreneurs in facilitating field emergence is threefold (see Figure 2.1). Firstly, they act as issue identifiers, who consequently need to engage in the initial meaning creation activities and theorization around a novel issue. To do this, they articulate and align the novel concepts and meanings with the existing, institutionalized framework to make them comprehensible to others. Such task requires good conceptual and rhetorical skills. The activity of detecting new ideas and influences is enabled by their access to macro-cultural discourses that transmit the seeds of novel issues around the globe. Hence, actors benefit from the embeddedness in various levels of cultural environment, where they are subject to different discourses and influences. This is manifested by being aware and subscribing to a variety of discourses in popular culture, business, science, as well as in other cultural domains.

Secondly, institutional entrepreneurs need to mobilize those meanings and discourses to broader audiences. In this task they are likely to face major inertia and challenge from the existing and competing institutions. They are also challenged by other actors to engage in disputes over the meaning and boundaries of the domain of action. In such disputes the role of institutional entrepreneurs as political and strategic, as well as networking and socializing, actors becomes prevalent. Their social and political skills and socially and bureaucratically legitimate position enable this activity. Hence, the actors engage in establishing the field of action in relation to the existing institutions through political and discursive means. The social movement approach underlying the notions of political agency stresses the political processes of mobilization and the cognitive processes of framing, where the existing discourses and institutions partly explain how they are externalized and formulated. Further, the social movement approach emphasizes the role of collective action, which complements the views of the institutional entrepreneurship literature on the activities of individuals and organizations in opportunistically maneuvering the change processes.

Thirdly, institutional entrepreneurs need to be able to maintain the established direction by sedimenting the frames and discourses into broader cultural, political and institutional contexts. The role of collective action materializes here – the more actors are present in

producing new institutions, the more likely they are to become objectified i.e. to become perceived as external reality to the actors, a given context for action (Berger & Luckmann, 1966), and the more likely the discourses actors create and mobilize are to become sedimented. During the birth of a new field, there are multiple meanings and activities that become externalized predominantly through discursive means by the initial members of the field. What eventually becomes objectified is a process that is nearly impossible for any single individual or organization to control. Hence, no actor alone can shape the emergence of the field in its totality, but the eventual boundaries and forms of the field represent a synthesis of various frames, ideas and collective action, shaped by a collective of actors in relation to the existing institutional context. In maintaining a new institution, institutional entrepreneurs benefit from their social and rhetorical skills in reframing and supporting the common direction, and from their political and strategic skills to enforce the action.

As this research focuses on the emergence of novel technological fields, and as the institutional theory provides few tools to investigate and satisfactorily conceptualize technology, the following section reviews the literature of socio-technical approaches to technology. Such views represent the underlying understandings of technology adopted for the current research, and contribute to the framework of the role of agency in the emergence of novel technological fields presented in the end of this section.

## **2.2 Technology emergence as a social process**

This section discusses the previous studies on technology and emergence in socio-technical literature. The aim of the current research is not to explicitly bridge any gaps of knowledge in this literature. Rather, it is used as a backdrop to complement the views of agency in technology emergence, which is an issue scarcely addressed in the new institutional theory. Firstly, I present Van de Ven and Garud's (1989; 1993) social systems framework. They build a bridge between the institutionalist and socio-technical approaches to technology by discussing in more detail the specific institutions that are necessary in institutional and technology emergence. Secondly, I present the literature on socio-technical approaches to technology, which describes in more detail the role of agency in birth of novel technologies.

### 2.2.1 Social systems framework

Van de Ven and Garud (1989; 1993) argue that new *industry* development is based on the gradual evolution of technology in several fields. Even technologies that may appear as radical innovations are based on “many incremental changes in and recombinations of existing technology and institutional arrangements, which add[ed] up to what might be called a technological revolution” (Constant, 1980, in Van de Ven & Garud 1993, p. 8). In their social systems framework, Van de Ven and Garud (1993) argue that industry emergence is a complex social and institutional process with multiple participants. In this view, there are a variety of actors contributing to industry emergence, and the process of technological innovation is a joint effort among several public and private constituents. According to Van de Ven and Garud (1993: 2), the development of an industrial system for innovation requires an infrastructure that includes

- (1) institutional arrangements to legitimate, regulate and standardize new technology;
- (2) public resource endowments of basic scientific knowledge, financing mechanisms, and a pool of competent labor; and
- (3) technical economic activities of applied R&D, manufacturing, marketing, and distribution by private firms to commercialize the innovation for profit.

Van de Ven (1993: 41) argues that the central processes enabling industry emergence evolve over time and are created “by the interdependencies that accumulate among firms engaged in numerous components of the emerging industry”. Further, the knowledge, which underlies technological innovations and makes the commercial birth of most industries possible, is most typically created in the basic scientific or technological research (Van de Ven & Garud, 1993). However, for a new industry to emerge, many complementary innovations in technical and organizational arrangements are required before a particular technology is mature enough for commercial application (Van de Ven & Garud, 1993). The social systems framework builds a bridge between an institutional base, in which such emergence takes place, and the activities and resources that help to further disseminate the results of scientific and technological research. The framework also shares many underlying conceptions of technology emergence with socio-technical approaches, such as the co-evolution of resources and the institutional structures. These are discussed next.

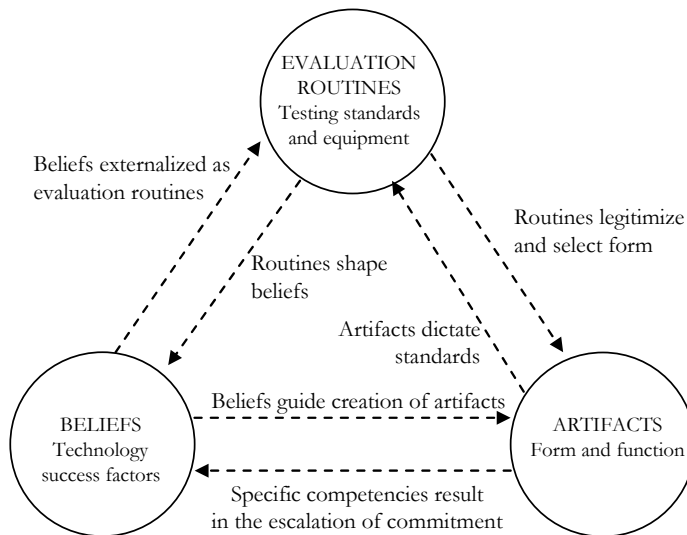
## 2.2.2 Socio-technical approaches to technology

Technology is a complex concept, and the emergence of technology has been scarcely addressed in institutionalist literature. According to Munir (2004), institutional theory provides explanations for how technologies become and remain dominant, but in his view such an approach represents predominantly 'black-boxed' understandings of technology. On the other hand, socio-technical approaches portray a dynamic view on technology emergence, where emergence of new technologies is an interactive process in which a multitude of actors take part (Constant, 1980; Bijker et al., 1987; Garud & Karnoe, 2003; Garud & Karnoe, 2005). Depending on their role and vantage point, agents begin to identify and attribute specific meanings to the objects that constitute the technological field (Garud & Karnoe, 2001). Hence, each actor enacts a specific frame of reference that consists of a set of beliefs, standards of evaluation, and behaviors (Bijker et al., 1987; Dougherty, 1992; Garud & Karnoe, 2001; Karnoe & Garud, 2001).

Socio-technical approaches reject the notion of technological determinism, where technological development follows some predetermined path, which is independent of human action. However, the socio-technical approach does not reject the notion of path or trajectory as a socially constructed understanding on how the technological development can and should proceed. In this view, for technological change to take place, the role of embedded agents, who deviate from the existing technological paths, is central. Garud and Karnoe (2001: 3) argue that "entrepreneurs attempt to shape paths in real time by setting in motion processes that actively shape emerging social practices and artifacts only some of which may result in the creation of a new technological field". However, they also argue that entrepreneurs are embedded in the structures they create together with other actors, and from which they are able to mindfully depart. By mindfulness they refer to an ability to disembed from those structures, and to an ability to mobilize a collective, though the entrepreneurs need to overcome resistance and inertia to do this. For Garud and Karnoe (2001: 3), "entrepreneurship is a collective effort where paths are continually and progressively modified as new technological fields emerge".

Pinch and Bijker (1984), on the other hand, stress the role of social groups in the evaluation of technology, and identify the interrelationship between a social group and an

artifact as constitutive in technological development. According to them, a social group shares the same set of meanings, which are attached to a specific artifact. So, the problem in an artifact is identified and constructed within a social group, and to the problem a variety of solutions can be found, which are again dependent on the perceptions of a specific social group, and which differ from one group to another (Pinch & Bijker, 1984). Synthesizing the views of Garud and Karnoe (2001) and Pinch and Bijker (1984) it can be argued that the role of entrepreneurial actors participating in technology development is to coordinate and mediate the meanings, problems and their solutions between different social groups.



**Figure 2.2:** *Socio-cognitive model of technology evolution (Garud & Rappa, 1994)*

Garud and Rappa (1994) propose three basic definitions for technology: technology as knowledge, technology as physical artifacts, and technology as evaluation routines (Figure 2.2). These authors argue that for an investigator to understand technological evolution, she needs to understand how beliefs form over time, how the form evolves and what functions the technology serves over time, and how the evaluation routines emerge over time (Garud & Rappa, 1994). There is an aspect similar to Giddens' (1976; 1984) notion of structuration present in Garud and Rappa's overall understanding of the technology evolution, and it is also visible in their definition of technology. Firstly, routines legitimize and select the form of technological artifacts, but on the other hand, artifacts dictate

standards, which then define the routines. Secondly, beliefs guide the creation of artifacts, but specific competencies in form and function result in the escalation of commitment, which shape the beliefs of actors. Thirdly, routines shape beliefs, but beliefs become externalized as routines, which again shape the beliefs of actors. Consequently, such view on technological evolution makes technology emergence also an inherently incremental process, where beliefs, evaluation routines, and artifacts are in constant interaction.

An implication of such a definition of technology is that technology evolves in relation to its environment, not only in relation to the actors who promote it. According to Geels (2004), previous research on technology discusses technology as a co-evolution (in evolutionary approaches, for clarity used here) or as a co-construction (in social constructionist approaches). Geels (2004) reviews co-evolution from various perspectives: co-evolution between technology and users (Kline & Pinch, 1996; Orlikowski, 2000); co-evolution between technology, industry structures and policy institutions (Nelson, 1994; Van de Ven & Garud, 1994); co-evolution between science and technology (Rosenberg & Nelson, 1994) and the market (Callon, 1991); co-evolution of technology and culture (Du Gay et al., 1997; Van Dijck, 1998); and co-evolution of technology and society (Freeman & Soete, 1997) (for a more profound review on co-evolution see Geels, 2004). Such approaches further suggest that technological development is deeply embedded in the different levels of society. Hence, the process of technology evolution is also a process of deinstitutionalization, where technological development also causes change in other institutionalized structures.

### **2.2.3 Implications of socio-technical approaches to field emergence**

Socio-technical approaches to technology emergence stress both the role of social environment as the boundary setting context for all activity, as well as the role of 'embedded agents' or technology entrepreneurs capable of mindfully deviating from the existing socially constructed paths and trajectories. Existing systems restrict but also provide resources for change, and technology entrepreneurs, not unlike institutional entrepreneurs, act as mobilizers and creators of novel resources, which enable technology development. Hence, socio-technical approaches to technology stress similar issues as the institutional entrepreneurship approach: actors are knowledgeable and opportunistic agents



of change, and they aim to build legitimacy for novel technology by acting as connectors between separate social groups and networks. Also, as with the institutional entrepreneurship approach, the task of agents is to act as initiators of the process of emergence of new technologies and as the mobilizers of a collective of actors, who then participate in and validate the novel technological trajectory.

Whereas the above notions of socio-technical systems are not discussed in detail in the essays, they create the basic assumptions of technology emergence for this research. The following section further summarizes and synthesizes the literatures for this thesis.

## **2.3 Towards the conceptual framework of the research**

### **2.3.1 Summary of the literature review**

After having presented the literature, I begin this section by summarizing the contribution of the theoretical approaches discussed in the literature review (Table 2.1). The previous institutionalist studies have addressed various aspects of agency, but also discourses and collective action, in the emergence of new institutional fields. What separates these approaches from the rest of the institutionalist literature is that they all, to a varying extent, stress the role of micro level activity in setting the institutional emergence in motion. The institutional entrepreneurship approach focuses on individual and organizational level characteristics, positions and tasks of opportunistic and knowledgeable actors. The social movements approach stresses the role of individuals as the initial mobilizers of the movement, though much of the literature tends to describe the movement and societal level dynamics that underlie the movement. Similarly, the institutionalization of the discourses approach acknowledges the role of individuals and organizations as the mobilizers and as the local exploiters of macro-cultural discourses.

While institutional theory provides the basic framework for the research and for each essay, socio-technical approaches provide further insights regarding the role of agency in technology emergence, and complement the black-boxed understandings of technology in institutionalist literature. Socio-technical approaches, like the institutional entrepreneurship

literature, position individuals in the centre of technological change, stressing, however, the role of collective action and the interaction of a multitude of actors. Here, the connecting point to social movements and mobilization of a movement can be seen. In sum, all the reviewed literatures contribute to understanding the micro-level agency in the process of the structuration of novel technological fields.

	<b>Level of analysis</b>	<b>Implications for field emergence</b>	<b>Authors</b>	<b>Contribution to the research</b>
<b>INSTITUTIONAL</b>				
Institutional entrepreneurship	individual, organization	IEs as socializing, mobilizing, political and strategic actors engaging in networking, institution building, theorization and maintenance in novel fields	Battilana 2006; Beckett 1999; DiMaggio 1988; Fligstein 1997; Garud et al. 2002; Lawrence and Phillips 2004; Maguire et al. 2004, Rao 1998	Essays II and III, main theoretical perspective; present in Essay I as a complementary perspective
Social movements	individual, organization, field	Social and political processes of framing of meaning and mobilizing actors	Benford & Snow 2000; Fligstein 1996; Lounsbury et al. 2003; McCarthy & Zald 1977; Rao 1998	Present in Essays I and IV as a complementary perspective
Institutionalization of discourse	individual, organization, field	Mobilization and institutionalization of discourses, which change actors' frameworks for reason and belief	Berger & Luckmann 1966; Green 2004; Hardy et al. 2005; Lawrence & Phillips 2004; Maguire & Hardy 2006; Phillips et al. 2004; Selsky et al. 2003; Suddaby & Greenwood 2005	Main theoretical contribution of Essays III and IV
<b>SOCIO-TECHNICAL</b>				
Social systems framework	industry	Industry emergence as a complex process, which requires participation of numerous actors and organizations	Van de Ven & Garud 1989, 1993	Underlying understanding necessary for all essays
Social construction of technology	individual, group	Technology emergence a result of mindful depart from existing path by an actor, followed by the mobilization of a collective	Bijker et al. 1987; Constant 1980; Garud & Karnoe 2001, 2003, 2004; Geels 2004	Represents the underlying assumptions of technology evolution

**Table 2.1:** *Summary of the reviewed literature*

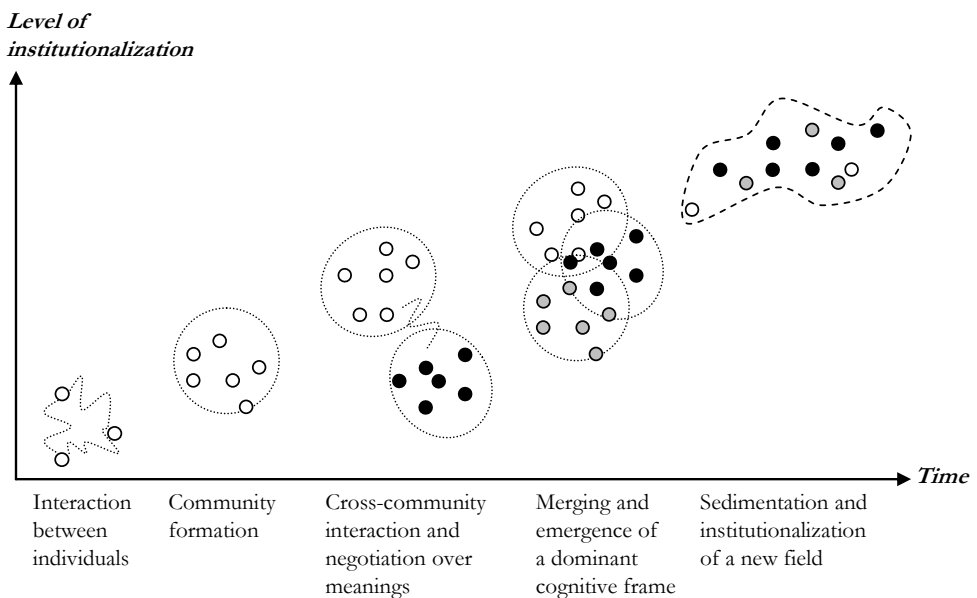
### 2.3.2 Framework for the research

First of all, the very possibility of emergence of new fields arises from the fact that actors are not members of only a single field or domain of activity. Each actor is embedded in different groups or communities, which form a part of other fields. This also gives rise to their 'singular social trajectories' (Bourdieu, 1990), which induce the need for change of an existing institutional context. Each organization and community provides different contexts and horizons for an individual to perceive the field and its boundaries. Such perceptions also stem from differing needs and preferences of what the field should be about. As a result, the boundaries of a field are fuzzy, and what consists of a perception of a field for one actor may be incomprehensible to another. This is especially the case for emergent fields, where the field frames are still under development and continuously contested. Consequently, the initial actors need to engage in creating the common concepts and meanings, and mobilize actors to form an embryo of a novel technological field.

Further, for a new technological field to emerge, new social relationships need to form and a mutual recognition and identity between actors, based on shared interests, goals and values, needs to be established. Emergence and construction of shared issues help to mobilize individuals to form communities around some ideas and goals. Actors begin to create common codes and artifacts that manifest the field, such as specified academic and trade journals, research centers, conferences, and eventually statistics, standards and so forth. Knowledgeability, bureaucratic or formal position, social and political skills, and connectedness of the actors have an impact on their potential to participate in the construction of a novel field. Also, the agendas of individual and organizational actors further influence which issues gain ground. Gradually, the understandings of the field become widely shared, objectivated and sedimented (Berger & Luckmann, 1966) and the relationships between actors become institutionalized. Consequently, field emergence is a process through which the meanings and boundaries become socially constructed as a result of the orchestration and mobilization activities of an initial coalition of individuals.

As depicted in Figure 2.3, field emergence can be conceptualized as going through five phases. 1) The starting point is individuals and their perceptions of some need for change of an existing institution. 2) These become interpreted and shared as meanings within a

community; which are 3) mobilized and disseminated further in relational networks of actors within and between communities. 4) Gradually some commonalities begin to emerge and some meanings and understandings become more salient than others. This depends on the capacity of the actors to make their particular view or framing ‘sticky’ in the changing institutional context. 5) Eventually, the most persistent meanings become sedimented as institutions, which again are under constant pressure for change. According to this framework, both individual and collective action play a major role, but in different processes that are all crucial to emergence. New fields also emerge in relation to the existing institutions in that domain, such as public funding agencies, research organizations and industries. Hence, fields include organizations that stand outside them, but which have influence on or constrain organizations in the field (DiMaggio, 1991). Previous memberships, experiences and relational networks of the actors affect the micro-level emergence. When moving towards meso and macro levels of field emergence, established institutional arrangements become increasingly important.



**Figure 2.3:** *The conceptual framework of field emergence*

Overall, in such a conceptualization of fields, both emerging and existing fields are in various states of transition, in constant move resulting from emerging perceptions and

novel relationships of the participants. Such conceptualization of fields suddenly turns them into dynamic and changing entities, and urges a question – how is it possible that fields *would* stay static and unchanged over time; and how is it possible that new fields *would not* emerge from such interactions? When a long enough time perspective, or a turbulent enough environment, is given, all fields of activity are in a constant flux.

## 2.4 Research questions

A multitude of studies has investigated agency in the emergence of new technological fields from a variety of perspectives. However, in the above literature review I have identified the gaps in the extant literature in the new institutional theory with micro-level implications to the emergence of new organizational fields. The gaps in this literature can be summarized as follows. Firstly, incorporating agency into the new institutional tradition also generates novel connections to other literatures, most notably to social movements and networks literature. In each of the four essays a complementary literature (related to social movements, cognitive aspects, translation of practices, and identity and image) is brought into interaction with the institutional entrepreneurship literature or otherwise addressed in order to explore these connections. Secondly, the role of institutional entrepreneurs as the gate keepers and mediators of various institutional processes has not been explored in any great detail. Essays II and III address this gap by investigating respectively, how institutional entrepreneurs create connections across cognitive, organizational and spatial gaps to enable the emergence a local field; and how they act as mediators and translators of global ideas to local issues. Finally, the entire literature on the institutionalization of discourses is still under development, especially in terms of empirical evidence of how discursive processes contribute to field emergence. Essays I, III and IV have implications for this gap in our current knowledge.

While each essay tackles an individual research theme and also more elaborate gaps in the literature than presented above, they all contribute to the overall research theme. The research theme and the particular research questions are described below.

***How do institutional entrepreneurs, i.e. entrepreneurial individuals and organizations, contribute to the emergence of novel technological fields?***

This question is divided into four sub-questions each of which are addressed in the essays:

**SubQ1:** How do institutional entrepreneurs engage in creating, mobilizing and counter-mobilizing field frames, and with this activity contribute to the emergence of new technological fields? (Essay I)

**SubQ2:** How do institutional entrepreneurs draw from their status and relational embeddedness to induce the emergence of novel science-based fields? (Essay II)

**SubQ3:** How do institutional entrepreneurs in science-based fields mediate between globally circulating discourses and local institutions and competences? (Essay III)

**SubQ4:** How do externally validated form identities emerge, and how can opportunistic actors take advantage of those identities during form emergence? (Essay IV)

The emergence of nanotechnology provides an excellent context to find answers to these research questions and extend the literature on institutional entrepreneurship. It is an institutionally established but technologically emergent field of activity, with various actors engaging in its development before and after its legitimation as a field. The empirical context of the research is presented in more detail in the next section.



### 3 NANOTECHNOLOGY – THE EMPIRICAL CONTEXT OF THE RESEARCH

#### 3.1 Definition and origins of nanotechnology

The millennium change was critical in the legitimization of nanotechnology. The launch of the National Nanotechnology Initiative in the United States in 2000 and the establishment of nanotechnology as a strategic focus area in Japan in 2001 and in the European Union in 2002, with the associated major public investments, marked an important point of legitimization of nanotechnology as a field of scientific and commercial activity. Since then, nanotechnology has been hyped, and many actors have adopted the ‘nanolabel’ to describe their activities due to its major attention and financial value. Nanotechnology has been defined by Wang (2004, 28) as “the construction and use of functional structures designed from atomic or molecular scale with at least one characteristic dimension measured in nanometers”. The concept is typically used when referring to the science investigating nanoscale, i.e. typically 0.1-100 nanometers, and to a collection of related technologies with strong ties to research in public and private research organizations. Operating on the size scale below 100 nanometers reveals the new scientific phenomena and characteristics of matter (Budworth, 1996; European Commission, 2004). Perhaps a more accurate definition for size scale would be 1-1000 nanometers<sup>3</sup>, because much of what is labeled as nanotechnology today actually reaches well into the micron world (refer to Appendix 1 to learn more about what the size scales mean in practice). Today, nanotechnology is largely used as the synonym for ‘advanced’, which was stated many times during the interviews.

The roots of ‘*nanotechnology*’ are twofold. Firstly, nanotechnology draws from scientific and technological development, which enables the investigation and manipulation of individual atoms and molecules, and the phenomena related to the ‘nanoscale’ size scale. Secondly, nanotechnology draws from the very emergence of the concept itself and its popular cultural embeddedness. Only the later adoption of the concept has resulted in redirecting

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<sup>3</sup> [<http://cnst.rice.edu/nano.cfm>]



and relabeling (and thus legitimizing) a variety of research and business activities as ‘nanotechnology’. These two roots of nanotechnology are discussed in the following.

### 3.1.1 Nanotechnology in science, or nanoscience

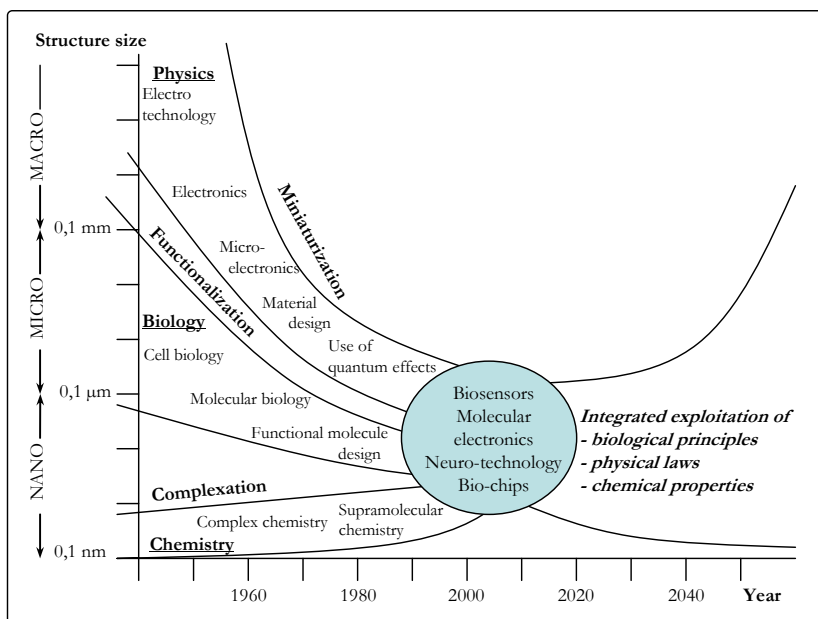
Miniaturization as a focus area within science is widely considered to have its beginnings in 1959 in a speech of Nobel Prize winning physicist Richard Feynman, who famously stated, “there is plenty of room at the bottom”<sup>4</sup>. Feynman did not use the concept nanotechnology, but his speech inspired many scientists and focused the attention on miniaturization and its limits within a variety of scientific disciplines such as physics, chemistry and biology. The first major steps towards ‘nanotechnology’ in science took place in 1978 with the establishment of the field of supramolecular chemistry, and with the launch of the scanning tunneling microscope (STM) in 1981, and the atomic force microscope (AFM) in 1986 (Koponen, 2002). These were the first tools that made it possible to see and manipulate individual atoms. Further important early stage innovations were C60 fullerene (also called buckminsterfullerene or buckyball) in 1985; single electron transistor and the establishment of microelectromechanical systems (MEMS) as a field in 1987; and the invention of carbon nanotubes in 1991. These and other inventions have encouraged research activities around the nano-sized phenomena. The field became initially adopted in science by establishing the first academic journals on nanotechnology in 1990 (*Nanotechnology* by the Institute of Physics) and in 1992 (*Nanostructured Materials* by Acta Metallurgica, Inc.). Table 1 in Essay I presents the chronology of innovations in nanotechnology, and Figure 3.1 below describes some of its antecedents.

After the initial innovations, a variety of atomic and molecular level manipulation methods have been developed. These include lithography, molecular synthesis, self-assembly, crystal growth and polymerization (Ratner & Ratner, 2003). Lithography in its various forms is the most popular method of production of nanosized structures today, also commercially. It presents the *top-down approach*, where smaller and smaller-sized structures are carved from bigger objects or structures. *Bottom-up approaches*, where structures are created atom up, such as self-assembly, are far less developed. Self-assembly is based on the idea that atoms and

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<sup>4</sup> Speech can be accessed from [<http://www.zyvex.com/nanotech/feynman.html>]

molecules always seek to settle into the lowest energy level available to them, and exploit this feature by making components that naturally organize themselves into desired structures (Ratner & Ratner, 2003). As opposed to carving or stamping smaller and smaller features on substrates, the bottom-up approach holds promise for the future mass production techniques of nanosized structures.



**Figure 3.1:** *Nanotechnology as an interdisciplinary area of research and application (Holtmannspötter & Zweck, 2001)*

Nanotechnology can also be divided into wet and dry nanotechnology<sup>5</sup>. “Wet” nanotechnology refers to a study of biological systems that exist in water environments, and focuses on genetic material, membranes, enzymes and other cellular components. All living organisms are governed by the interactions in nanometer-scale structures. “Wet” nanometer-sized structures are successful in self-assembly, if we take for instance a cell or a virus as an example. “Dry” nanotechnology, on the other hand, draws from surface science and physical chemistry, and is involved with the fabrication of structures of carbon such as fullerenes and nanotubes, silicon and other semiconductors, and other inorganic materials such as

<sup>5</sup> The following definitions of wet, dry and computational nanotechnology draw from [http://cnst.rice.edu/nano.cfm]

metals. “Dry” nanotechnology provides promising avenues for the development of electronic, magnetic and optical devices. Self-assembly presents a challenge in this domain, and the goal is to develop attributes of self-assembly for “dry” structures. The third domain of scientific development is *computational nanotechnology*, which refers to the modeling and simulation of complex nanometer-scale structures to predict and analyze their form and function. In addition to the developments in science and technology, nanotechnology is also essentially a social and cultural phenomenon. The antecedents and implications of popular culture for nanotechnology will be discussed next.

### **3.1.2 Nanotechnology as a cultural phenomenon**

The term nanotechnology was used for the first time by Professor Norio Taniguchi in 1974 (Taniguchi, 1974). However, ‘nanotechnology’ did not exist in science or technology until the concept was reinvented in 1986 by Eric Drexler in his book “Engines of Creation: the Coming Era of Nanotechnology”. The book gained much attention because of its provocative claims concerning the self-replicating molecular machines that can build anything atom-up by stacking atoms together. Also great threats were sketched in this vision of nanotechnology. If the self-replication process should get out of control, the tiny assemblers would consume all the resources in the world, turning the earth into *gray goo* filled with tiny self-replicating machines. Eric Drexler can be characterized as a visionary futurist rather than a scientist, and the book was overlooked and rejected by the scientists, who considered such visions as science fiction. However, especially in the US, the press became inspired by Drexler’s statements. The media post-rationalized and labeled the innovations in the tools and materials, reaching to the atomic world, as the initial steps towards Drexlerian visions of Molecular Nanotechnology. Further, in science fiction and especially in its cyber punk genre, the compelling concept was greeted with enthusiasm, and dozens of novels were published between 1990 and 2000. The novels typically portrayed dystopian views of the future, where humans had been altered or ‘improved’ by technology; or where out-of-the-control self-replicating machines had caused a major crisis or destruction of all life. These views became culturally embedded and disseminated among the public, also reaching the policy makers. Due to the cultural persistence of such framing, these initial understandings of nanotechnology are still prevalent today, and have been further reinforced by more recent fiction such as the best-selling novel *Prey* by Michael

Crichton (2002). Figure 2 in Essay I presents some of the books and movies that have adopted the concept in popular culture.

Such popular interest towards the concept of nanotechnology was a major driver of its becoming a label for so many different activities worldwide. In fact, during the 1990s in the US, most of the news stories discussing nanotechnology were book reviews of science fiction novels. The growth of nanotechnology in news also illustrates its adoption and spread. Figure 5 in Essay I presents the growth of the number of articles mentioning nanotechnology in selected top US newspapers; an exponential growth from less than 30 in the mid-1990s to over 800 by 2005 has taken place. Through popular media, a variety of ideas and expectations concerning nanotechnology has diffused and continues to do so. This has contributed to the controversial views on nanotechnology in the minds of the public. However, the popular attention to nanotechnology has also contributed to its adoption at government level by increasing the familiarity of the concept as well as attaching the meanings such as ‘advanced’ or ‘next generation’ to it, albeit also ‘hazardous’ and ‘out-of-control’. In Europe, however, the reporting on nanotechnology has been far more focused on advances in technology and science, and the policy makers have had fewer challenges to change the distorted views on what nanotechnology actually is.

### **3.2 Public and private investments in nanotechnology**

Since 2000, a de facto armament race in investments in nanotechnology has taken place. The high level of attention, as well as national and transnational investments in nanotechnology, have resulted in a major surge of public funding into the field. There seem to be two main justifications for such investments: firstly, the justifications related to growing importance and the enormous commercial and technological potential of nanotechnology; and secondly, the justifications associated with keeping up with the investments of other countries, regions and companies, and, hence, and managing the competition over innovation and intellectual capital in general. Since the year 2000 statistics on activities related to nanotechnology have been collected by various organizations in order to compare the activities in the nanotechnology domain in different nations and regions.

### 3.2.1 Public and governmental funding

Figure 1 in Essay I establishes the amount and growth of government funding to nanotechnology, which will be discussed in more detail in this section. In Europe, the initial public investments into nanotechnology were made around the mid-1990s in different countries. The European Union<sup>6</sup> supported 80 research projects involving nanotechnology in the 4th Framework Programme during 1994-1998 for some €30 million. In the 5th Framework Programme (1998-2002) the funding increased to €45 million. In the 6th Framework Programme 2002-2006, nanotechnology and nanosciences were adopted as one of the main priority areas, and the research was granted some €1.3 billion, which increased the EU funds 28-fold compared to previous program. Such investments reflect strongly the new competitive situation between regions and countries in the public investments in nanotechnology. In the 7th Framework Programme 2007-2013, the EU is planning to invest €3.5 billion during the seven-year period<sup>7</sup>. On top of this, member countries invested in 2003 double the amount invested by the EU (European Commission, 2004).

In Asia, Japan was among the first countries in the world to endorse nanotechnology-related research in the early 1990s with a ten-year research program centering on nano and meso-scale phenomena (Siegel et al., 1999). However, the program did not employ the concept of nanotechnology. The annual funding of nanotechnology grew steadily from some \$120 million in 1997 to \$270 million in 2000. In 2001 nanotechnology became one of the focus areas of research in Japan; in 2001 Japan invested \$400 million, \$800 million in 2003, and some \$950 million in 2005 (the figures have been taken from President's Council of Advisors in Science and Technology, 2005). In other Asian countries, South-Korea has invested some \$2 billion for a ten-year period, and Taiwan some \$600 million over a six-year period (European Commission, 2004). China is a rising superpower in terms of scientific activity also in nanotechnology (Zhou & Leydesdorff, 2006).

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<sup>6</sup> This information on funding has been taken from the European Commission website: [[http://cordis.europa.eu/nanotechnology/src/ec\\_programmes.htm](http://cordis.europa.eu/nanotechnology/src/ec_programmes.htm)]

<sup>7</sup> Source: [[http://cordis.europa.eu.int/nanotechnology/src/ec\\_programmes.htm](http://cordis.europa.eu.int/nanotechnology/src/ec_programmes.htm)]

The United States is the country that triggered the armaments race in nanotechnology with President Clinton launching the National Nanotechnology Initiative in 2000. Also before this there was already a large amount of research being conducted on nanotechnology. In 1997, US government agencies supported nanotechnology research with some \$116 million, and by 1999 there were also several universities with interdisciplinary centers for nanotechnology (Siegel et al., 1999). US investments increased gradually from \$190 million in 1998 to \$255 million in 1999 to \$270 million in 2000 (President's Council of Advisors in Science and Technology, 2005). The launch of the National Nanotechnology Initiative (NNI) made nanotechnology a strategic research topic in 2001. Investments in US have increased from some \$465 million in 2001 to more than \$1 billion in the year 2006<sup>8</sup>.

As Figure 1 in Essay I visually indicates, the investments across different regions have been very much in line with one another. This is not coincidental. The investments on nanotechnology between different countries have been following each other. The constant comparison to other regions has balanced out any major differences between regions. Interestingly, nanotechnology became the focus area of research in the EU, Japan and the US in 2001 or 2002. Even smaller regions are competing with one another and aim to create local 'nanoclusters'. Nanoclusters typically involve the strong research competence of local universities, which are spinning out from academic start-ups and cooperating with local small and medium sized companies as well as multinational companies. Industry-university collaboration has been seen as one central enabler of the development of nanotechnology and other emergent technologies. Nanotechnology still largely takes place in basic and applied research. It seems that the public funding on nanotechnology may be stabilizing to its current level (Lukkari, 2006). In the following I discuss the private funding allocated to nanotechnology.

### **3.2.2 Corporate and venture capital**

Lux Research (2004) estimates that of the \$8.6 billion invested globally in nanotechnology in 2004, \$3.6 billion was corporate money. Of this amount, 46% or \$1.7 billion was invested by North American companies; 36% or \$1.4 billion was by Asian firms; and 17%

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<sup>8</sup> Source: [<http://www.nano.gov/html/about/funding.html>]

or \$650 million by European businesses; and only under 1% (\$40 million) by companies in other regions (Lux Research, 2004). Government and public organizations are still leading investors in nanotechnology, which is an indication of the overall early stage development of the field. Much larger industry investments are likely to drive the R&D in nanotechnology, when companies begin to perceive more short-term business opportunities. A major part of the research and development of nanotechnology-related innovations is conducted in multinational corporations (MNCs). For example, the scanning tunneling microscope was invented at IBM, the single electron transistor at Bell Laboratory, and carbon nanotubes at NEC Laboratory. Table 3.1 presents the current nanotechnology research activities of some multinational companies. A major part of the current development areas is related to materials and tools, i.e. the enabling technologies. However, increasingly other domains are also covered such as nano- and quantum electronics and nanobio related areas.

<b>Company</b>	<b>Development areas</b>	<b>Funding &amp; research centres</b>
<b><i>DuPont</i></b>	Nanocoatings, color technologies, nanoelectronics and technologies	Partner in the Institute for Soldier Nanotechnologies
<b><i>General Electric</i></b>	Biomimetics, nanotubes, nanowires, nanocomposites, nanostructure optoelectronics	GE Global Nano Research
<b><i>General Motors</i></b>	Nanocomposites, hydrocarbon fuel cells	GM Nano Research Center
<b><i>Hewlett-Packard</i></b>	Molecular electronics, nanowires, nanodevices, nanocomputing, architectures, biochips, AFM	Quantum Science Center
<b><i>IBM</i></b>	Chemical AFM, magnetic imaging, dynamic force microscopy, nanoscale integrated circuits, quantum computing, self-assembly	Millipede
<b><i>Motorola</i></b>	Biochips, molecular electronics, nanotubes, AFM, self-assembly	Motorola Research Labs
<b><i>Xerox</i></b>	Nanoparticles, nanomagnets, nanoelectronics	Palo Alto Research Center

**Table 3.1:** *Multinational companies and their development activities in nanotechnology*  
(Berube, 2006: 221)

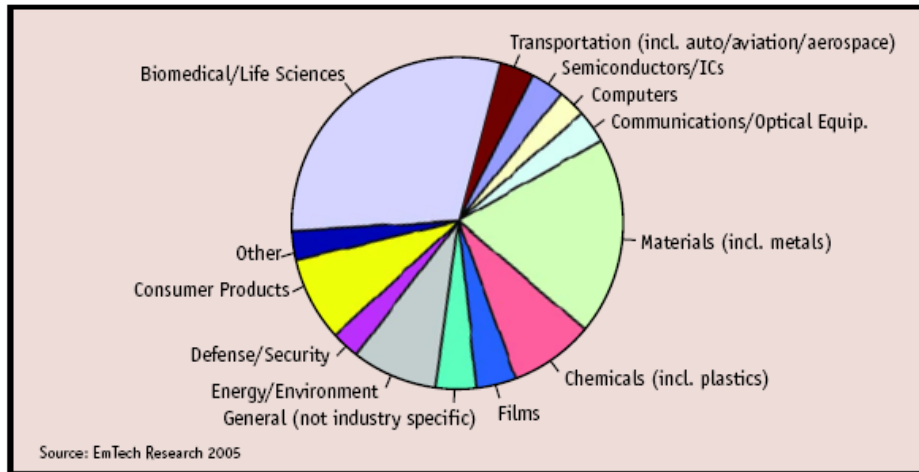
There have also been some venture capital investments in nanotechnology, but very few initial public offerings (IPOs) so far. Lux Research (2004) estimates that approximately \$1.1 billion of venture capital has been invested in nanotechnology between 1998-2004. Of this investment, 41% has been directed to electronics and semiconductors; 40% to nanobiotechnology; 14% to specialty chemicals and nanomaterials; and 5% to instrumentation (Lux Research, 2004). According to Berube (2006), more than 95% of the venture capital associated with nanotechnology is focused on enablers of nanotechnology in microscopy, nanomaterials and production tools. In 2004, the total venture capital investments in nanotechnology were about \$400 million (Lux Research, 2004). There are four publicly traded nanotechnology companies, including NanoPhase Technologies (IPO in 1997), Immunicon (2004), Cambridge Display Technology (2004), and Lumera (2004) (Berube, 2006). There is an increasing realization of the long development period for most nanotechnology products, which has made companies and venture capitalists more critical towards nanotechnology. Such realization has also taken the 'air' out of the nanotech-related stocks (Berube, 2006).

### **3.3 Business activity and products in nanotechnology**

The challenge of 'nanobusiness' lies in identifying which companies are truly occupied with nanotechnology rather than just positioning themselves into the sector and labeling their activity as nanotechnology. There are very few companies in the world that focus solely on nanotechnology – typically it is a part of some larger sets of applications or products, which companies serve to established industries. Figure 3.2 summarizes the private sector activity in nanotechnology. According to the EmTech Research (2005) survey, the largest industries active in nanotechnology are biomedical, and life sciences and materials. If plastics and films are also regarded as materials, then materials form the largest sector of the application areas (EmTech Research, 2005; President's Council of Advisors in Science and Technology, 2005). Figure 3.2 also establishes, how wide a range of industries nanotechnology covers, which further stresses that it is a horizontal field of activity and nanotechnology itself is an enabling technology for various applications. The US President's Council of Advisors in Science and Technology (2005: 22) identified also the near-, mid-, and long-term areas, where nanotechnology is likely to have a major impact.



These are presented in Appendix 2. The drivers of nanotechnology business today are materials, and tools for diagnostics and manufacturing, but there are also some consumer products on the markets. These are discussed next.



**Figure 3.2:** Target industries for companies involved in R&D, manufacture, sale and use of nanotechnology in 2004 (n=599) (source EmTech Research, 2005; President's Council of Advisors in Science and Technology, 2005)

### 3.3.1 Production tools

The production tools are the nuts and bolts of nanotechnology. The surge of government funding has resulted in establishing many new research and production units for nanotechnology. These centers need to be equipped with materials and tools that allow the observation, manipulation and production of nano-sized structures. A major part of public funds is directed to purchasing new tools and instruments, which has provided good business opportunities for tool and other enabling technology manufacturers. According to Smalltimes (2003), there are about 300 companies worldwide developing tools for nanoscale imaging, manipulation and manufacturing. This market is not enormous, but the tools represent the first products with revenues in nanotechnology (Smalltimes, 2003). The major companies in nanomicroscopy include Hewlett-Packard, IBM and Technical Instruments; in nanomaterials Altair International, Nanophase Technologies and Nanomat; and in production tools Intel, Molecular Imprints and Veeco (Berube, 2006). These tools used to be tailor-made, expensive and very difficult to use. However, the emergence of the

markets and competition for the tools has resulted in better production methods for the machines, which have become easier to use, more reliable and cheaper. Producing tools and instruments has proven to be an area of business, which has increased the R&D investments in the sector. The continuing development of the enabling technologies is crucial for the further development of the field of nanotechnology. However, both stabilizing levels of public funding and more modest growth in the number of nanotechnology research institutes may cause the tool producers to face a new situation in the nanotechnology production tools markets. On the other hand, companies may be increasingly joining this market, and acquire new manufacturing tools for mass production, which is currently an area of vigorous development in nanotechnology tools and instruments.

### **3.3.2 Consumer products**

The Nanoforum Report “Nanotechnology in Consumer Products” (Gleiche et al., 2006) summarizes the consumer products that are already in the markets and are utilizing nanotechnology. According to the report, the great majority of the current consumer products are based on the *interface effects*, where nano-sized particles are added to bulk material or on a surface. Bulk material behaves in the manner that is familiar to us. For instance, gold has the typical color and other characteristics, such a melting temperature and chemical properties, that enables us to recognize it. However, material in nanosize particles is not tied to the bulk of material, which averages out some chemical and physical interactions (Ratner & Ratner, 2003). Consequently, nanosize particles exhibit different characteristics compared to the bulk material. For instance, nanoparticulate gold is highly reagent, and has a different melting temperature and color (which depends on the size of the particle) from the bulk gold (Ratner & Ratner, 2003). Gold has been used since the middle-ages to dye glass red, which is a widely used example of ‘early nanotechnology’.

The surface products include, for instance, easy-to-clean surfaces for windows and sanitary products; anti-graffiti coatings for public spaces and transportation; antibacterial coatings for hospitals and sanitary products; waterproof textiles which employ Gore-Tex, based on Teflon; antifog coatings for windows and diving and swimming masks; scratch resistant paints for cars; UV protection used in e.g. sunscreens; liposomes used in body lotions; self-

cleaning surfaces; and fire protected coatings for various materials (also Gleiche et al., 2006). This is just to mention a few of the applications of the surface effects. Further, adding nanoparticles to bulk material changes the characteristics of the material, for instance by reducing the weight and increasing its tensile and impact strength (Gleiche et al., 2006). Examples of such products are tires to which are added carbon black particles; lightweight but strong construction materials; carbon composite materials in tennis rackets and so forth (also Gleiche et al., 2006). The developers and sellers of these products are both established multinational companies (Amer, L'Oreal, Pilkington, DuPont, to mention few) and smaller start-ups capitalizing on some innovation related to active materials. The products based on interface effects are highly dependent on the development of new materials and composites.

There are rare products in nanotechnology that actually draw from the *quantum-mechanical effects* that are revealed by the small size scale. According to the Nanoforum Report (Gleiche et al., 2006), these are tunneling effect, and giant magneto resistance (GMR) and tunneling magneto resistance (TMR) effects. Tunneling effect is used in flash memories to store electrons on an electrically isolated gate, but it is also used in tunneling magneto resistance (TMR) elements to separate adjacent ferromagnetic layers (Gleiche et al., 2006). TMR is employed in non-volatile memories (MRAM: magnetoresistive random access memory), which are today still under development (Gleiche et al., 2006). GMR, on the other hand, is widely used in read-and-write heads of hard disc drives (Gleiche et al., 2006). It is 'true' nanotechnology in every way, and presents a multi-billion euro business annually. However, interestingly, it has not been widely adopted into the charts presenting the size and growth of nanotechnology business. A former director of a major American data storage company stated on GMR,

*And you may not know this with all the talk and hype about nanotechnology, the biggest single revenue generating product using true definition of nanotechnology is the computer hard disc drive because giant magneto resistance is an entirely new phenomenon that happens at that scale, new physics that allows us to operate computers and this data storage. [...] It is 100-200 billion revenue in dollars. [...] The next big one is actually cosmetic products and suntan lotions. [...] So it tells you how much hype is here. Both of these happened with very little, in fact, nothing to do with nanotechnology initiative and the hype with nano. These were done by companies, who needed [...] breakthroughs to extend their product line. Necessities of moderate inventions...*

Consequently, there are many products in e.g. materials and memories that have been available in the markets already before the nanotechnology buzz happened. Some of them have been labeled as nanotechnology along with the nanohype. However, it is peculiar that some have been excluded from this ‘market’ while collecting the statistics on nanotechnology. Adding a 200 billion data storage market to the current estimates of nanotechnology-related product markets might have a negative impact to the perception of novelty and ‘mysteriousness’ of nanotechnology.

### **3.4 Nanotechnology as a research context**

As a result of the described drivers and characteristics of nanotechnology, it provides an excellent context in which to study micro-level processes in the emergence of new technological fields for several reasons. Firstly, nanotechnology has its origins in the futurist visions from which it became embedded in popular culture, and only later has been adopted in science. This provides a unique and extremely interesting context in which to explore the early contestation of competing cognitive frames by different actors, as presented in Essay I. Secondly, nanotechnology has emerged about the same time across different localities in industrialized countries. The dynamics of local emergence are contrasted and compared with another emerging field, functional foods, in Essays II and III. Thirdly, the local emergence processes were enabled to a differing extent by the massive attention and surge of funding to nanotechnology, which has had an important overall impact on the specific dynamics of the emergence of the nanotechnology field. The resulting demand for activities has contributed to strong institutionalization of this technologically emergent field, which has also provided tools and resources for entrepreneurial individuals and organizations to exploit. The consequences of the strong demand for nanoactivity are discussed in particular in Essay IV, but also in Essays II and III.



## 4 METHODOLOGY

In this section I describe the data for the thesis, and explain the methods that were used in the data collection and analysis. The methods for each paper are discussed in the essays. Hence, in this introductory section I concentrate on the common issues for all the essays or on such methodological issues as I have not been able to discuss in the essays. In this section I first reflect upon the choice of methods, and after that present the data and methods for data collection and analysis. At the end of the section I discuss the underlying ontological and epistemological assumptions that have guided this research.

### 4.1 Choice of methods

This research employs qualitative methods to investigate the phenomenon of field emergence. Qualitative, interpretive methods are especially suitable when the aim is to explore the emergence of new domains of social reality (see also Lee, 1991). As discussed, in this thesis the underlying assumption is that field emergence is a process of social construction, where individuals, organizations and groups of actors jointly shape the meanings and understandings of what later becomes a new field (also Kenis, 1992). I have used different research strategies to investigate this process. The research adopts a case study approach to investigate the emergence of nanotechnology as a field of social action. Nanotechnology represents an exploratory case study, which can be characterized as similar to Columbus' exploration of the New World, where some rationale and direction guides the exploration even though the initial assumptions may be wrong, and the 'reality' [or researcher's more elaborate interpretations of it] will be exposed during the exploration (Yin, 2003). However, according to Stake (2005), the case study is not a methodological choice but a choice of what is studied. Case studies provide the tools to understand both *how* and *why* questions through the use of various sources of data, such as interviews and public and private documents (Yin, 2003). Further, all the essays in the thesis involve more than one unit of analysis due to the multilevel nature of the phenomenon under

investigation. Hence, I have adopted an approach similar to Yin's (2003) holistic design. The aim of the empirical research is to increase understanding of the core concepts and new ideas (Sutton, 1997) brought about by nanotechnology, and to investigate the connections between them, with the aim of developing new theoretical insights.

Due to the complexity of the technology and the concepts in question, the starting point for the research was to make sense of what nanotechnology is. In the beginning I used a grounded approach (Glaser & Strauss, 1967) to do this. I had some expectations and attitudes towards nanotechnology, but I knew very little about the antecedents, actors, technologies and potential impacts of nanotechnology. Thus, the initial stage of the research was concerned with sense-making of both the empirical context of the research as well as finding suitable theoretical and conceptual approaches to address it. Extensive interviews, combined with an analysis of the publicly available and more exclusive documents were a powerful (and perhaps the only) means to create an in-depth understanding of this novel field of activity. Glaser and Strauss (1967) stress that the grounded method is a process. This, according to Charmaz (1983 in Easterby-Smith et al. 2002), results in the discovery that theory and development proceed simultaneously, and the processes and outcomes of research are shaped from the data rather than from preconceived logically deduced theoretical frameworks. Dubois and Gadde (2002) call the approach, where theoretical framework, empirical framework and case analysis coevolve, systematic combining. Also for this research, data collection was an iterative process, where I made several dives into the data, which was followed by the need to immerse myself into the literature to make sense of the observed phenomena.

The collected data have been exploited differently in each essay (refer to Table 4.1 for a summary of methodological choices for the essays). Essays II and III present comparative two-case case studies (Yin, 2003) in an attempt to investigate field emergence with possibilities for some broader generalization. A two-case case study combines contextual insight, i.e. the strength of rich and deep descriptions of a single case (Dyer & Wilkins, 1991), and the replication logic of multiple case studies (Eisenhardt, 1989). Comparing the two cases forced us, the authors of the comparative essays, to understand both cases in depth in order to identify some commonalities and differences between them. We were also both forced to expose our ideas to the scrutiny and critique of the co-author. Also,

having two authors for these articles provided a ‘stereo view’ on the topic, which resulted in a deeper, multidimensional view of the topic. Further, comparing two cases as the joint effort of two researchers enhanced the creative potential of the research and helped us to overcome some problems related to bias and validity (Eisenhardt, 1989), but also to foster broader and more reflexive consideration of the research context (Cox & Hassard, 2005). Consequently, Essays II and III combine data triangulation with investigator triangulation (Denzin, 1978).

<b>Essay #</b>	<b>Research question</b>	<b>Level of analysis</b>	<b>Research strategy</b>	<b>Data collection methods</b>	<b>Analysis methods</b>
<b>I</b>	How do institutional entrepreneurs engage in creating, mobilizing and counter-mobilizing field frames, and with this activity contribute to the emergence of new technological fields?	Micro and meso	Field analytic approach	Interviews, content analysis of newspaper stories	Coding interviews, content analysis
<b>II</b>	How do institutional entrepreneurs draw from their status and relational embeddedness to induce the emergence of novel science-based fields?	Micro and meso	Comparative case study	Interviews, archival data	Qualitative cross-case comparisons
<b>III</b>	How do institutional entrepreneurs in science-based fields mediate between globally circulating discourses and local institutions and competences?	From macro to micro and from micro to macro	Comparative case study	Interviews, archival data	Qualitative cross-case comparisons
<b>IV</b>	How do externally validated form identities emerge, and how opportunistic actors take advantage of those identities during form emergence?	Micro and meso	Grounded theory, analysis of discourses	Interviews, content analysis of websites	Coding interviews, content analysis

**Table 4.1:** *Summary of the methodological choices in the essays*

Essays I and IV investigate the field emergence in a single case setting, which makes it possible to draw a more accurate picture of the features that are special for nanotechnology. Many of the classic case studies are in-depth analyses of single cases (common examples include Allison, 1971 and Selznick, 1949). According to Dubois and Gadde (2002), the interaction between a phenomenon and the context in which it takes



place is best understood through in-depth case studies. The more cases are studied, the less the researcher has a chance to gain understanding of the deeper social dynamics and the tacit and less obvious aspects of the phenomenon under investigation (Dyer & Wilkins, 1991). Further, nanotechnology is in many ways both a unique and extreme case (Yin, 2003) of field emergence, as will be further explained in the essays, which also justifies such a focus. Because the essays with a comparative case setting were written first, a critical approach towards the single case was also gained in the process. As a result, it was easier to identify and analyze the special characteristics of the emergence of nanotechnology, in particular, in the essays that draw from single cases.

## **4.2 Data and data collection**

According to Peräkylä (2005), the interview is a very popular method for collecting data because it allows the researcher to access areas that would otherwise remain inaccessible, such as people's experiences and attitudes. It also provides a way to have access to past events and experiences by interviewing people who took part in them (Peräkylä, 2005). However, interviews tend to be plagued by post-hoc rationalization and selective remembrance of past events. Conducting many interviews on the same field of activity results in an understanding of what happened and renders more interpretations of the events visible. Combining interviews with other qualitative data collection methods helps in building a more comprehensive understanding of the events across time and space. Hence, to uncover the processes of field emergence, this research draws from three sources of evidence: interviews, content analysis of newspaper articles, and other public documents.

### **4.2.1 Interviews**

According to Bertaux and Bertaux-Wiame (1981, in Eskola & Suoranta, 1998), qualitative data reaches saturation point during some stage in the inquiry, when collecting more data does not translate into additional information. The amount of interviews needed for reaching saturation point varies according to the research topic, but Eskola and Suoranta (1998) suggest that 15 interviews is estimated to be sufficient per cultural area. Consequently, such a number was held as a rule of thumb for the interviews. The principal

data set consists of 57 interviews, of which 21 were conducted in Finland, 17 in Öresund, a region bringing together Eastern Denmark and South-Western Sweden, and further 16 in California. The interviewees included people from the following groups: researchers, representatives of large multinational companies and small start-ups in nanotechnology related activities, representatives of public funding agencies and lobbying organizations, and venture capitalists. The interviews took place between November 2004 and June 2007, and started with a pilot inquiry. During the pilot phase of the research 11 interviews were conducted in Finland between November 2004 and March 2005. This helped with building an understanding of what nanotechnology is – and is not – about. These initial informants were people that had given talks about nanotechnology in workshops and seminars in which I had participated prior to starting with the interviews. From these interviewees and public documents I obtained more names of the people to be interviewed.

After the analysis of the pilot interviews, I moved to the second phase of interviews from August 2005 onwards. Firstly, I interviewed the rest of the people in Finland that I had identified as important for the local emergence of nanotechnology. Secondly, I had a contact person<sup>9</sup> in the Öresund region, who helped me to find the informants for the first round of interviews in September 2005. During these interviews, again, more names of the significant people in the Öresund region came up, whom I then interviewed during my second trip to Öresund in October 2005. The third set of interviews was conducted in California between March and May 2006. A major part of the interviews in California were carried out jointly with a colleague Fredrik Hacklin from the Swiss Federal Institute of Technology. The informants were found with the help of a local informant<sup>10</sup>, who also helped with access to the interviewees, as well as industry catalogues. The interviews lasted some 70 minutes in median, varying from 30 to 240 minutes. All interviews were recorded and transcribed verbatim.

Semi-structured interviews permitted me to cover a pattern of questions, but also allowed the interviewees to influence the direction of the interviews. In each interview, the informants were asked to tell me what is new and significant in nanotechnology from their point of view. Hence, the informants were themselves allowed to define the novelty aspect

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<sup>9</sup> My sincere gratitude to Mattias Dinnetz of Nano Öresund.

<sup>10</sup> The assistance of Judy Kleinberg, Council Member and Mayor of Palo Alto, is gratefully acknowledged.

of nanotechnology. Further, the informants were asked to describe their activities related to this emerging field in order to understand the technologies and the context in which the informants were working. Informants were also asked to explain the core technologies and what part nanotechnology plays in their work. The interview protocol is presented in Appendix 3. Consequently, the interview situation was not standardized, where a preset pattern of questions defines what the informant is supposed to perceive as important. Such an approach imposes the interviewer's perceptions on the informant. Rather, the interviews were open and active social situations, where the interviewer's role was to activate narrative production (Holstein & Gubrium, 1997). I was actively present but my aim was to make the questions as open as possible to guide the situation and the informant in the least possible way, but still have some control of the direction and content of the discussion. I acknowledge that interview is a moment of construction of knowledge between informants and interviewers (Holstein & Gubrium, 1997), and that each interview was a unique event.

#### **4.2.2 Newspaper stories**

It was important to move backwards in time from the present discourse of the interviews, and build a timeline that chronicled the early emergence and consequent framing activities of the media. News stories describe well the initial actors, perceptions and media framing of nanotechnology without post-hoc rationalization, and hence, complement the interview data. I started collecting newspaper stories by making a search for the searchwords 'nanotech\*' and 'nanoscien\*' in the Factiva database on the top US newspapers. After removing the duplicates, during the years 1986-1994, 1996 and 1998 there were 24 or less hits and all the articles of those years were analyzed, resulting in 111 articles. During the years 1995, 1997, 1999 and 2000, the articles on the 1<sup>st</sup> and 15<sup>th</sup> day of the month, or closest after were selected. This resulted in 96 news stories. Consequently, altogether 207 news items were analyzed.

#### **4.2.3 Publicly available documents**

A variety of publicly available documents, i.e. reports, books, presentations and transcripts related to nanotechnology form the third source of evidence for this research. During the early phase of the research I read books on nanotechnology, such as Ratner and Ratner

(2003) and Scientific American on Nanotechnology (Scientific American, 2002) and various reports by The National Technology Agency of Finland, VTT Technical Research Centre of Finland and by the EU Commission. Also the reports by Budworth (1996) and Koponen (2002) gave an initial understanding of the foundations of nanotechnology in general and Koponen especially for the Finnish context. The presentations in the workshops and seminars formed another important source of information. Despite these documents not being analyzed as such for this research, they provided valuable background material for further investigation. In the later phase of the research, however, I analyzed the transcripts of two US Congressional Hearings, where nanotechnology in its early stage was discussed. The first hearing took place on June 26, 1992 on the topic “New Technologies for a Sustainable World”, and it was held by the US Senate Committee on Commerce, Science, Technology, and Space. The second hearing was a part of the preparation for the National Nanotechnology Initiative and it was held on June 22, 1999. The hearing was called “Nanotechnology: the State of Nanoscience and Its Prospects for the Next Decade”. Both documents include a transcript of the hearing, and formal written testimonies of the witnesses on the issues in question. The first document is 62 pages and the second 143 pages long with appendices.

### **4.3 Data analysis**

Methods for data analysis are presented more in detail in each essay. However, an overview of the analysis of different data is presented in the following.

#### **4.3.1 Analysis of interviews**

In the pilot phase of the research it was important to understand what nanotechnology is, and what is new and significant about it. The interviews conducted during the pilot phase were analyzed first, and the interview strategy modified for the following interviews according to the findings of the pilot study. Throughout the data collection, interviewing was an iterative process, where the research questions evolved along with the understanding of the field. Consequently, the data analysis already started during the fieldwork phase. According to Eisenhardt (1989), overlapping data analysis and data

collection allows the researcher to be flexible during the data collection and make adjustments accordingly. Also, data collection and analysis are inherently intertwined and cannot be separated, because the research tool is the mind of the researcher, and some learning inevitably takes place during the interviews, affecting both interviews and analyses.

Interviews present the first immersion into the data. The second and far deeper immersion takes place during the transcription of the interviews. All the interviews were transcribed verbatim. The process is slow and cumbersome, but essential for getting to know the data well. I transcribed myself all but nine interviews, which were transcribed by an undergraduate student<sup>11</sup>. After transcribing, all the interviews were coded in NVivo, a computer assisted qualitative software. The coding was conducted by reading and re-reading the interviews during several rounds of analysis. I started by coding about one third of the data first, due to the massive amount of the transcribed pages. After this initial round of analysis I took a careful look at my emergent categories and modified them according to my learning and experience from this initial coding. Then I started the coding again from the beginning. During the first full round of coding all the interviews, some further modifications were made to the coding scheme. Hence, I coded all the interviews once more, resulting in some two and one third rounds of coding. After this, the emergent categories were analyzed and the coded texts in each category were read through carefully a number of times. This initial analysis revealed that by far the most loaded category was the one related to the discursive nature of nanotechnology that became named as 'Nanolabeling and nanohype'. After immersion into the data, it emerged as an aspect that was common in the emergence of nanotechnology across all the groups of informants in all regions. There were also other emergent categories, such as commercialization of nano (however, many informants said that it is no different to any commercialization of new technology); the division of labor between public and private sector in the development of nanotechnology (however, again, there are arguably relatively clear roles, which apply to nanotechnology as well); and many definitions and description of technology, which provided the essential understanding of the novelty or path-dependency of nanotechnology. This analysis essentially guided the papers that I wrote and the theoretical frameworks that I employed in those papers.

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<sup>11</sup> My sincere gratitude to Julian Sommer of the Swiss Federal Institute of Technology in Zurich

### **4.3.2 Content analysis of newspaper stories**

All 207 newspaper stories were analyzed in an Excel spreadsheet as follows: Firstly, I gave each news story an identification number. Secondly, I identified the actors related to nanotechnology that were mentioned in the text (0=corporate researcher, 1=researcher in university, 2=government actor, 3=business or economy related actor, 4=futurist, 5=private funder, 6=fiction author incl. science fiction, 7=other, 9=columnist, 10=TV and movies related actor, 11=artist). Thirdly, I identified what kind of attitude towards nanotechnology the news story signaled (1=very negative, 2=negative, 3=neutral, 4=positive, 5=very positive). Fourthly, I identified the country of origin of the newspaper as presented in Section 4.2 for the first round of analysis. In addition to this, a short description of the topic of each news story was written. Then I cross-tabulated the actors across the years as well as the perceptions on nanotechnology they presented to illustrate their views and how each group of actors was presented in the media in relation to nanotechnology. With this analysis I was able to investigate the framing of nanotechnology by the media and the emergence of meaning within various groups of actors in a more systematic manner. The results of this analysis are presented in Essay I.

### **4.3.3 Publicly available documents**

As I mentioned in the previous section, various publicly available books, reports and presentations were used as a source of information for this research, but were not formally analyzed. However, they contributed in forming an initial framework for further data collection and analysis. Towards the later phases of the research I analyzed two Congressional Hearing transcripts. The data analysis was conducted by identifying the different actors in the documents and the frames or understandings of nanotechnology they promoted. These were coded and illustrative quotations were selected to present the framing activities of different groups of actors. The Congressional Hearing documents were used as data for Essay I on studying who were the ones chosen to represent the community of nanotechnology, and what kind of arguments they were using for persuasion and framing nanotechnology as an important area for national level investment.

#### **4.3.4 Comparative data set**

The comparative data set on functional foods presented in Essays II and III was collected by Tiina Ritvala, a doctoral student from the Helsinki School of Economics. This data set consists of 32 interviews of public research organizations, managers of start-up firms and food and pharmaceutical multinational corporations as well as other field participants such as a legislative authority and external consultants. The interviews were conducted in Finland and the US between August 2004 and April 2007, and they focused on the dynamics of the emergence of functional foods. Ritvala also conducted a trade journal analysis of *New Nutrition Business*, the oldest journal on the business of food, nutrition and health. The data set for functional foods also included a variety of documents such as industry reports, symposium materials, and legislative proposals. Further, Ritvala conducted a patent analysis in the United States Patent and Trademark Office's online search engine and esp@cenet worldwide database of the European Patent Office to investigate the patenting activity in cholesterol lowering functional foods. Finally, Ritvala utilized the U.S. Food and Drug Administration (FDA) Center for Food Safety and Applied Nutrition web service in investigating the emergence of cholesterol-lowering functional foods market in the U.S. Documents relating to health claims, petitions, and FDA response letters and discussion papers were evaluated. The comparative data set on functional foods helped in the mutual endeavor to find common and divergent characteristics for the emergence across different fields.

#### **4.4 Validity and reliability**

Validity is a debated issue, which manifests the differences between paradigms. According to Lincoln and Guba (2000), despite such disagreements, there are two sets of arguments that are typically taken into account when discussing the validity of qualitative research. The first one is borrowed from positivism, and it argues for a kind of rigor in the application of methods, and the second argues for both community approval and a form of rigor in assessing the salience of one interpretation over another and for positioning the interpretive study itself (Lincoln & Guba, 2000). In this section, I discuss first the more traditional views on validity in qualitative research with the help of Maxwell (2002), who

distinguishes between descriptive validity, interpretive validity, theoretical validity, generalizability and evaluative validity; and Yin (2003), who has identified construct validity, internal validity, external validity and reliability. These ‘validities’ are based on a realist ontology and are partly overlapping and partly complementary. They provide a guideline for reflecting certain aspects of rigor present in my research. This is followed by the discussion of interpretive and naturalistic views on validity following Lincoln and Guba (2000). The discussion on validity is summarized in Table 4.2.

<b>Type of validity</b>	<b>What does it mean?</b>	<b>How addressed in this research?</b>
<b><i>Descriptive validity</i></b>	Factual accuracy of data collection and recording methods	Use of recording devices, careful transcription of interviews
<b><i>Theoretical validity</i></b>		
Construct validity	Correct operational measures	Multiple sources of evidence, having the informants read case reports
Internal validity	Establishing causality, internal cohesion	Pattern-matching, explanation-building
<b><i>External validity</i></b>		
Internal generalization	Generalizing within a community or group	In-depth case study and comparative case study
External generalization	Generalizing to other communities	Comparative case study
<b><i>Reliability</i></b>	Repeatability of the study and ending with similar conclusions	Explicit reporting of the steps of the research, developing databases
<b><i>Interpretive validity</i></b>	Understanding the stance of the informant, views of validity of different interpretive communities	Interviewing many within a community, establishing the domain of contribution of the research
<b><i>Validity as authenticity</i></b>		
Ontological and educative authenticity, evaluative validity	Increasing awareness of the topic, engaging in moral critique; application of an evaluative framework to objects of study	Aim is not to make value statements in this research; however, apparent in the basic assumptions of the researcher
Fairness as authenticity	Quality of balance, all stakeholder views are present	Interviewing multiple communities and reporting many voices
Catalytic and tactical authenticity	The way in which inquiry induces action; training of the stakeholders	Popularizing the findings of the research

**Table 4.2:** *Validity and reliability in the research*



*Construct validity* refers to establishing the correct operational measures for the concepts under investigation (Yin, 2003) and, thus, forms the basis for qualitative research design. According to Yin (2003), in case studies construct validity is enhanced by using multiple sources of evidence, and establishing the chain of evidence. As I discussed in the previous section, the current research draws from multiple sources of evidence such as interviews and extensive content analysis of newspapers and other documents. Immersing myself into this data, in addition to other documents such as reports and various statistics, has helped with establishing an understanding of how the events related to the phenomena under investigation unfolded. Also, a way to assess construct validity is to have the key informants to review the drafts of the case study reports (Yin, 2003), which I have also done with the case reports.

According to Maxwell (2002), *descriptive validity* creates another basic foundation for the validity of a research. It refers to the factual accuracy of a researcher's account, e.g. to the accuracy of data collection and recording methods (Maxwell, 2002). During the field phase I recorded and transcribed all the interviews. Hence, the possibility of mistakes and selective memory in note taking was eliminated. I was also able to return to both tapes and transcripts later and assess what, how and in what context something was said. A further form of validity is *internal validity*, which according to Yin (2003) is valid for explanatory or causal studies only, and not for descriptive or explanatory studies. This research falls into the latter category. However, e.g. pattern-matching and explanation-building (Yin, 2003) were employed in this research. I made several rounds of analysis of both interviews and public documents, and patterns and categories began to emerge from the data as a result of this analysis. NVivo, a qualitative data analysis software, provided a tool for both pattern-matching and explanation-building.

*Theoretical validity* as described by Maxwell (2002) signifies an account's validity as a theory of the phenomenon under investigation. According to him, any theory has two components: the concepts or categories that the theory employs, and the relationship that is proposed to exist between these concepts. Consequently, this results in two levels of validity of such accounts: the validity of the concepts themselves and their applicability to the phenomenon, which comes very close to construct validity; and the validity of the

proposed relationships between the concepts, which is very similar to internal validity (Maxwell, 2002).

Another set of validity arguments is related to the generalizability of the results of the study. *External validity* refers to the generalizability of a study's findings (Yin, 2003). Maxwell (2002) distinguishes between two types of generalizability: *internal generalizability* i.e. generalizing within a community, group or institution to settings that were not studied; and *external generalizability*, i.e. generalizing to other communities. For the current research, internal generalizability draws from the deep immersion into the single-case study of nanotechnology, and the generalizability may take place within different groups of actors in this field of activity. Both internal and external generalizability were addressed by comparing the emergence of new fields in functional foods and nanotechnology, and mapping the similarities and differences between them. Essays II and III present some commonalities that were promising in their application to the investigation of other emergence processes. However, such generalization is analytical rather than statistical (also Yin, 2003). Also, I have reported carefully in the methodology section how I have conducted the data collection and analysis, which gives the necessary information for another investigator to replicate the study.

Reporting how the research was done also contributes to the *reliability* of the research. Reliability means the extent to which a later researcher or 'auditor' could follow the same procedures and come to the same conclusions as described by the initial researcher (Yin, 2003). This stresses the transparency of the research process. In addition to carefully documenting all the phases of this research, I created a database in which I wrote down the information from all the interviews. In addition, the interviews were carefully transcribed, which according to Peräkylä (1997) provides "a highly detailed and publicly accessible representation of social interaction". I also created a database for the content analysis of articles. These databases make the data visible and can easily be accessed and audited by another researcher.

However, there may be criticism that the above approaches to a large extent extrapolate the perceptions of validity and reliability from quantitative, positivist tradition to qualitative, interpretive research. For example, the perception of causality assumed for internal validity

is too narrow and naïve to address the empirical, experiential world, where complex webs of events are linked with complex webs of outcomes and are embedded in the specific context in which they occur. A researcher may need to confine herself to the fact that there are multiple explanations and interpretations for a certain set of events and its outcomes. Secondly, regarding the reliability of the research results and the replication of the study, as I discussed in Section 4.2, each interview is an occasion of social construction, which is dependent on the experiences and characters of, and interaction between, the interviewer and the informant. Hence, a different informant would inevitably come to at least a somewhat different interpretation of the events.

This brings us to *interpretive validity*, which refers to the aspect of understanding “the phenomena not on the basis of researcher’s perspective and categories but from those of the participants in the situations studied”, and is unique to qualitative research (Maxwell, 2002: 48). Further definition for interpretive validity by Altheide and Johnson (1994) is that validity depends on the interpretive communities or the audiences to whom the research is presented, as well as on the goals of the research. Hence, validity is perceived differently by different audiences (Altheide & Johnson, 1994). As a result, at minimum the goal is to become familiar with the context, where the informant operates. This was achieved in this research by interviewing many people from the same group or community. However, the informants were only interviewed once, which necessarily leaves a superficial understanding of the stance from which the informant speaks. This is where the large quantity of interviews poses a challenge for validity. Another way to address the interpretive validity is to define to which community or school of thought this research is intended to contribute. These are described in the Introduction and Literature review sections.

What kind of research setting is chosen and how the events are interpreted and transformed into written accounts depends on the evaluative framework, which draws from the ontological and epistemological standpoint of the researcher. Also the perceptions of whether a research should have emancipatory goals are intertwined with such views. *Evaluative validity* refers to value statements and applications of an evaluative framework to the objects of study rather than a descriptive, interpretive or explanatory one (Maxwell, 2002). Evaluative validity moves towards what Guba and Lincoln (1989) in Lincoln and Guba (2000) call *validity as authenticity*. In their account validity as authenticity

refers to ontological and educational authenticity, fairness, and catalytic and tactical authenticities. These draw from the criteria for judging the processes and outcomes of naturalistic or constructivist inquiries. *Ontological and educative authenticity* designates the criteria for raising the level of awareness of different stakeholders and engaging in moral critique during and after the research process (Lincoln & Guba, 2000). This is to some extent related to Maxwell's evaluative validity and critique and the researcher is able and bound to present drawing from the findings of the research.

However, to be able to have a balanced view and account of the events, *fairness* rises into an important role. Fairness refers to a quality of balance, where all stakeholder views, claims and voices should be apparent in the text so as to prevent the marginalization of certain parties (Lincoln & Guba, 2000). In this view, omission of a participant voice presents a form of bias (Lincoln & Guba, 2000). During the data collection I aimed to identify all the groups of actors that played a role during the emergence of nanotechnology, and in retrospect, to a large extent I succeeded. I interviewed members of what today are the marginalized actors in nanotechnology and have critically discussed their role and perceptions of the emergence of nanotechnology, especially in Essay I. However, during the data analysis new groups were also identified, such as non-governmental organizations that began to claim regulation and control of nanotechnology in early 2000, and laymen. On the other hand, due to issues such as the focus and cohesion of the research, setting boundaries for the data collection is necessary. The differing views and voices of the interviewed groups are seen in the essays, especially in Essays I and IV, which present the in-depth single case inquiries on nanotechnology.

Finally, Lincoln and Guba talk about *catalytic and tactical authenticity*, which signifies the way in which an inquiry induces action on the part of research participants, and the participation of the researcher in training the stakeholders of the research. This study is not action research, nor has it the aim of influencing or generating any major action. However, in a general vein I do have the aim to popularize the research results to wider audiences, and such reporting may have some direct or indirect policy or organization level impacts.

The approaches to validity presented by Lincoln and Guba (2000) propose that qualitative studies have emancipatory goals. Such goals are less obviously present in the current

research, where I have abstained from making value statements on whether some action or development is good or bad. However, I acknowledge that my 'evaluative framework' is reflected in the overall choices and assumptions that underlie this research, which I discuss in the next section in more detail. Some of these I am able to identify and analyze, and some of them remain invisible to me because they have been so deeply internalized over a long period of time.

#### **4.5 Some ontological and epistemological considerations**

Perhaps the most challenging task of this research has been to define my ontological and epistemological standpoint as a researcher. This PhD thesis draws mostly from constructivist assumptions. Constructivism draws ontologically from relativism, where realities are locally and specifically constructed; epistemologically from transactional and subjectivist findings; and methodologically from hermeneutical and dialectical approaches (Lincoln & Guba, 2000). In Blaikie's (2003: 203) words, "a constructivist ontology entails the assumption that social reality is produced and reproduced by social actors; it is a preinterpreted, intersubjective world of cultural objects, meanings and social institutions". Hence, "'reality' is determined by people rather than by objective and external factors" (Easterby-Smith et al., 2002: 30). As a consequence of such a position, in any social situation there are multiple realities (Blaikie, 2003). Epistemologically this means that rather than collecting facts and measures of the occurrence of certain patterns, social scientists should appreciate the different constructions and meanings that people attribute to their experiences (Easterby-Smith et al., 2002).

Giddens' (1976; 1984) structuration theory, inherently constructivist in its ontological assumptions (Blaikie, 2003), has provided guidance in method and form for the current research. The basic interrelationship for this research is the one between actor and structure, which was discussed briefly in Section 1.2. The aspect of structuration theory that is of interest for the current research and also widely adopted in the academic community, is the relationship between individual and society, and between agency or action and structures, which also represent the relationship between the deterministic and voluntarist theories of human behavior (Blaikie, 2003). According to Giddens (1976: 157),

*The production of society is brought about by the active constituting skills of its members, but draws upon resources, and depends upon conditions, of which they are unaware or which they perceive only dimly.*

Giddens (1976: 157) identifies three aspects of production of interaction: the constitution of meaning, morality and relations of power, and continues,

*The means whereby these are brought into being can also be regarded as modalities of the reproduction of structures: the idea of duality of structure is a central one here, since structures appear both as condition and consequence of the production of interaction.*

By the ‘duality of structure’, Giddens means that “social structures are both constituted by human agency, and yet at the same time are the very *medium* of this constitution” (Giddens, 1976: 121, emphasis in original).

Giddens' levels	Social research occurring at this level	Present in essays
Level 1	Hermeneutic elucidation of frames of meaning	I, III, IV
Level 2	Investigation of context and form of practical consciousness	I, II, III
Level 3	Identification of bounds of knowledgeability	I, III
Level 4	Specification of institutional orders	I, II, III, IV

**Table 4.3:** *Giddens' (1984) four related levels of social research and their presence in the essays*

This has many implications for social research (these has also been discussed in Blaikie, 2003). Giddens (1984: 327) suggests that social research can occur at four related levels: 1) hermeneutic elucidation of frames of meaning; 2) investigation of context and form of practical consciousness; 3) identification of bounds of knowledgeability; and 4) specification of institutional orders. This implies that in the endeavors of the current research to investigate field emergence, the researcher can move from exploring the birth of a concept and answering the why-questions that originate from “the mutual unintelligibility of divergent frames of meaning” (Giddens, 1984: 328) (level 1); to the emergence across different contexts within a society or between societies, with the aim to establish generalizations about its common elements (Giddens, 1984; Blaikie, 2003) (level

2); to identifying the limits of social actors' knowledgeability in shifting contexts (Giddens, 1984) (level 3); and analyzing the conditions of social and system integration by discovering the main institutional components in field emergence both on a societal scale or that of smaller or larger systems (Giddens, 1984; Blaikie, 2003;) (level 4). The content and composition of each essay in this research is consistent with such guidelines, as depicted in Table 4.3. Also, Pettigrew (1997) and Pettigrew et al. (2001) point out that it is necessary to examine embeddedness through multiple contexts and levels of analysis while studying organizational change. According to Pettigrew et al. (2001: 698), "theoretically sound and practically useful research should investigate the contexts, content, and process of a change together with their interconnections over time". Giddens' (1984) structuration theory also encourages such an approach, and results in multilevel accounts in explaining social emergence and change.

According to Easterby-Smith et al. (2002), even though it is possible to form comprehensive lists of assumptions and methodological implications that each paradigm carries, it is not possible to find a single philosopher who would subscribe to all the aspects of a particular view. Hence, such definitions of paradigms present ideal types, and the researchers move in the terrain between them. In a similar vein, it is not entirely given that the methods I (or we, where appropriate) have used and the choices I have made in the essays are unambiguously constructivist and follow constructivist guidelines. During the research process, I have been moving in the gray terrain between realism and constructivism, and pondering to what extent social reality exists independently from the observer, and how much I as a researcher am trying to approximate the reality as opposed to making interpretations of the social world that is visible to me. This thesis is also a representation of this process. Hence, writing the PhD thesis has been an iterative process, where the understandings, views and awareness of positions evolve and unfold along with the research.

## 5 SUMMARIES OF THE ESSAYS

The main body of the thesis consists of four essays, each of which addresses the micro-level activity in the emergence of new technological fields from different perspectives. Table 5.1 provides an outline of the essays, and a summary of each essay is presented below to provide a short introduction to the main literature, data, findings and contributions of the essays for the overall thesis. The complete essays are provided in Part II of the research.

### **Essay I:**

**Granqvist, N. & Laurila, J.**

#### **Mobilization by framing – The emergence of the US nanotechnology field, 1986-2000**

Essay I develops a perspective that exploits and extends both the social movement and institutional entrepreneurship literatures through the study of the recent emergence of the US nanotechnology field. These conceptual perspectives are especially helpful in understanding the processes through which different actors created and disseminated competing understandings of what the nanotechnology field was about, and how this corresponded with and contributed to the development of the field. The study focuses on the early micro-level framing, i.e. activity where the “schemata of interpretation that enable individuals to locate, perceive, identify, and label occurrences” (Goffman, 1974, in Benford & Snow 2000: 614) are shaped. The social movement perspective, focusing on more collective aspects of framing, sensitized us to the contested nature of the framing activities preceding any governmental level legitimation. The perspective provides tools to analyze the interests and grievances that motivate various actors to collectively take part in framing processes. The institutional entrepreneurship perspective, with its focus on individual and organizational level activity, provides tools to understand and conceptualize the skills, activities and positions through which involved actors are able to initiate and maintain



Essay no.	Research question	Literatures	Focus of analysis	Contribution
<b>I</b>	How do institutional entrepreneurs engage in creating, mobilizing and counter-mobilizing field frames, and with this activity contribute to the emergence of new technological fields?	Social movements, institutional entrepreneurship, framing of meaning	Micro-level process through which successive framing and counter-framing activities contributed to the emergence of the nanotechnology field in the US during 1986-2000	Establishes that framing and mobilization activities create a micro-level connecting point between institutional entrepreneurship and social movement approaches; framing contests contribute to defining the boundaries of emerging fields; frames gain their power from both cultural and political embeddedness.
<b>II</b>	How do institutional entrepreneurs draw from their status and relational embeddedness to induce the emergence of novel science-based fields?	Institutional entrepreneurship, framing of meaning, spatial scales	Role of institutional entrepreneurs, drawing from their relational embeddedness and status, in bridging across cognitive, organizational and spatial gaps in the emergence of functional foods and nanotechnology in Finland	The very capacity to operate across various domains of activity is an important capability that defines the possibilities to act as an institutional entrepreneur in science-based fields. Capacity of individuals versus collective actors to induce change depends on the type of the field and the nature of change they aim to put forward as well as on their relational embeddedness and status.
<b>III</b>	How do institutional entrepreneurs in science-based fields mediate between globally circulating discourses and local institutions and competences?	Institutional entrepreneurship, discursive approaches to institutions, spatial scales	Role of key individuals and organizations as the translators and mobilizers of global discourses into local issues in the emergence of functional foods and nanotechnology in Finland	Conceptualization of institutional entrepreneurs in science-based fields as such actors how are able to operate across spatial scales; and as mobilizers of counter-discourses. Processes local actors needed to engage in depended on the scope of the issue, the nature of the field, and its novelty and alignment with existing institutions.
<b>IV</b>	How do externally validated form identities emerge, and how do opportunistic actors take advantage of those identities during form emergence?	Ecological literature on identity and organizational forms, constructionist literature on identity and image	Strategic and opportunistic labeling activities of business managers of nanotechnology firms in Northern Europe and US to gain access to novel resources	Rather than “possessing”, identity organizations may be included into a novel field through top management signaling activity, especially when the field is characterized by ambiguity and rewards for participation. Resulting transmutations of existing firms form a major part of the business activity in emerging fields.

**Table 5.1:** Summary of the essays

those processes and mobilize other actors to join in. Prior to this study, neither of these conceptual perspectives has sufficiently covered the process in which individual and collective actors and frames interact, nor have they been able to provide implications on how the outcomes of this interaction contribute to the development of a technological field. This is because the institutional entrepreneurship perspective has not paid sufficient attention to the contested nature of framing processes, and the social movement perspective has downplayed the potential of individual actors as the creators and mobilizers of novel frames.

The focus of the empirical investigation is the formation of nanotechnology as a field of activity in the US during 1986-2000. The case draws from 16 interviews in the US and 38 in Europe as background information, and the content analysis of 207 newspaper and professional journal articles in the top US newspapers, as well as the analysis of two Congressional Hearings. Nanotechnology presents an intriguing case of the emergence of new technological fields. The origins of nanotechnology are in the vision of a set of futuristic technologies labeled by Dr. Eric Drexler as nanotechnology, which was originally regarded as science fiction by the scientific community. The concept disseminated broadly in the media and popular culture, and gained a strong foothold in science fiction. Nanotechnology became acknowledged also in the highest forums in Washington in the early 1990s, but more so towards the late 1990s. Scientists also came to see the social and political value of adopting the concept within science due to the political imbalance in funding between physical and medical sciences. This resulted in clashes and competition between the futurists and the research community over the dominance of definitions and understandings, i.e. the frames for the novel field. When the framing was led by the futurists, a clear definition and vision about what nanotechnology is, existed. However, the scientists began to promote a completely different meaning for nanotechnology, which was far vaguer and broader and hence more useful, in order to accommodate various areas of research under its banner. By 2000, scientists were able to get their view through to the government level and undermine the Drexlerian approach. However, in the public understanding of nanotechnology Drexler's visions combined with science fiction are still very powerful even today, for instance in shaping the public opinion of the terrible risks and enormous possibilities of nanotechnology.

The findings of the study are as follows. First, by combining institutional entrepreneurship and social movement perspectives, we are able to conceptualize the processes through which particular frames may first become culturally embedded, then marginalized due to the lack of their political embeddedness, yet remain influential through their cultural embeddedness and being mixed with subsequently dominant frames. Our analysis especially suggests that one framing may create the initial receptivity for activities, which gradually materialize into a field. However, other actors and their framing may build on this receptivity to support different set of activities, which, in however minor a way, conform to some extent to the original framing. Hence, these competing actors employ using the frame for different purposes and goals, and all this activity takes place under the same conceptual banner. Second, our analysis may be among the first to define how and to what extent the emergence of a technological field is influenced by framing in general, and by the initial framing activity of individual actors in particular. We show how such initial understandings create the basis for technological development in the long run as they contribute to the subsequent birth of forms, functions and evaluation routines (cf. Garud & Rappa, 1994) that are crucial in the surfacing of a new technological field.

## **Essay II:**

**Granqvist, N. & Ritvala, T.**

### **Institutional entrepreneurship in the emergence of science-based fields: Comparative study of functional foods and nanotechnology in Finland**

Essay II develops the theory of institutional entrepreneurship by investigating how new science-based fields come into existence. Science-based fields are curiously neglected contexts for institutional emergence in this approach, and there is a scarce understanding on who the institutional entrepreneurs are, and what they do to set a science-based field in motion. Science has been conceptualized as a vehicle for producing texts to build new institutions (Maguire & Hardy, 2006), or as a cultural resource to challenge old practices by means of analytical theories and tools to gain status for a new practice (Lounsbury & Ventresca, 2002; Lounsbury & Crumley, 2007). Hence, scientists are important agents enabling change in the society. Public policy actors, on the other hand, hold an important role in validating scientific agendas put forward by the scientists. The study also participates in the ongoing debate on individual versus collective agency. Previous research on

institutional entrepreneurship both endorses and criticizes the capacity of individuals to act as institutional entrepreneurs. To address this issue, our study focuses on investigating the micro processes of emergence leading to a more collective adoption of the promoted practices and, hence, creates understanding on the succession of individual and collective activities underlying institutional emergence.

Drawing both from the conceptual discussion on institutional entrepreneurship and the empirical analysis we identify three domains of activity, namely cognitive, organizational and spatial, within and across which institutional entrepreneurs bridge in science-based fields. In this task, they draw from their relational embeddedness and status, which we conceptualize as resources rather than positions. First, cognitive gaps refer to non-existing understandings and frames of action, which institutional entrepreneurs create in a process characterized by multiple realities and contestation. Institutional entrepreneurs act, accordingly, as the editors and transformers of new ideas into understandable and valid form for relevant communities. Second, organizational gaps refer to building connections towards dispersed organizations, which are necessary in the mobilization of vital resources and credibility. Mobilization may take place, for instance, through political negotiation processes. As a result, bridging across organizational gaps stresses the role of institutional entrepreneurs as political actors, where agents strive to put forward new standards and practices and gain access to material and immaterial resources. Third, novel fields may emerge rather simultaneously across spatial scales, which represent the third domain of activity across which institutional entrepreneurs bridge. In science-based fields epistemic communities, in particular, create a context for such cross-scalar activity. To investigate these bridging activities in practice the study draws on a comparative case study of functional foods and nanotechnology in Finland consisting of altogether 53 interviews and analysis of public and private documents.

The study puts forward several findings on the above described research issues. Firstly, regarding relational embeddedness and status, we suggest that institutional entrepreneurs benefit from embeddedness and high status in renowned research and public funding institutions. On the issue of individual versus collective activity, we found that the deeper the social and institutional change required, the broader the institutional context, the larger amount and the more dispersed communities involved, and the less identifiable the leading

organizations; the more institutional entrepreneurship is about collective mobilization. When opposite is true, the greater the chance for individual orchestration. Secondly, on the issue of bridging cognitive gaps the findings suggest that scientists need to frame novel scientific concepts into locally significant form to gain funding for them. Public policy actors, on the other hand, select and theorize around certain concepts and encourage the redirection and relabelling of research activities so that they are aligned with those funding schemes. Thirdly, regarding the organizational gaps, we suggest that in general scientists control the ideational, and public policy actors the material, resources which enable the emergence of a new science-based field. Fourthly, we found that the very capacity to operate across spatial scales is an important capability that defines the possibilities to act as an institutional entrepreneur in science-based fields. Finally, we put forward a framework, which summarizes the empirical and conceptual discussion on how institutional entrepreneurs bridge gaps in the cognitive, organizational and spatial domains by drawing from their relational embeddedness and status.

The essay contributes to the inquiry of micro-level processes in the emergence of new science-based fields by identifying the enablers of agency and the domains of activity across which actors need to operate. Conceptualizing institutional entrepreneurs as bridging agents over cognitive, organizational and spatial gaps deepens the understanding on the nature and complexity of activities they need to engage in. The study also contributes to the debate on individual and collective agency in the emergence of novel fields by defining the field-specific contextual factors that enable individuals or require the mobilization of collectives.

### **Essay III**

**Ritvala, T. & Granqvist, N.**

#### **Institutional entrepreneurs as mediators between global discourses and local institutions – Emergence of functional foods and nanotechnology in Finland**

In this paper we draw on a comparative case study of functional foods and nanotechnology in Finland to investigate, how globally disseminating discourses become nested in local institutional contexts, and how such a process contributes to the ‘global’ emergence of a new field. While institutional entrepreneurship literature has been able to cast light on the

various roles active agents play in the emergence of new fields, it still falls short on explaining how institutional entrepreneurs act at the intersection of local institutional and global macro-cultural discourses in field emergence. The study identifies that scientific and other epistemic communities and various globally operating organizations mediate global trends to localities. The local forms they take, however, depend on the activities of entrepreneurial individuals, who identify and construct them into local issues. According to Hoffman (1999: 352), “issues define what a field is, making links that may not have previously been present”. Further, previous literature argues that localization of globally disseminating discourses is not a process of mere diffusion, but the ideas need to be translated into a locally meaningful form (Czarniawska & Joerges, 1996; 2005). Consequently, agency is crucial in embedding global discourses locally. Again, local successes and sometimes failures in problem solving and community building around an issue are mediated back to ‘global’ level as examples of an emerging domain of activity through epistemic communities, macro-cultural discourses and global organizations.

The data for the comparative case study consist of altogether 89 interviews, which helped to investigate processes of localized dynamics in the emergence of global fields. These unique data compare two different emergence paths in Finland as local representations of a global field. Cholesterol-lowering functional foods represent a case, where the Finnish actors have been the global pioneers and, hence, have influenced the forms and functions that the field has taken globally. Nanotechnology, on the other hand, was already established as a domain of activity in some countries before it became institutionalized in Finland, though the Finnish actors were among the first adopters, and Finland among the first countries to start national technology programs around nanotechnology.

Our findings suggest that institutional entrepreneurs interpret the generic concepts embedded in global epistemic communities in science into local transepistemic issues, which form a local embryo for a new technological field. There is a variety of discourses present globally, but only some of those ideas will result in local activity. In the empirical cases this depended on the timing of the local activities, available resources, and on the skillful actors able to identify and construct a local issue. For both cases emergence was critically dependent on individuals, who began to theorize and build coalitions around the issue and make it widely salient. However, this required different skills and activities for the

involved actors. In the case of functional foods, the actors needed to institute from scratch the understandings and discourses that enabled its emergence. The actors engaged in evangelizing and educating people in order to create understanding on the diet-disease link, which was groundbreaking at the time. For this reason they also needed to deal with the major inertia and opposition of the existing system and a variety of involved communities. In the case of nanotechnology, the task of local actors was to translate the concept and practices present in other institutional contexts so that they suited the local context, and construct the need for local activity among academic elites. Rather than building an institution from scratch, the actors needed to modify the local system to accommodate the novel combination of research activity. This was partly legitimated by referring to activities elsewhere. For both cases, Finland provided us with both an institutionally bounded and technologically advanced 'laboratory' for such an investigation.

This paper contributes to developing the theory of institutional entrepreneurship by investigating the activities of institutional entrepreneurs in field emergence. Firstly, the study complements the understandings on the interaction between macro level emergence and micro level agency by discussing how local agents contribute to the macro-cultural discourses rather than merely use them as resources. Secondly, the study investigates agency across spatial scales to address the weakness of this literature, namely the concentration on geographically delimited areas. Thirdly, our comparative research setting as such is a contribution, as is our particular focus to study the emergence of science-based fields, which are curiously understudied contexts for institutional entrepreneurship.

#### **Essay IV**

**Granqvist, N.**

#### **Nanotechnology or nanolabeling? Identity, projected image, and the construction of new organizational forms**

This study investigates the emergence of the nanotechnology business as a potential new organizational form by exploring the interplay between form identity, organizational identity, and strategic and opportunistic behaviors of top managers of nanotechnology firms. The study draws on both ecological and constructionist literature with the aim of increasing understanding of the origins and the role that form level identities play in form

emergence. In ecological studies identity is conceptualized as the main signifier of being a member of a form, and as an external code for such a categorization of firms. This literature stresses the role of external observers as constitutive in defining and observing form identities. However, this literature gives scarce understanding on the origins of the form level identity notions, as well as the processes through which they contribute to form emergence. The current study proposes that the contested processes of framing of meaning (Essay I) also define the range of possible identities for the form level actors. Also, emerging fields are characterized by ambiguity of its boundaries and lack of comparative basis to assess the organizations belonging to a form. For this reason, external observers may not be able to evaluate the ‘true’ identity of organizations. Rather, they are inclined to adopt the images of the organization’s identity signaled by the strategic and opportunistic top managers.

To study the above described processes of form emergence and identity notions, the study draws on 25 interviews with top managers of 22 nanotechnology companies in Northern Europe and the US, as well as on the analysis of the company websites and nanotechnology business directories. Nanotechnology is characterized by two important contextual factors: a major demand for the nanolabel due to an “armaments race” between different nations, as well as a great ambiguity of the boundaries of nanotechnology for both participants and external observers. Hence, it provides with a unique context to investigate signaling and labeling processes in emerging technological fields.

The analyses of the nanotechnology companies present in this study provide with many interesting findings. Firstly, of the 22 companies only half were *true nanotechnology* firms, and half *quasi nanotechnology* firms, which signaled nanotechnology but failed to match the commonly accepted definition of nanotechnology as operations in the size scale of 1-100 nanometers. The presented contextual factors have resulted in that business managers have been able to successfully signal nanotechnology, even though their core technologies or activities would not be in line with its widely accepted definition. For almost all organizations, nanotechnology tended to be the secondary concept to define their domain or activity. The analysis also showed that small and new firms are more likely to engage in nanolabeling in order to gain access to novel resources, whereas established firms have fewer incentives to do so. Small, technologically advanced firms fit the frame of



nanotechnology as novel, radical and close to science, whether or not they are true nanotechnology firms. However, incumbent organizations in established industries, such as chemical industry, have had challenges to be fully included into nanotechnology domain, because they do not fit this frame though they would fully match the size driven definition. However, the major demand for examples of established firms using and developing nanotechnology has brought many such companies under the nanoumbrella.

The study indicates that the initial business activity, especially in novel forms with high rewards for participation, is largely a product of such labeling activities and transmutations. Transmutations refer to processes where existing practices of business organizations in established industries are provided with new meaning and content (Strandgaard Pedersen & Dobbin, 2006). The external pressures gradually result in changing perceptions of what the companies are doing and what industries they serve. Also, labeling activity contributes to the emergence of a pool of organizations, reflecting certain image, however decoupled from their 'true' identities. As a result, new identities and collective meanings may emerge that become shared in emergent communities and form the basis for a new form with novel identity notions. This study argues that such processes are very important during the early emergence stage of a new field because they create the visibility for a novel organizational form, but also provide an opportunity to construct novel identities by the involved organizations.

## 6 CONCLUSIONS

The aim of the entire research was to explore the individual and organizational level activities that contribute to the emergence of new technological fields from the institutional entrepreneurship perspective. This was addressed from four differing points of view in the essays that form the main body of this doctoral research. Essay I investigates the initial shaping of the boundaries of a field through framing and mobilization of meaning by institutional entrepreneurs, bringing together the institutional entrepreneurship and social movements literatures. Essay II develops the institutional entrepreneurship approach by investigating empirically how actors, drawing from their formal status and relational embeddedness, bridge cognitive, organizational and spatial gaps present in embryonic fields. Essay III addresses the role of institutional entrepreneurs as the translators of globally disseminating discourses suitable to a local institutional context, and deepens the micro level understandings of these cross-scalar processes in field emergence. Finally, Essay IV studies the strategies of business managers to become associated with novel fields and to gain access to the resources offered by them, as well as the outcomes of such activity for the emergence of new organizational forms, in this case, the nanotechnology business. For this endeavor, the essay employed the literatures on images and identities. Essays I and IV focus solely on the context of nanotechnology, whereas Essays II and III draw on a comparative case study of nanotechnology and functional foods, where the processes of emergence are contrasted across the two fields in different stages of emergence.

These studies, together with the introductory section, provide multiple theoretical contributions to the institutional entrepreneurship approach drawing from many literatures. Also, the research process has revealed interesting aspects related to both nanotechnology as well as industry and field emergence, which may be beneficial for practitioners. Naturally there are some limitations to the research which, together with the findings, provide ideas for further studies. These issues are discussed in this final section.

## 6.1 Theoretical contribution

While each essay addresses a more elaborate research gap and a narrower set of implications, this section considers the overall contribution of the doctoral research. The main research question driving the inquiry was *How do institutional entrepreneurs, i.e. entrepreneurial individuals and organizations, contribute to the emergence of novel technological fields?* A multitude of studies in the new institutional theory have investigated agency in the emergence of novel fields from different perspectives. However, the current research identified three important gaps in this literature, which are summarized as follows. Firstly, incorporating agency in the new institutional tradition also generates novel connections to other literatures, a link which remains largely unexplored. The research addresses this gap in the literature by drawing on social movements, relational approaches, socio-economic approaches to technology, institutionalization of discourses, and literature on identity and image. Their implications for the further development of the institutional entrepreneurship approach are analyzed below. Secondly, the theory on skills, roles, activities and positions of institutional entrepreneurs as enablers and mediators of various processes of institutional emergence is still under development. The multidisciplinary approach, comparative case studies and the extensive empirical data reported in the essays contribute to further strengthen the theory on institutional agency in the emergence of novel fields. Finally, the entire literature on the institutionalization of discourses is still inconclusive, especially in terms of empirical evidence on how various discursive processes contribute to field emergence. The current research also provides implications for this emerging literature. All of the above research issues are aligned and, hence, an attempt to create a synthesized set of implications is put forward. In the following, I start by discussing the contribution of each addressed literature towards extending the institutional entrepreneurship approach. Subsequently, I summarize the contribution of these approaches to understanding the activities and positions of agents in institutional emergence.

Firstly, incorporating the social movement approach into the institutional entrepreneurship literature establishes a micro-level connecting point between the approaches. From this perspective, institutional entrepreneurs are movement leaders, the orchestrators of cognitive framing processes, and the initial mobilizers of new ideas and concepts, the

dissemination of which results in shared meanings that shape the boundaries of a field. This combination of literatures is beneficial in order to deepen the understanding of the collective processes that institutional entrepreneurs as individual and organizational actors are required to set in motion. The social movement perspective, with its focus on the very collective aspects of framing, sensitizes an observer to the contested nature of the framing activities preceding any legitimation, or even identification, of a field. The institutional entrepreneurship perspective, on the other hand, provides tools to understand and conceptualize the skills, activities and positions through which involved individual and organizational actors are able to initiate and maintain these processes and mobilize other actors to join in. The research establishes that social movement like activity results in cultural embeddedness of a novel frame. However, while setting up a movement may result in a wider recognition of a field, political agency is crucial for its further embedding and access to resources in a specific institutional context. Political activity is required to move the field from margins to mainstream. In the cultural and political embedding of a frame, different capabilities and positions of actors play an important role. For cultural embedding of a frame, its visionary aspects, which inspire imagination, and the concepts adopted and audiences addressed play a major role. Actors are not always able to choose which audiences come to embrace the frame and which to reject it. Political embeddedness, on the other hand, is closely aligned with the position of actors in the existing institutionalized system.

Secondly, incorporating socio-technical views of technology to the institutional entrepreneurship approach provides many tools for deepening the understandings of technology emergence in the new institutionalist theory. Bringing in agency to the institutional approaches creates a connecting point with the socio-technical view to technology and contributes to a better understanding of the processes of both technology emergence and institutionalization. Firstly, socio-technical approaches to technology stress the role of social environment as the boundary setting context for all activity. Hence, it acknowledges the importance of institutional environment in the shaping of forms and functions for an emerging technology. Secondly, socio-technical approaches stress the role of 'embedded agents' or technology entrepreneurs capable of mindfully deviating from the existing socially constructed paths and trajectories. These trajectories represent the cognitive and social limitations for technology development. However, they also provide

resources for change. Technology entrepreneurs, not unlike institutional entrepreneurs, act as mobilizers and creators of novel trajectories and resources, which enable the development of a new set of technologies. Consequently, such 'embedded agents' are knowledgeable and opportunistic actors, who aim to generate technological change. From the point of view of the institutional entrepreneurship approach, the task of such agents is to act as the initiators of emergence of novel technological trajectories, to build legitimacy for the technology by acting as connectors between separate social groups and networks, and to mobilize a collective of actors, who then validate and legitimize the new trajectory.

Thirdly, bringing the institutionalization of discourses literature into interaction with the institutional entrepreneurship approach contributes to understanding how individual and organizational agents create, identify and mobilize novel discourses by translating them into an understandable form for wider audiences, or by opportunistically adopting labels that enable access to new resources. The nanotechnology case presents a strong example of the role that discourses play in the creation of technological fields. Nanotechnology is characterized by *hype*, or a process of strong institutionalization of mutually supportive macro-cultural discourses (Berger & Luckmann, 1966; Lawrence & Phillips, 2004), resulting in action and adoption of the concept and aligned practices. Macro-cultural discourses provide cultural tools for active agents to draw from (also Rao, 1998). However, agency is crucial in embedding and re-enacting local cognitive frames from macro-cultural discourses. The seeds for new fields are embedded in local issues which, however, only come into being when they are identified and theorized by local agents (cf. Lawrence & Phillips, 2004; Maguire et al., 2004). Globally disseminating ideas and discourses may trigger this local identification. In such a case, local agents act as translators and issue embedding agents of global discourses to local institutional environments. Previous studies suggest that country of origin has a major impact on the potential of firms to develop distinctive organizational forms (Tainio & Lilja, 2003; Lamberg & Laurila, 2005). Complementing such views, entrepreneurial individuals and organizations benefit from a position where they are subject to both local issues and global trends.

Finally, the literature on identity and image also contributes to understanding the processes through which organizational actors institutionalize discourses by drawing from cultural resources. The current research suggests that business managers are important strategic and

opportunistic actors in the emergence of nanotechnology business, a novel form in the nanotechnology field, by adopting the nanotechnology label to access the resources available to it. This opportunistic labeling activity is greatly facilitated by hypes and a resulting demand for the nanotechnology label. By adopting a label and signaling an image, the top managers contribute to the construction of the domain of business activity in novel fields. From this point of view, corporate image and reputation can be conceptualized as discursive components, the adoption of which further institutionalizes an emerging field into labels, directories and discourses.

The processes mentioned above are partly summarized in Figures 2.1 and 2.3, which illustrate respectively the capacity to act for institutional entrepreneurs, and the institutionalization of a concept and its embeddedness across a variety of groups of actors over time. According to the model for the capacity to act (Figure 2.1), an institutional agent is embedded in three types of opportunity structures: culture-bound; political and institutional; and social and interpersonal. Each of these requires certain skills and positions from the actors, and results in different forms of agency, which are respectively conceptual, political, and social agency. Together these form the agent's capacity to act as the facilitator and enabler of institutional emergence. According to the framework for institutionalization (Figure 2.3), emergence and construction of mutual issues help to mobilize individuals to form communities around ideas and common goals. Gradually actors begin to create shared codes and artifacts that manifest the field. Also, the hidden agendas of individual and organizational actors further influence which issues gain ground. Their capacity to act defines their potential to participate in the initiation and construction of a novel field. Gradually, the understandings of the field become widely shared, objectivated and sedimented (Berger & Luckmann, 1966) and the relationships between actors become institutionalized. Drawing from such conceptualization, both individual and collective action play a major role in various processes that are all essential for the emergence of a novel technological field.

Indeed, as demonstrated by the current research, the further development of the institutional entrepreneurship approach benefits greatly from the exploration of its connections to other, more established streams of literature. These bonds provide powerful tools to deepen our prevalent understandings of agency in institutional emergence. In the

following, the implications of the research for practitioners are explored, after which the limitations and avenues for future studies are presented.

## **6.2 Implications for practitioners**

### **6.2.1 Business managers**

Nanotechnology is an intriguing set of technologies, which are estimated to provide in the future a multitude of radically new business opportunities. Nanotechnology has also been estimated to make some existing industries redundant, or radically change their logics. While a multitude of developments in the technologies reaching very small size scales offer interesting possibilities, and in the longer term, a potential for radical innovations, representations of nanotechnology as some kind of unified industry are premature and even misleading. According to Christensen (1997), markets that do not exist cannot be analyzed, and yet, the companies should be aware of the opportunities they provide. However, in the case of nanotechnology the situation seems to be quite the opposite. Hying on nanotechnology has resulted in a situation, where the markets that do not exist have been analyzed extensively by dozens of market research companies and consultancies, and a wide range of possible future business opportunities and growth prognoses have been put forward.

In the light of the current research, nanotechnology does not exist as an independent industry, and much needs to happen before that can be the case. If we take the definition of an industry as “a population of organizations operating in the same domain as indicated by the similarity of their services or products” (Scott, 2001: 83), it may be argued that there are no nanotechnology services or products that form an industry. For this there are several reasons. Firstly, nanotechnology does not carry an industry label because it has too few unique characteristics that separate it from existing industries. For example, the mere size scale related definition of nanotechnology taking place in 1-100 nanometers covers extensive and established parts of existing industries such as electronics, chemistry, pharmaceuticals, biotechnology and materials. Indeed, almost all of the companies that have adopted the nanobanner hold these industries as their primary industries. For them

association with nanotechnology is an additional resource and reference base which has recently opened as a possibility and, in some cases, been imposed on them. Secondly, and aligned with the first point, none of the companies present in this research were what I call 'nano-nano' companies, but rather nano-electronics, nano-optics, nano-materials, or just simply biomedical or chemical companies. In general, few highly advanced science-based companies globally develop technologies, which can create an embryo of a novel future industry around quantum phenomena. If one or many industries will emerge from these seeds, and any of those around 'nanotechnology', still remains to be seen.

Consequently, there are two possible development paths for nanotechnology as a domain of commercial activity. Either nanotechnology will become an industry in its own right with dedicated business activity, a more coherent set of technologies, and an offering that exploits the quantum phenomena derived by the nanoscale; or, perhaps more likely, nanotechnology is an interim concept on the way towards more specific solutions within the existing industries, or generates perhaps more focused new industries that are yet beyond the horizon. No matter what the outcome, inarguably the major focus on nanotechnology has set in motion the commercial development of tools and processes that help innovation and larger scale production in the 'small scale technologies', which will have a major impact on the society of the 21<sup>st</sup> century.

In addition to the 'nanotechnology as industry' related implications, the research casts light on the issue of trends. The research employs widely the notion of macro-cultural discourse, which may roughly be translated as 'trends'. Trends are a cultural resource for various actors to draw from in terms of e.g. legitimacy and attention. However, they are unpredictable and difficult to shape due to the variety of influences affecting them. The research shows that the emergence of novel technologies and domains of innovation is a culturally rooted process. An interesting case in point, the concept of nanotechnology was created by a futurist and widely disseminated in popular culture before it became acknowledged, albeit in a different form, by the scientists and public policy actors. Only when these actors joined in, did 'nanotechnology' become a legitimate domain in science and innovation. However, among the mind of public the science fiction connotations of nanotechnology are even still prevalent. In science certain developments had taken their course, but the emergence of the concept nanotechnology in popular culture strongly



directed activities also in science. Similar ‘macro-cultural’ developments are likely to be found as the enablers of currently emergent domains of commercial activity. Such understanding of the cultural roots of both trends and technologies may provide business managers with deeper insights on where to search for novel ideas and how to disseminate them within and outside of the organization.

### **6.2.2 Policy makers**

Similar implications to those described above apply also to policy makers. The enormous interest and investments in nanotechnology globally has resulted in competition, where each country and region must keep up with one another. As a consequence, investing in nanotechnology became competitive behavior during the early 2000s worldwide. According to some of the scientists interviewed for this research, such hypes and fashions in science and technology may distort the interest towards research, and hamper the long-term scientific development. As fashionable domains of science are funded the ‘unfashionable’, but fundamentally important ones, may lack resources. Policy makers in science and innovation funding institutions are typically well informed about the overall stage of development of science and the potential commercial applications of new technologies. However, when such hypes occur, public policy makers need to pay careful attention to the drivers of these hypes and also identify less fashionable and seemingly more incremental developments within science. Arguably the mapping of the ‘ordinary’ domains of science and technology is in place in well-functioning funding and policy organizations, and may play a major role in the emergence of divergent and innovative local technologies.

As in the case of nanotechnology, such focused attention and aligned abundant resources to a single or a set of interrelated domains may, however, create novel and unique national strongholds, and from their part also contribute to the local emergence of global industries. Local public funding agents play a crucial role as gate keepers in deciding which areas of research are considered strategically important. In countries, such as Finland and other Nordic countries, which are dependent on public funding of research and innovation, the role of these actors is accentuated, and their decisions is likely to have an important impact on the timing of emergence, or even non-emergence, of local industries. Nevertheless, the recent strong focus on nanotechnology worldwide directs the activity and attention, and is

likely to significantly promote science and technology in very small size scales. This focus has also resulted in actors in both public and private research being forced to pay attention to the wider applicability and the possibilities of commercializing nanotechnology. In the end, such hypes result in learning and necessary change in local and global institutions, which may eventually give rise to completely new industries, and even result in golden ages of technologies (Arthur, 2002).

### **6.3 Limitations of the research**

When studying complex processes, such as the emergence of new technological fields, each individual study can cast light only on a fraction of the potential research issues, and provide incremental new knowledge related to such processes. Furthermore, each conceptual and methodological choice for a research is also a choice of discarding other, often equally suitable approaches. Hence, each research is a reflection of the personality, preferences, and interests of its conductors. The limitations for the current research stem also from these notions. While the essay format of the research enabled addressing the agency in field emergence from a variety of viewpoints and conceptual approaches, there were other viewpoints that were not addressed in this research.

Firstly, there are limitations regarding the conceptual approaches present in the research. Yin (2003) defines theories according to their level of analysis into individual, group, organizational and societal theories. The aim of this research was to discuss how micro-level processes result in macro-level emergence of a new field of activity. For this purpose both micro and macro level theories, many of the latter drawing from sociology, were applied. New institutional theory can be characterized as an organizational field level theory, and social movement approach as a group level or societal level theory, depending on the viewpoint of the respective study. The institutional entrepreneurship approach, to which this research mostly contributes, more clearly address micro and meso levels of inquiry. However, this research does not employ psychological individual level theories describing individual decision making processes. This is mainly because they tend to downplay the role of the institutional and social environment in which the individual behavior is embedded. Nor does the research to a large extent address the social-

psychological theories discussing group dynamics, which may be valuable for the investigations of the emergence, adoption and dissemination of new trends and ideas. This is acknowledged as a potential challenge for the current research. However, the theories and conceptual approaches used in this research are well embedded in the management literature, and well aligned with each other and with the aims and contributions of the research.

A second limitation concerns the methodological choices for the research. It may be argued that conducting a multitude of interviews among many groups of actors contributes to neither gaining a true micro-level nor a true macro-level understanding of the phenomenon at hand. A more focused sample of interviews within a carefully defined group involved with a specified aspect of nanotechnology might provide an opportunity to create deeper understanding of the micro-level processes driving the emergence of nanotechnologies. On the other hand, owing to the micro-level focus of this research, it provides many interesting findings the existence of which in wider populations, however, cannot be established without a broader sample size. Hence, a variety of propositions can be made from this explorative research, but whether they will still be valid in a broader population of actors calls for further research. However, the adopted exploratory research strategy enabled the development of both a broad contextual understanding of nanotechnology as an emerging domain of activity, as well as focusing on narrower research issues identified before and during the research process.

Thirdly, while the data for the research was collected from different geographical and institutional areas, the cross-country comparative potential was not fully exploited. This was a conscious decision, and a cross-industry case was chosen in preference to a more innovative option of contrasting the differences between the local emergence processes novel fields of nanotechnology and functional foods. This decision does not reject the notion that a cross-country approach to analysis might produce interesting findings. Hence, such approach are likely to be further explored in the post PhD phase.

Finally, it may be argued that being entrepreneurial is a part of the legitimate script of the existing institutionalized systems, where a heroic lone rider attacks the established institutional order. Being entrepreneurial is one of the dominant scripts of the current

“field emergence paradigm” among new institutionalist researchers, perhaps at the cost of focusing on broader institutional and collective practices. While the current research addresses institutional entrepreneurs as initiators and enablers of collective processes leading to emergence, there is a danger that such approaches may overly simplify the complexity of emergence processes. However, the research strongly indicates that the exploration of such micro-level processes is warranted as the emergence processes can, more often than not, be traced to certain significant individual and organizational actors and their initial mobilization activities.

#### **6.4 Avenues for further research**

Even after this research, a wide variety of issues still remain to be explored to uncover the processes of field emergence. These suggestions for further studies stem from the theoretical and methodological limitations of the current research as well as from the discovery of topics that I have identified as important and interesting for further inquiry during the research process.

The current research mapped many interconnections between the institutional entrepreneurship and other literatures, drawing mostly from sociological approaches in management. However, as discussed in the previous section, inquiries investigating the type and nature of institutional entrepreneurs, drawing from psychological and social psychological theories would provide further fruitful directions to develop the institutional entrepreneurship approach in particular and understandings on field emergence in general. These approaches would cast light on the issues of how individuals and organizations can impact their social conditions by drawing from a variety of individual and group level theories. Methodologically, this translates into the development of micro-level studies that focus on narrow processes which have been identified as underlying field emergence. On the other hand, while the current research did identify many such underlying processes through an in-depth qualitative approach, a quantitative survey investigating their wider adoption in a population of organizations would be beneficial in the next stage. For instance, a quantitative survey on the nature of and motivations for business organizations

claiming nanotechnology would be very likely to widen our knowledge on the emergence of business activity in novel technological fields.

Moreover, though the research conducted a cross-case comparison between nanotechnology and functional foods, further cross-case and cross-country comparisons on the institutional processes of emergence in different fields and industries calls for further attention. Such studies would provide important contributions to the investigation of those components of local systems which make an idea or a set of knowledge “sticky”, and able to create an embryo for a novel industry. Finally, the impact of popular culture on technology development, especially in terms of how popular cultural notions shape the cognitive frames that then create a range of potential forms and functions of technology among its developers and adopters, provides an interesting avenue for future research.

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## **PART II**



## **ESSAY I**

### **Mobilization by Framing: The Emergence of the U.S. Nanotechnology Field, 1986-2000**

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**Abstract:** This study explores how contested framing by individual and collective actors shape the boundaries of an emerging technological field. To do this, we apply and extend the social movement and institutional entrepreneurship literatures. The empirical context for the investigation is the recent emergence of the U.S. nanotechnology field. The study draws on the analyses of 54 interviews and 207 newspaper articles. We show how the initial framing of nanotechnology created the overall cultural receptivity for the concept. This enabled different actors to create resources for the field, resulting in its materialization in novel form, yet under the same nanotechnology banner.

**Keywords:** Social movement theory, institutional entrepreneurship, framing, field emergence, nanotechnology

## 1. INTRODUCTION

The birth of new organizational fields is critically dependent on the formation of frames for interpretation that provide the involved actors with an understanding of how their activities relate to one another, and what measures they should take in relation to an emerging domain of activity. Two prominent but independently developed streams of research have recently come to address the issue of framing in this context. First, neo-institutional organization theory has highlighted the contribution of active agents, i.e. institutional entrepreneurs (DiMaggio, 1988; Fligstein, 1997; Beckert, 1999) in the creation of new institutions, such as standards and policies, that are not only aligned with their interests, but also support the emergence and development of a new technological field (Garud et al., 2002). These works suggest that institutional entrepreneurship is enabled by certain skills, positions and resources. Recently, this stream of research has been extended to cover the meaning work through which institutional entrepreneurs occupy subject positions and introduce and legitimize new practices that may then constitute a new organizational field (Lawrence & Phillips, 2004; Maguire et al., 2004). However, even these extensions to the institutional entrepreneurship perspective have not materialized in systematic investigations of the role of individual and collective framing and counterframing activities in the emergence of new technological fields.

Second, the social movement perspective on organizations (Zald & Berger, 1978; Davis & Thompson, 1994) has paid special attention to political processes and collective action taking place within and between organizations. Previous studies have established that such

processes contribute to the emergence of new industries and fields (Rao, 1998; Rao et al., 2000). While organizational actors are inevitably the focus of this perspective, research has concentrated on the role of formal hierarchical and power positions of actors and various tangible resources accessible to them (Zald, 2005). More recently, advocates of the social movement perspective have incorporated culture into their inquiries with attention to identity and to the meaning construction and cognitive framing processes involved in collective action (Benford & Snow, 2000; Zald, 2000). After this 'cultural turn' (Zald, 2000; Lounsbury et al., 2003), more research on the formulation and orchestration of collective action frames (Snow et al., 1986; Benford & Snow, 2000) has emerged. While systematic attention on framing brought the social movement perspective on organizations into fluent collaboration with contemporary institutional theorists, the role of framing in the emergence of new technological fields is not yet fully understood in this perspective (McAdam & Scott, 2005). Previous studies have paid only little attention to the movement-counter movement dynamics in general, and to the contests between different frames in particular (Vogus & Davis, 2005). The roles of individual and collective actors in these contests also require further attention.

Hence, the institutional entrepreneurship and social movement literatures share many features, which can benefit the study of organizational fields (Hargrave & Van de Ven, 2006; Rao & Georgi, 2006). In particular, further research on the influence of framing and counterframing processes on the emergence of new technological fields drawing from both literatures is warranted. In this paper, we examine these issues through a qualitative study on the birth of the U.S. nanotechnology field during 1986-2000. To our knowledge, while there are examples of studies in other fields (e.g. Lounsbury et al., 2003), framing processes in the context of emerging science-based and technological fields have not been previously examined from this perspective. This is although in emerging fields framing is both more critical and complicated than in established fields (Armstrong, 2005). Emerging technological fields, in particular, provide a context where there are many opportunities and motivations to participate in the framing activities. Technological fields are characterized by the difficulty in anticipating the consequences of the contestation of for view of the emerging forms, functions and evaluation routines (Garud & Rappa, 1994) of a novel set of technologies. Further, the birth of new technological fields requires substantial rearrangement of the prevailing social structures and institutionalized organizational

practices. Inquiry into such processes gains from the application of both institutional entrepreneurship and social movement literatures, and also contributes to further extending these streams of research.

In the present study, we particularly investigate how and why the concept of nanotechnology, initially introduced in a popular book by Eric Drexler in 1986 and soon adopted in science fiction, eventually turned into the National Nanotechnology Initiative (NNI) in the U.S. In other words, a concept that first lacked credibility and substance among the scientists relatively soon became turned into a prestigious research program with substantial material resources. The NNI, announced by President Clinton in 2000, comprises a several-hundred-million dollar government investment in nanotechnology research and development. In our analyses, we examine how the various framing activities of the actors involved contributed to the materialization of nanotechnology as a technological field. The social movement perspective sensitizes us to the contested nature of the framing activities, such as those preceding the NNI, and provides tools to analyze the interests and grievances that motivated various actors to take part in these processes. At the same time, the institutional entrepreneurship perspective provides tools to understand and conceptualize the skills, activities and positions through which involved actors were able to initiate and maintain processes that bring other stakeholders to see value in and give support to these activities. In our analyses, we draw on the evidence obtained in 54 interviews, 207 newspaper and professional journal articles, and the transcripts of two Congressional Hearings addressing nanotechnology.

The contribution of the present study is twofold. Combining the institutional entrepreneurship and social movement perspectives provides an opportunity to investigate the early framing and mobilization activities by a handful of individuals, but also to study the gradually unfolding process with multiple actors, frames and stages of field emergence and development. The current study shows how particular frames may first become culturally embedded, then marginalized due to the lack of political opportunities, and still remain influential due to the very cultural embeddedness and mixing with subsequently dominant frames. Prior to this study, neither of the addressed conceptual perspectives has sufficiently covered this process in which individual and collective actors and frames interact, nor have they been able to provide implications on how the outcomes of this

interaction contribute to the emergence of a technological field. This is because, on the one hand, institutional entrepreneurship perspective has downplayed the contested nature of framing processes by concentrating on explaining how an innovative frame emerges and how it replaces the previously dominant frame (e.g. Hargadon & Douglas, 2001; Sherer & Lee, 2002). On the other hand, the social movement perspective has largely neglected the potential of individual actors as the creators and mobilizers of novel frames. Second, our analysis is among the first to define how the longer term development of a technological field is influenced by framing in general, and by the initial framing activity of individual actors in particular. We show how such initial understandings create the basis for technological development in the long run as they contribute to the subsequent birth of forms, functions and evaluation routines (cf. Garud & Rappa, 1994) that are crucial for the surfacing of a new technological field.

The remainder of the paper is structured as follows. We start by reviewing previous literature on the role of framing in field emergence, with particular attention to the contests between conflicting frames. Subsequently, we discuss the methodological underpinnings of the study and present a detailed analysis of the role of framing in the emergence of the nanotechnology field in the U.S. We end the paper by presenting the theoretical propositions derived from the study and some implications for further research in the emergence of technological fields.

## **2. AGENCY AND FRAMING IN NEW TECHNOLOGICAL FIELDS**

### **2.1 Fields, frames and field frames**

Lawrence and Phillips (2004: 691), building on DiMaggio and Powell (1983), define an organizational field as “a set of organizations that constitute a recognized area of life, are characterized by structured network relations, and share a set of institutions”. Hence, as a concept, organizational field refers particularly to a domain in which different actors operate and collaborate in some essential respect on similar issues. In this spirit, nanotechnology is an organizational field in which different actors operate on the research, development and commercialization of atomic or molecular scale structures. An



organizational field, however, cannot be recognized without framing that defines its boundaries and content. Goffman (1974, in Benford & Snow 2000: 614) defines a frame as “schemata of interpretation that enable individuals to locate, perceive, identify, and label occurrences within their life space and the world at large”. It is through such frames that organizational fields are structured as some activities become deemed more appropriate than others (Lounsbury et al., 2003).

The fact that an organizational field has been established, however, does not mean that there is only one frame shared by all actors involved. On the one hand, this is because such ‘meaning work’ by any actor necessarily involves the generation of interpretive frames that not only differ from existing ones but may also challenge them (Benford & Snow, 2000). On the other hand, this reflects the presence of many competing institutions that lie within individual populations or classes of constituencies that inhabit a field (Hoffman, 1999). Each such population has its own interpretation of what the field is about and what kind of activities take and should take place within the field. Hence, different actors put forward their views of what is going on or what should be going on, i.e. their frames of collective action (Benford & Snow, 2000).

Fields are hardly static systems, but rather a constant struggle takes place over resources, stakes and access (Bourdieu & Wacquant, 1992; Maguire et al., 2004), keeping fields in constant flux. This is especially the case during field emergence, when practices, positions, understandings and relationships are unestablished (Armstrong, 2005). Even after these have become institutionalized, change in organizational fields is initiated by the inherently contentious nature of framing. Prevailing field frames are constantly challenged and modified by institutional entrepreneurs (Rao & Georgi, 2006). Various actors, such as professional bodies and governmental actors initiate new field frames, which are maintained and eroded through discourse in public forums such as Congressional Hearings, and industry and media events (Lounsbury et al., 2003). Such field frames may also act as initial templates for macro-cultural discourses, i.e. “broad discourses and associated sets of institutions that extend beyond the boundaries of an institutional field and are widely understood and broadly accepted in a society” (Lawrence & Phillips, 2004: 691). Hence, when competing frames become embedded in such discourses, they also become culturally embedded, and a part of the society at large. The media plays an

important role in establishing and disseminating such macro-cultural discourses, which again affect the emergence of a new field.

## **2.2 Actors and competition between frames in field emergence**

During the emergence phase of a new field, some individuals may take the key role in the framing activity. Previous literature (e.g. Rao & Georgi, 2006) suggests that institutional entrepreneurs are ideological activists who take risks and invest themselves in fighting for a larger cause. These entrepreneurs are especially active in providing both a diagnosis of problems that need attention and a prognosis on the ways in which these problems could be tackled (Campbell, 2005). According to Maguire et al. (2004), institutional entrepreneurs benefit from positions with wide legitimacy and possibilities to bridge across various stakeholders. This enables them to engage in the theorization of new practices by aligning their message with contradictory interests. Typically, the trigger for such activities is a perceived failure of the existing institutions to address some social issue, or an opportunity to promote concepts or issues that are aligned with individual or collective interests (Rao et al., 2000). In the words of Benford and Snow (2000: 613), these entrepreneurs can be viewed as signifying agents that actively engage in the production and maintenance of meaning for “constituents, antagonists, bystanders or observers”, and hence, participate in the “meaning work – the struggle over the production of mobilizing and counter-mobilizing ideas and meanings”. Consequently, entrepreneurs construct new spaces by defining opportunities, identifying distinctive resources, and attracting them to new uses (Rao, 1998).

When such persuasion and convincing activities coincide with suitable political opportunities and mobilizing structures, new organizational fields may come about in a way that resembles the emergence of social movements (Fligstein, 1996; Rao, 1998). That is, a large number of actors come to simultaneously invest in activities introduced and framed by institutional entrepreneurs as adequate and timely. Abrahamson and Fairchild (1999) have addressed similar processes in their study of management fashions. The social movement like nature of nanotechnology materialized in the rapid rise in the amount of researchers, research funding and public attention in technological research and development on the atomic and molecular scale from the late 1990s onwards. Hence,

framing nanotechnology in a particular way provided access to novel resources for a large variety of actors and encouraged them to initiate activities in this field. Institutional entrepreneurs may further amplify such a process by being deeply engaged, along with the media, local governments and the state, in what Hall (1982) refers to as the politics of signification (Benford & Snow, 2000) that may provide further resources and disseminate the understandings of an emerging field.

The shaping of meanings and frames is especially intensive during the early formation stage of a new field. We may expect several competing framings to come about, whose advocates compete with each other by employing various political and discursive strategies. However, as rival entrepreneurial coalitions promote incompatible frames we may expect that this results in clashes and power struggles between actors (Rao, 1998). Building on Benford and Snow (2000), it is likely that the most persistent frames in such situations are the most consistent and empirically credible ones. Hence, a frame may be internally fully consistent, but would not survive an empirical validity test. Further, the persistence of a frame also depends on the credibility (Benford & Snow, 2000) and social position (Stevenson & Greenberg, 2000) of its proponents. Thus, the more credible and compelling the frame, the better chances a skilful entrepreneur holding an appropriate social position has of mobilizing supporters for it.

The framing/counter-framing contests may take many forms. A frame that recognizes a new technological field challenges the dominant frame that does not. Contestation between frames may be delayed as the challenge provided by institutional entrepreneurs towards a dominant frame is not recognized or taken seriously by incumbent actors in an organizational field (cf. e.g. Lukes, 2005). This does not prevent the new framing from gaining increasing support and starting to re-shape the field (Lawrence & Phillips, 2004). Often, only when the dominant frame becomes seriously undermined or challenged by the new frame that gains momentum, do the incumbents react (an example is the study by Hoffman, 1999). The proponents of the conflicting frames are not the only actors involved in the processes that follow. Instead, various groups of actors are motivated to participate “in the institutionalization of organizational archetypes” (Hensmans, 2003: 375) as the media plays a central role in reporting the competing frames to wider audiences (Gamson & Wolfsfeld, 1993). This process shapes also public understanding of the emerging field.

Further, certain events, such as collective meetings, may also significantly shape the frame through a dialectical tension between collective action frames and events (Ellingson, 1995; Benford & Snow, 2000). It is through such a contested process that a new dominant frame typically emerges. However, the dominance of a frame is always only temporary as new challenging frames continuously emerge, especially in new technological fields where technological change challenges the status quo.

The discussion above, thus presents the current understanding of framing processes in the extant literature. The contribution of the present study to this body of knowledge is twofold. First, we concentrate on the micro-level activities in these contested processes, a focus that has not been sufficiently applied in the previous literature (Campbell, 2005; Osterman, 2006). Second, we investigate these micro-level activities in the context of the framing of a specific technological field, nanotechnology. Technological fields have been under-represented in previous research at the interstices of institutional entrepreneurship and social movement literatures (McAdam & Scott, 2005). While investigations of such emerging fields provide an empirical basis for conceptual extensions of these literatures, they are also helpful in providing further insight into the processes through which the evaluation basis for new technologies come about (cf. Garud & Karnoe, 2001).

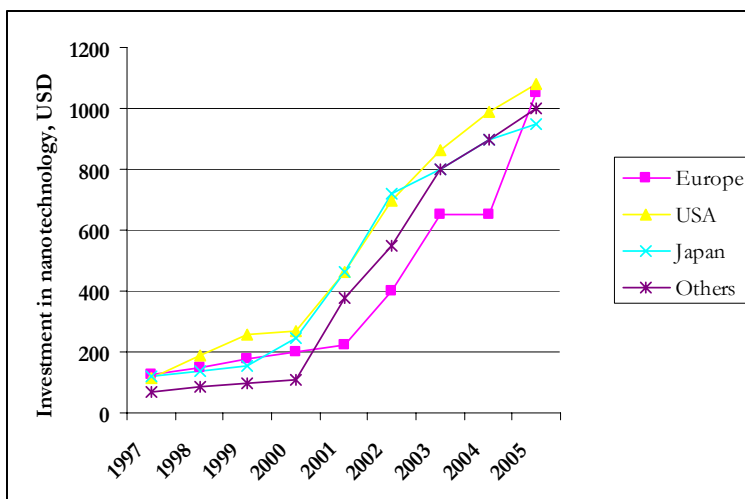
To meet these promises, we present a detailed account of the framing processes in the emergence of nanotechnology in the U.S. Nanotechnology provides an interesting research context for such an inquiry as a technologically emergent, yet institutionally established domain of activity. In our analyses, we concentrate on the micro-level framing activities by individual entrepreneurs and the process through which contests between several initial framings has gradually led to the forming of a new dominant frame. This frame then presents the basic assumptions of the new field covering, for example, which actors are involved in the process and in what kinds of activities they engage. At the same time, we acknowledge that the emergence and development of an organizational field is not only dependent on framing, but also on opportunity structures and resource mobilization (cf. Rao & Georgi, 2006). For this reason, we find it worthwhile to pay particular attention to how existing structures enable the activities, but also to investigate how they become modified during the framing processes.

### 3. METHODOLOGY

This study takes a qualitative case study approach (Butler, 1997; Numagami, 1998; Stake, 2005) to investigate the emergence of the nanotechnology field. This allows us to address both the *why* and *how* questions related to this process and to employ various sources of data, such as interviews, and public and private documents. Lounsbury et al. (2003) and Scott et al. (2000) call the special types of case study, which explore changes in the fields, as a *field analytic approach*. Field analytic approach especially draws on interviews and historical evidence, such as trade journals and news stories, to track changes in a system of meaning or field frames over time, and follow how associated practices and their social organization takes place (Lounsbury et al., 2003; also Washington, 2004). Also, the current study adopts a field analytic approach to map the process of the early emergence of nanotechnology by investigating how the framing activities of individual and collective actors contribute to the emergence and development of a new technological field.

#### 3.1 Research context: Nanotechnology as a technological field

In 2007, nanotechnology is surprisingly established as a technological field with respect to its relatively short history. In 2000, President Bill Clinton announced the National Nanotechnology Initiative (NNI) in the U.S. This announcement set the focus on the development of nanotechnology globally, and a large number of nanotechnology initiatives from individual countries and regions all over the world soon paralleled the NNI. Ever since, nanotechnology has been characterized by constantly growing public and private investments in research and development. Figure 1 presents the public and governmental funding in nanotechnology during 1997-2005. According to Lux Research (2004), private investments in nanotechnology were \$3.8 billion in 2004, whereas the public sector invested \$4.6 billion. Simultaneously, nanotechnology has been introduced in the media as one of the dominating sets of technologies of the 21<sup>st</sup> century, with potential implications comparable to the steam engine, electric light, or electronic communication technologies.



**Figure 1:** *Estimated public investments in nanotechnology (Source: President's Council of Advisors in Science and Technology, 2005)*

Nanotechnology has several distinctive characteristics as an organizational field. It is important to note that the concept does not refer to any homogeneous set of technologies, but rather is employed as an umbrella concept for various activities and organizations. Even today, many of the organizations active in the field do not hold their primary identities as nanotechnology organizations, but tend to associate themselves with other, more established domains of activity. This implies that nanotechnology is not yet mature and defined enough as a field so as to function as the only or main reference base for the organizations involved. Investigating the emergence of nanotechnology, however, broadens our understandings of the framing processes involved in the following ways.

Firstly, nanotechnology helps us to map the interconnections between actors representing science and popular culture as the concept has its origins in science fiction rather than science. It was only after its inception that nanotechnology was adopted by the scientific community. In the present study we particularly concentrate on the framing and counterframing activities that facilitated this shift. Secondly, the nanotechnology case helps us to map the micro-level activity in framing during the birth of a technological field. It is possible to identify a few influential individuals that were particularly active in formulating the initial frame of nanotechnology. Although these individuals resided outside the research

community, they were able to frame and promote nanotechnology in ways which allowed the scientists to recognize it and later to adopt the concept in a revised form. Similar processes are also likely to influence the emergence of other organizational fields.

### **3.2 Data collection**

Our research approach comes close to what Dubois and Gadde (2002) call systematic combining. This concept refers to the co-evolution of analytical concepts, research questions and conducted case analyses. The study draws from three sources of primary evidence. Firstly, 16 interviews of managers, researchers and policy makers closely involved with nanotechnology were conducted in the San Francisco Bay Area between March and May 2006. In these interviews, the informants were asked to describe what is new and significant in nanotechnology from their point of view, what their relationship is to nanotechnology, and what the core technologies are that they are developing and using. The interviews lasted approximately 50 minutes on average.

As the second source of evidence, this paper draws on a content analysis of newspaper articles. We made a search for the words ‘nanotech\*’ and ‘nanoscient\*’ in the Factiva database on major U.S. newspapers. The basis of sampling for the newspaper articles was to select the first articles of the 1<sup>st</sup> and the 15<sup>th</sup> day of the month, or closest after. For the years with less than 24 hits, all news articles were analyzed. After removing the duplicates, for the years 1986-1994, 1996 and 1998 there were 24 or less hits and all the news articles of the year were analyzed, resulting in 111 articles. During the years 1995, 1997, 1999 and 2000, two articles per month were selected according to the same selection principle. This resulted in 96 news articles. Hence, altogether 207 news items were analyzed.

As the third source of evidence, we used the transcripts of two Congressional Hearings, where nanotechnology was discussed. The first hearing took place on June 26, 1992 on the topic “New Technologies for a Sustainable World” at the U.S. Senate Committee on Commerce, Science, Technology and Space. The second hearing was a part of the preparation for the National Nanotechnology Initiative and it was held on June 22, 1999. The hearing was called “Nanotechnology: the State of Nanoscience and Its Prospects for the Next Decade”. Both documents include a transcript of the hearing, and formal written

testimonies of the witnesses on the issues in question. The first document is 62 and the second 143 pages long with appendices.

While the interviews conducted in the U.S. form the primary interview material for this study, they benefited from the previous knowledge gained during the fieldwork in Northern Europe, a region with a substantial amount of activities in nanotechnology. The informants in these 38 interviews which were conducted in Denmark, Finland and Sweden, included university researchers, representatives of public agencies engaged in basic and applied research, or coordinating national and trans-national level programs, small start-ups and large multinational firms, and venture capitalists. These interviews took place between November 2004 and March 2006. This indicates that we had substantial information on nanotechnology that helped us to formulate interview questions and challenging the views of interviewees in the fieldwork conducted in the U.S.

### **3.3 Data analysis**

The data analysis comprises three main stages. In the first stage of the study it was important to understand how the informants cognitively constructed nanotechnology. To do this, all the interviews were transcribed and coded using qualitative data analysis software, and the emergent categories were analyzed. These categories were related to the roles and activities of different actors in the emergence of nanotechnology, the employment and the technological potential of nanotechnology, and to some aspects of commercialization of nanotechnologies. However, from this initial analysis it became clear that by far the most loaded category in our interview material described the ways in which various actors benefited from and exploited the emergence of the nanotechnology label. We named the category as 'Nanolabeling and nanohype'. Our interview material indicated the ways in which the currently prevailing view on nanotechnology had gradually emerged through a process of framing and counterframing activity. The interview material also revealed critical junctures in this process that could be examined and elaborated with the material obtained from the other sources. In this aim, we moved backwards in time from the present discourse of the interviews, and built a timeline that chronicled the early emergence and consequent framing activities of the media. For this, we conducted a content analysis of newspaper articles.



Material adopted from the newspaper articles from 1981 until 2000 allowed us to identify how the individual actors and the emerging nanotechnology field were addressed at each point. All the documents were analyzed with particular attention to the actors mentioned and the attributes given to nanotechnology. Also, a short description of the main contents of each article was written down. With this analysis we were able to use quantitative indicators on the framing of nanotechnology in the media. The Congressional Hearing documents provided us with information on who were chosen to represent the community of nanotechnology at two analytically different stages of its development as a technological field. They also revealed the kinds of arguments that these individuals were using for persuading and framing nanotechnology as an important area for a national level investment. The data analysis in particular focused on the frames or understandings of nanotechnology that the respective actors were promoting. Illustrative quotes on these framing activities of the different actors will be provided in the case analysis that follows.

#### **4. FRAMING AND COUNTERFRAMING IN THE EMERGENCE OF THE U.S. NANOTECHNOLOGY FIELD, 1986-2000**

Nanotechnology is a very broad and somewhat confusing concept with strong ties to research in both public and private research organizations. Nanotechnology has been defined by Wang (2004: 28) as “the construction and use of functional structures designed from an atomic or molecular scale with at least one characteristic dimension measured in nanometers”. To illustrate the size, the diameter of the period at the end of this sentence is about 500,000 nanometers. The concept of nanotechnology is typically used when referring to science and to a collection of related technologies, where the operations take place on a size scale between 0.1 and 100 nanometers (Budworth, 1996; European Commission, 2004). Such a small size scale reveals novel scientific phenomena and characteristics of matter as the laws of quantum physics become prevalent. Investigating such phenomena requires cooperation between physicists, chemists, engineers, material scientists and biologists, among others. Consequently, nanotechnology is inherently a horizontal and multidisciplinary field of activity. However, it is important to note that most of what today is called nanotechnology refers to the defined size scale rather than to the employment of quantum phenomena or other aspects that were originally related to the concept. The

analysis below addresses the framing and counterframing processes that contributed to the present condition of the nanotechnology field.

#### **4.1 The introduction and adoption of the Drexlerian futurist framing of nanotechnology, 1986-1990**

Nanotechnology represents a larger trend towards miniaturization in science and technology. Miniaturization as a focus area within science is widely considered to have had its start in 1959 in the luncheon speech of a Nobel Prize winner, the physicist Richard Feynman, who stated “there is plenty of room at the bottom”<sup>12</sup>. Feynman did not employ the concept of nanotechnology, but his speech became widely disseminated and it inspired many scientists. He focused attention on miniaturization and its limits within a variety of scientific disciplines, most importantly in physics, biology and chemistry. The trend was reflected also in the miniaturization of computing following the Moore’s Law<sup>13</sup>. Computing was a significant driver towards micro- and nanotechnology in electronics from the 1960s onwards. Feynman’s visions came closer to fruition in 1978 with the establishment of the field of supramolecular chemistry, and the launch of the scanning tunnelling microscope (STM) in 1981 and the atomic force microscope (AFM) in 1986. STM and AFM were the first tools that made it possible to see and manipulate individual atoms. Further, the development of micro-electromechanical systems (MEMS) was a hot topic in the respective fields of science in the 1980s in the U.S., Japan and Europe alike. These and some other developments towards a smaller scale in science but also in popular culture are presented in Table 1. The later inventions of new forms of carbon such as fullerenes and carbon nanotubes, as well as single electron transistors and molecular switches, have marked major scientific breakthroughs in small-scale science which have also enabled some commercial activities.

As a result of these trends, miniaturization in science had already taken a steady course by the mid-1980s. However, none of it was referred to as nanotechnology until Dr. Eric Drexler introduced the concept of Molecular Nanotechnology (MNT) in his widely

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<sup>12</sup> Feynman’s speech in its entirety can be found from [<http://www.zyvex.com/nanotech/feynman.html>]

<sup>13</sup> [<http://www.intel.com/technology/silicon/mooreslaw/>]

Year	Event
1959	Nobelist Richard Feynman's speech: "There is Plenty of Room at the Bottom"
1974	The term 'nanotechnology' is introduced by Japanese Professor Norio Taniguchi
1978	Launch of supramolecular chemistry by French Jean-Marie Lehn (Nobel Prize in 1987)
1981	Launch of scanning tunneling microscope (STM) by Heinrich Rohrer and Gerd Binnig of IBM in Switzerland (Nobel Prize in 1986)
1985	Richard Smalley and Robert Curl (Rice University) and Harold Kroto (University of Sussex in Brighton, UK) invent C60 fulleren (Nobel Prize in 1996)
1986	Launch of atomic force microscope (AFM) by Gerd Binnig, Calvin Quate and Christoph Gerber Eric Drexler publishes <i>Engines of Creation, the Coming Era of Nanotechnology</i> and establishes <i>Foresight Institute</i>
1987	Theodore A. Fulton and Gerlad J. Dolan develop the first single electron transistor at Bell Laboratory Establishment of MEMS as a field
1988	William deGrado and his group design and develop first protein in DuPont Laboratory
1989	The word "IBM" is written with 35 xenon atoms by Donald Eigler and team at IBM in California, USA First Foresight Technological Conference in California
1990	The first academic journal in the field called "Nanotechnology" is established by Institute of Physics in USA
1991	Sumio Iijima invents carbon nanotubes in NEC Laboratory in Japan
1992	Journal Nanostructured Materials is established by Acta Metallurgica, Inc.
1992-2001	Joint Research Center for Atom Technology received 10 year budget for nanotechnology related research in Japan
1994-2002	Transnational projects in nanotechnology in EU within 4th and 5th Framework Programmes
1996	Federal program officers at the National Science Foundation (NSF) and other agencies begin to meet and share information on efforts in nanoscale science and engineering in USA Launch of the national research program "Nanowissenschaften" and program "Micro- und Nanosystemtechnik" (MINAST) in Switzerland Rice Center for Nanoscale Science & Technology (CNST), 1996, the world's first nanotechnology laboratory is established
1997	Nadrian Seeman from New York University demonstrate the first nanomechanical device based on DNA
1997-1999	Nanotechnology Research Program by the National Technology Agency in Finland
1998	Establishment of the Interagency Working Group on Nanotechnology by US government
1999	Mark Reed and James M. Tour from Yale University produce the first molecular switch Cees Dekker of the Delft University of Technology designs the first carbon nanotube transistor. Congressional hearing in USA before the Subcommittee on Basic Research of the Committee on Science about 'Nanotechnology: the State of Nano-Science and Its Prospects for the Next Decade'
2000	President Clinton announces the National Nanotechnology Initiative (NNI) in the USA

**Table 1:** *Chronology of the milestones in the development of nanotechnology, 1959-2000*

disseminated book “*Engines of Creation: the Coming Era of Nanotechnology*” in 1986. Drexler’s book gained a lot of attention due to its provocative claims about molecular assemblers that may create minuscule copies of themselves by stacking atoms together. In the book, nanotechnology was represented as the future of manufacturing with amazing potential to build anything synthetically, atom up through self-replication. Manufacturing through self-replication would result in, for example, endless riches and abundance, much longer or even eternal life through cell repair and cryogenics, and the possibility to colonize space. However, great threats were also associated with nanotechnology. Should the self-replication process go out of control and let the small assemblers consume all the resources in the world, the Earth would turn into grey goo<sup>14</sup>. Consequently, Drexler also proposed the development of policies and regulation or abstinence from developing such technologies. The concept and the visions that he put forward were compelling, and the U.S. public media as well as fiction authors especially in the cyber punk genre greeted the concept with enthusiasm. In the media, Drexler was referred to as a scientist based on his Ph.D. from the Massachusetts Institute of Technology and his later affiliation with Stanford University. These made it possible to characterize him as a legitimate and serious actor in the field of science.

In 1986, Drexler and his wife Christine Peterson established the Foresight Institute, a non-profit making institute to promote the Drexlerian views of nanotechnology and to inform people about Molecular Nanotechnology. Christine Peterson told about the forming of the Institute in an interview as follows:

*His book called the Engines of Creation [...] laid out the basic technological possibilities and also the policy issues that appeared to be at that time. At that stage, both he and I could see that this was going to be a very big deal. The people that read the book would want more information. So, in the back of the book it says, ‘Please contact Foresight Institute’ and it has my number on it. So many people contacted us [...] that was the initial founding.*

Soon thereafter, further actions in building the recognition for nanotechnology were taking place in the form of research meetings and conferences. In 1988, Dr. Drexler founded the

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<sup>14</sup> [[http://en.wikipedia.org/wiki/Grey\\_goo](http://en.wikipedia.org/wiki/Grey_goo)]: “Grey goo refers to a hypothetical end-of-the-world scenario involving molecular nanotechnology in which out-of-control self-replicating robots consume all living matter on Earth while building more of themselves [...] ‘goo’ meaning a large mass of replicating nanomachines lacking large-scale structure, which may or may not actually appear goo-like.”

Nanotechnology Study Group at MIT, where discussions took place about the pros and cons of nanotechnology. A year later, the first Foresight Technical Conference was held, bringing together futurists and interested scientists to discuss the potential of nanotechnology. In 1991, joined by some Silicon Valley business executives, Drexler established the Institute for Molecular Manufacturing, another non-profit organization that provided small grants for nanotechnology research. In addition, as a means to create legitimacy around his views, Drexler suggested from the beginning that he would act in the spirit of Professor Feynman, and in 1993 the Foresight Institute began to award Feynman Prizes for individuals doing 'a great job' for nanotechnology. As a result of these efforts, Drexlerian views on nanotechnology became widely disseminated in the media. For example, in 1989 IBM scientists were able to demonstrate the use of the new tools by writing the word IBM using Xenon atoms. The event received a wide media coverage that addressed this event in particular as the first step towards nanoprecise manipulation in its Drexlerian meaning. Hence, in the early 1990s, there was a relatively precise meaning given to nanotechnology among the actors that formed part of this emerging field. As Ms. Peterson describes:

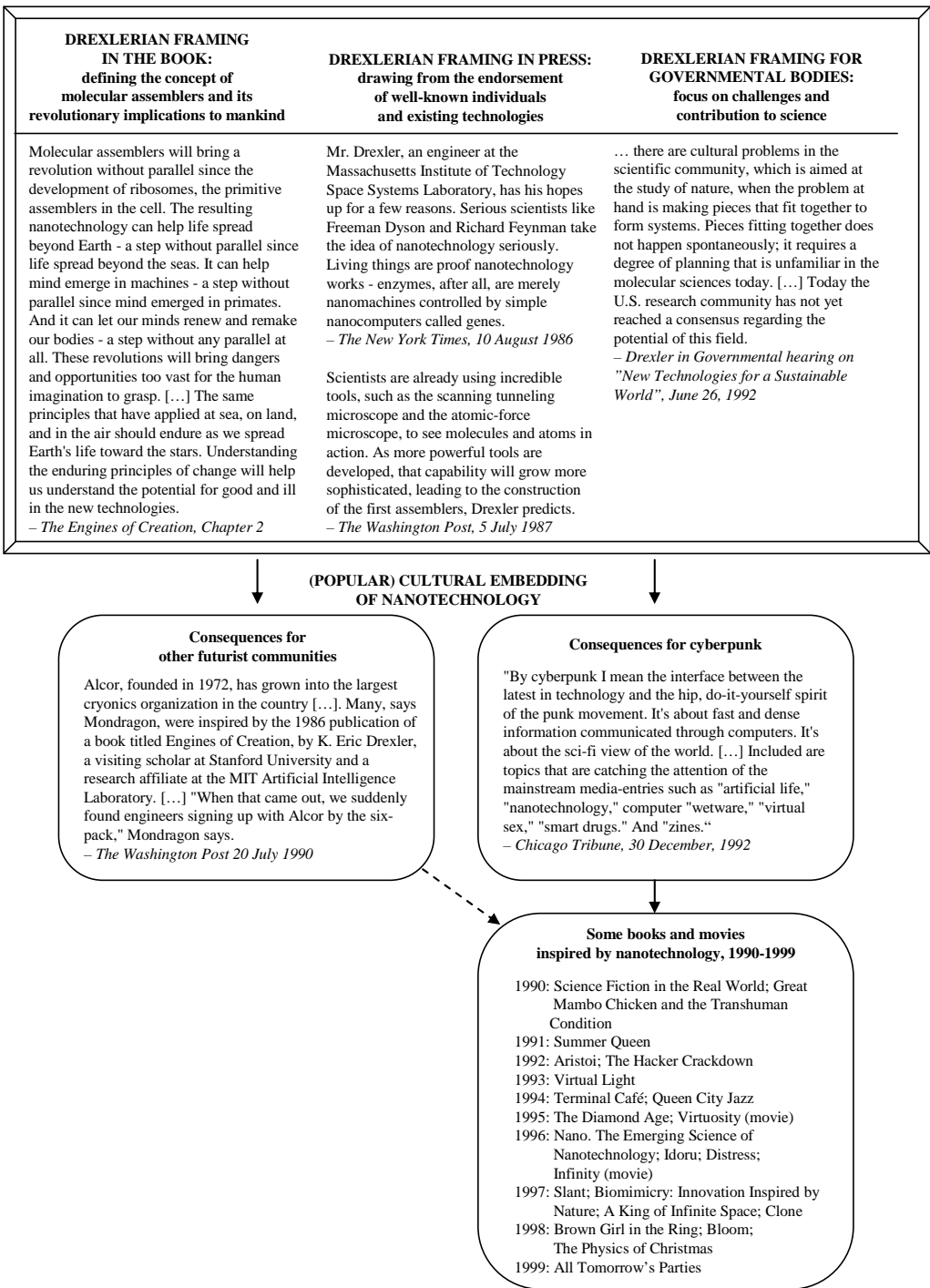
*In the earlier days, the term nanotechnology and the body of ideas around it, there was coherence to it. It was about atomically precise construction and in a particular scenario. At the time it was a very new idea and it was a coherent body of knowledge that many people shared.*

Dr. Drexler had been especially successful in creating a following among the futurists and the concept was also adopted in science fiction literature. At the same time, however, in the scientific community Drexler's frame was on the fringe. Briefly stated, scientists considered him a futurist and his ideas those of science fiction. From the scientists' point of view, the difference between futurists and scientists is that the futurists present great visions on how things may be one day, whereas scientists tend to limit their statements to scientific facts that have been validated by rigorous empirical examination and reviewed by anonymous peers in the scientific community. Public media easily mixes up these two groups, especially when technologically savvy futurists with compelling ideas represent themselves as a part of the scientific community or as members of distinguished research organizations. This was also the case with Drexler. In the beginning, most scientists remained indifferent to Drexler's claims, which in their view had no scientific foundation whatsoever. As stated by a prominent American scientist and a pioneer in nanotechnology:

*The word futurist is what I would say about Drexler. The most prophetic guy. He is not a lab scientist; he is not someone like Richard Smalley who won a Nobel Prize for doing real things. He is trying to sort of motivate the world to take a particular interest in his flavour of nanotechnology.*

The initial Drexlerian frame was formulated and legitimated in slightly different ways to different audiences (see Figure 2). The first of these ways was present in the book “Engines of Creation” in 1986. The second, as presented by the press, built the legitimacy of the Drexlerian frame on the reputation of the institutions and individuals involved, as well as on claiming that the first steps towards the Drexlerian nanotechnology had already been taken in science. The third was the presentation of Molecular Nanotechnology in a Congressional Hearing in 1992 as a potential solution to certain cultural challenges in science. Hence, the initial frame for nanotechnology was based on the Drexlerian views on Molecular Nanotechnology. In this framing, nanotechnology referred to the processes of atomic level self-replication, which provide infinite possibilities to build anything atom up, but which are difficult to control, and hence, potentially detrimental to life on Earth. The Drexlerian frame thus contributed to the development of nanotechnology as a field by introducing the concept and making it widely recognized.

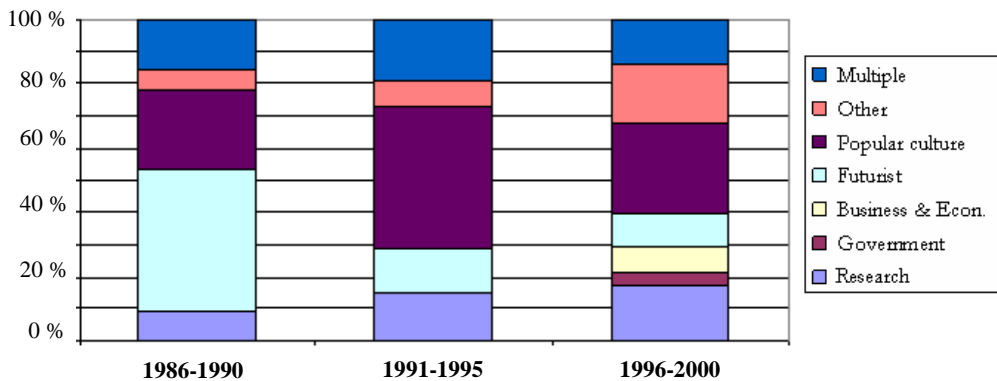
The Drexlerian frame in its different forms received a bipartite response after it had been introduced. On the one hand, there were cyberpunksters and the futurist community who embraced the Drexlerian framing. This was indicated by the fact that basic Drexlerian ideas of nanotechnology were adopted and built upon in many science fiction books. On the other hand, there were the scientists who strongly opposed the Drexlerian frame, but many of whom also realized that the popularity of the concept provided opportunities for the scientific community. Hence, the scientists began their attempts to reformulate the Drexlerian understandings of nanotechnology to a direction where the concept would be more beneficial and suitable for their specific purposes and needs. Over time such activities resulted in the forming of a new frame of nanotechnology and the gradual marginalization of the Drexlerian frame.



*Figure 2: Initial Drexlerian frame of nanotechnology and its cultural embeddedness*

## 4.2 Adoption and framing of nanotechnology in cyberpunk, science and government level activities, 1990-2000

Outside the futurist community, nanotechnology first became adopted in science fiction, and particularly in its cyber punk genre. Figure 3 shows how nanotechnology as a concept was used to refer to an increasing number of different groups of actors in the U.S. media from 1986 to 2000. From 1986 to 1995 popular cultural and futuristic notions of nanotechnology dominated the press reporting. However, the balance began to tilt towards the presence of multiple groups and views of nanotechnology towards the end of the century.



**Figure 3:** Distribution of news articles on nanotechnology by the indicated focal actor in major US newspapers, 1986-2000, N=207

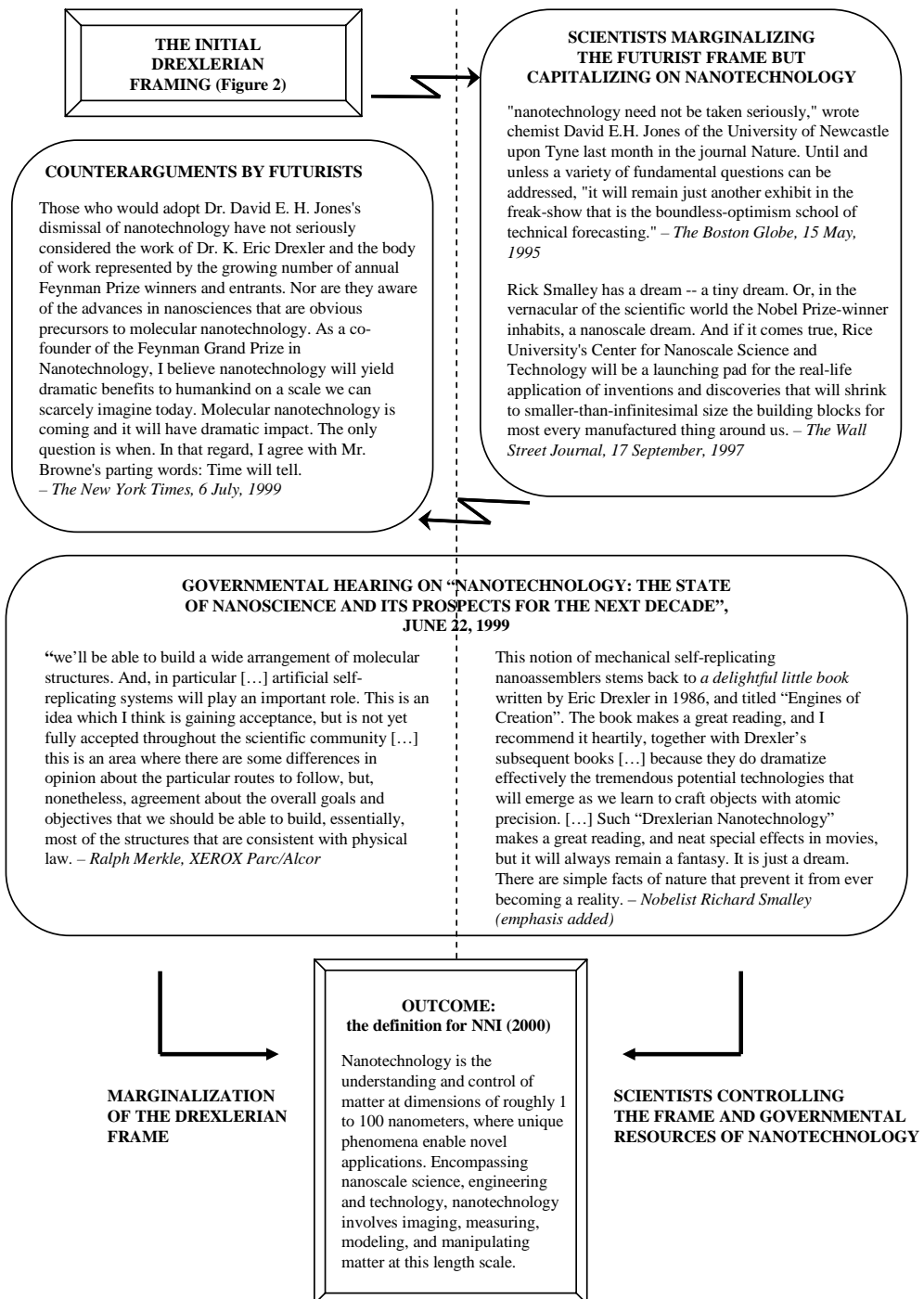
Indeed, during the entire 1990s a major part of nanotechnology news coverage consisted of reviews of cyber punk genre books and major feature films. According to Person (1998), “classic cyberpunk characters were marginalized, alienated loners who lived on the edge of society in generally dystopic futures where daily life was impacted by rapid technological change, a ubiquitous datasphere of computerized information, and invasive modification of the human body”. In these books, nanotechnology provided the tools to manufacture anything through self-replication; improve human body and mind infinitely, for example, by downloading data into human minds, which allowed humans to have many personalities simultaneously; as well as to heal all the sicknesses, which made humans immortal. In the same vein, cryogenists considered nanotechnology as a solution to revive the human body



after a long period of deep freeze. The books also described worlds where nanotechnologies were used to control human beings. In the literature and press, cyberpunksters and cryogenists structured the macro-cultural understandings of nanotechnology by addressing and developing further its utopian and dystopian aspects. Such framing of nanotechnology strengthened the embeddedness of the concept in popular culture.

Consequently, it is probably no surprise that in the early 1990s most scientists who had heard of nanotechnology regarded it as science fiction. We have already noted that before and around the time when Drexler presented his ideas on nanotechnology, there had been important scientific advancements in the domain of miniaturization (see Table 1 above). Thus, there were a substantial number of scientists who were initially interested or involved with studying the micron and sub-micron world. Nonetheless, in the late 1980s the scientific community remained more or less completely oblivious towards the activities conducted under the nanotechnology banner and would not interact with Drexler. This did not, however, prevent Drexler from driving Molecular Nanotechnology up to federal government level. He was invited to testify on June 26, 1992 in front of the U.S. Senate Subcommittee hearing on Science, Technology and Space on the topic “New Technologies for a Sustainable World” held by the Vice President, Senator Al Gore. This subcommittee aimed to map technologies that would help with lowering CO<sub>2</sub> emissions. In this hearing, Drexler referred to the scientists’ dismissal of Molecular Nanotechnology in science as “cultural problems in the scientific community” and suggested that the former would unleash the potential of designing atomic and molecular structures (see also Figure 2 above).

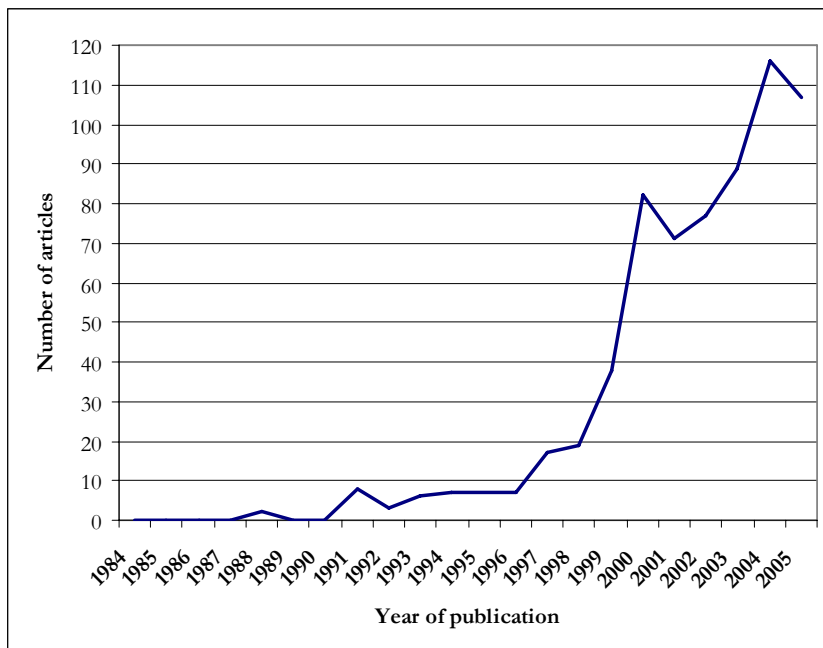
This means that at this point, in addition to a significant following outside the scientific community, Drexler and his framing on the nanotechnology field had also been able to gain the attention of the government. These two aspects together forced the scientists to take a new stand. Figure 4 presents the consequent contestation of frames that both the scientists and futurists engaged in during the 1990s. A visible part of the framing and counterframing activities took place in the media. Perhaps the most crucial contestation event occurred in the Governmental Hearing for the preparation for the National Nanotechnology Initiative (NNI) in 1999. Even before this the scientists had already



*Figure 4: Contestation of frames in news and governmental hearings*

actively engaged in framing nanotechnology in a way that was more suited to their purposes. There had also been some pioneering researchers, who early on saw the possibilities for adopting the concept of nanotechnology in science. According to one of the scientists interviewed,

*So I think the word nanotechnology became legitimate probably by the mid-90s. There was this early period in the late 80s, early 90s where there wasn't someone like Smalley or Steve Chue. They call up and say "oh, we are gonna use nanotechnology, yes there is some people who view this as a miraculous wonder technology and all, but they can sort of have their conferences and motivate extreme future things. Maybe that is good, but actually we'll start some journals." So once it became a field, there was a lot of it.*



**Figure 5:** Number of articles in Science and Nature mentioning 'nanotech\*' or 'nanoscient\*', 1984-2005.

As a result, the first journal “Nanotechnology” was established in 1990 by the Institute of Physics, followed by “Nanostructured Materials” by Acta Metallurgica, Inc. in 1992. These were the first signs of the adoption of the nanotechnology concept by scientists. However, it took a long time before the concept became more widely applied in this domain. Science

and Nature are perhaps the two most distinguished journals for the researchers in natural sciences. Figure 5 exhibits how some initial adoption of the concept took place between 1990 and 1998 in scientific community, whereas the occurrence of ‘nanotechnology’ or ‘nanoscience’ did not begin to grow exponentially before 1999. This coincides with the U.S. government’s preparation of the National Nanotechnology Initiative (NNI).

Activities that provided new resources for the emerging nanotechnology field took place at both the federal and national government levels. At the former, the attempts to coordinate work on the nanoscale research and development began in November 1996, when staff members from several federal agencies agreed to meet on a regular basis to discuss their plans and programs in nanoscale science and technology. Their work was informal until September 1998, when it was designated as the Interagency Working Group on Nanotechnology under the National Science and Technology Council. Their work resulted in the report *Nanostructure Science and Technology: A Worldwide Study* in September 1999. This laid the foundation and justification for starting a national level nanotechnology initiative<sup>15</sup>. However, for nanotechnology activities to become known and legitimate at the government level, the efforts of policy lobbyists, such as Tom Kalil, were significant. Kalil worked for President Clinton in the White House Economic Council watching over issues related to science and technology, and was occupied primarily with information and communication technologies during the first half of the Clinton administration. In 1999, he started to educate various members of the White House about the importance of nanotechnology, and of the long-term benefits of investing in it. This lobbying for NNI by him and others in the agencies<sup>16</sup> resulted in Bill Clinton announcing the NNI in his speech at Caltech in January 2000. Tom Kalil depicted the context that facilitated the establishment of NNI in an interview as follows:

*[...] there was a certain room for policy entrepreneurs, so there was a certain amount of agency involved as well. In terms of the broader contextual factors I think I would point to the following: Number one, the administration had entered with the real interest in making more investments in research and development [...] we actually had lots of surpluses so it was more possible to make arguments for increased investment entering the last couple of years [of the administration]. [...]*

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<sup>15</sup> [<http://www.nano.gov/html/about/history.html>]

<sup>16</sup> According to Kalil, Neil Lane from the Office of Science and Technology Policy, Mike Roco from the NSF and Jim Murday from the Office of Naval Research.

*Number two, there was a lot of concern within the scientific community about the imbalance between biomedical research and physical sciences and engineering. NIH<sup>17</sup> was ensuring very strong support to double its budget over a five-year period. Biomedical research was increasing but for physics, chemistry, engineering was stagnant. The National Nanotechnology Initiative was one way of getting the public in the Congress and elected officials excited about investing in the physical science and engineering.*

Hence, nanotechnology had become a legitimate technological field that could obtain substantial government funding. The compelling visions and stories that were presented by the lobbyists about the revolutionary future potential of nanotechnology partly facilitated this situation. Researchers interested in gaining more funding for basic research in physics, chemistry and engineering, as opposed to biotechnology, were able to frame nanotechnology as a strategic research area for the nation, and to obtain funding for it. Because nanotechnology was a means for such funding, the scientists also strived for a definition that was large enough so as to accommodate various areas of research. As noted by one of the scientists involved:

*It's nice to have something so broad that failure is not an option, but maybe from the funding agency point of view it would be a little like saying, will there be breakthroughs in chemistry in the next decade, and the answer is yes. And nanotechnology is at least that broad, or broader [...] I guess there has been a lot of hyping way beyond Drexler by people, who work in the research community attempting to get the major funding initiative that President Clinton signed off.*

The recognition of nanotechnology at the governmental level was also later directly influenced by individual actors who followed the initial Drexlerian futurist framing on nanotechnology. One of those was Ralph Merkle, who worked as a research scientist at Xerox PARC research laboratory at the time. Merkle was the first and only person at Xerox assigned to investigate the potential applications of nanotechnology. In the U.S. media he was often cited as an expert on nanotechnology and his views were widely reported. Merkle was also a cryogenist and an Alcor director<sup>18</sup>. Despite being engaged in such controversial topics, Merkle was one of the witnesses and an advocate of the Drexlerian framing, when

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<sup>17</sup> National Institutes of Health, the primary Federal agency for conducting and supporting medical research

<sup>18</sup> The non-profit foundation specializes in cryonics, i.e. “in the science of using ultra-cold temperature to preserve human life with the intent of restoring good health when technology becomes available to do so”, [<http://www.alcor.org/>]

the Congressional Hearing “Nanotechnology: The State of Nanoscience and Its Prospects the Next Decade” for the preparation of the National Nanotechnology Initiative was held in June 1999. In the transcripts of the hearing the clash between the two advocate groups of different versions of nanotechnology is clearly present. In the hearing itself the witnesses for nanotechnology seemed to act more or less as a unified front, but in the written testimonies attached to the hearing documents their views deviate strongly. For example, Nobelist Richard Smalley strongly criticized the Drexlerian frame, which Ralph Merkle had advocated in the hearing (see also Figure 4 above).

Taken together, the analysis above suggests different roles for each group of actors involved with the framing and counterframing processes of nanotechnology (see Table 2). Despite embracing the concept in general, most scientists wanted to distance themselves from the Drexlerian futurist frame of nanotechnology, or Molecular Nanotechnology, which was adopted and extended in the cyber punk community. The fact that the scientists retained the concept of nanotechnology in their significantly revised framing of the emerging field allowed them to benefit from the wide recognition of the concept in the popular culture. This had been enabled by Drexler and other futurists. The scientists’ main motivation was to mend the gaps in the public funding infrastructure in order to shift the emphasis of funding of nanotechnology from biomedical related activities towards the physical sciences and engineering. From the beginning, the scientists advocated an altogether different meaning for the concept, which helped them to exploit it to its full potential for their purposes. The very broad and ambiguous definition of nanotechnology as a size scale between 1-100 nanometers employed in the NNI differs clearly from the initial narrow framing of the Drexlerians. Such a definition allowed scientists to place a large variety of activities under the nanotechnology banner. Further, the scientists and their lobbyists were able to obtain novel resources dedicated to these activities. Indeed, their counterframing activities contributed to the fact that no direct funding from the NNI has been provided to Drexlerian research projects. The scientists’ broad frame of nanotechnology captured governmental level support and the key financial resources for developing the emerging field. Despite the contribution of the Drexlerians to the emergence of nanotechnology as a technological field in the first place, they were pushed to the fringe in the field they originally initiated. However, at the same time, the Drexlerian framing of nanotechnology still prevails in the minds of the public at large.

	<b>Drexlerians</b>	<b>Cyberpunksters</b>	<b>Scientists</b>
<b><i>Frame</i></b>	Molecular Nanotechnology driven by self-replication of assemblers; involves enormous potential but also horror scenarios	Versions of Drexlerian frame describing utopian and dystopian futures enabled by e.g. nanotechnology	Nanotechnology as a size scale between 1-100 nm
<b><i>Motivation to participate</i></b>	Technology vision, need to control the development of novel technologies	Compelling Drexlerian futurist vision aligned with cyberpunk imagery and potential for self-expression	Nanotechnology as an enabling concept in the creation of novel resources for engineering and physical sciences
<b><i>Role in field development</i></b>	Creation and mobilization of the concept; creating receptivity for nanotechnology	Cultural embeddedness through books and movies	Governmental and scientific embeddedness, policy entrepreneurship
<b><i>Position of dominance in the end</i></b>	Institutionally in the fringes, but strongly present in cultural understandings	Dominates popular cultural understandings and imagery of nanotechnology	Dominant on policy and governmental level

**Table 2:** *Comparison of the actor's role in the framing of nanotechnology*

## 5. DISCUSSION

The case of nanotechnology provides some interesting viewpoints for the discussion of micro-level activities and processes of field emergence (e.g. Rao, 1998; Lawrence & Phillips, 2004; Maguire et al., 2004) by highlighting the under-explored issue of how individual and collective actors frame and counterframe events and occurrences in a way that set boundaries for an emerging technological field. In this study we argue that a new field becomes widely recognized only through the processes of framing, which in the beginning may be orchestrated by individual visionary actors. Previous literature has recognized that the adoption of new organizational forms, or the emergence of new fields, require that institutional entrepreneurs frame them in a way that encourages other actors to endorse, support and join them without compulsion (Hargadon & Douglas, 2001; Strang & Jung, 2005). Previous literature has not, however, systematically investigated the

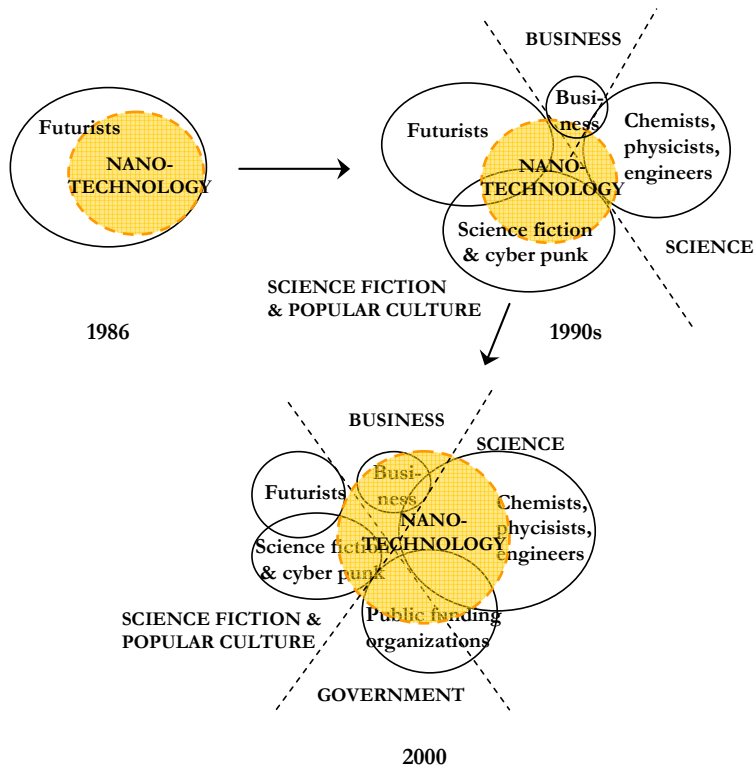
mechanisms and processes through which the initial ideas and visions of individual actors, providing a basis for the framing, result in the emergence of a new technological field.

For the case of nanotechnology, the emergence of this technological field in the US can be traced back to the writings and institution building activities of Dr. Eric Drexler. He had a specific vision on the potential offered by the distinctive atomic and molecular scale technologies, and he engaged in framing activities that allowed the diffusion of his views on Molecular Nanotechnology. Our findings suggest that while the initial framing by individual actors lays the foundation for a new technological field (cf. Garud & Rappa, 1994), it eventually materializes in a form that has been influenced by the contributions and involvement of various other actors. For example, the initial Drexlerian framing of nanotechnology was successful in mobilizing public interest, and it particularly inspired science fiction. As a result, nanotechnology as a concept and some of its core ideas became culturally embedded in the books and films produced by the advocates and representatives of this genre. However, this framing was not able to attract any significant governmental resources. Such development is a result from the way in which Drexler presented his ideas. The rhetoric and persuasion methods he used, and the people he was associated with signaled a closer relationship to science fiction than to science. This was the case especially towards one prominent stakeholder group, the scientists, whose support for his visions Drexler was unable to secure. Rather, the Drexlerian framing of nanotechnology generated fierce opposition among this group. Such opposition did not, however, inhibit the Drexlerian take on nanotechnology from becoming culturally embedded and highly influential. This framing was perhaps more compelling to the wider public than the framing of the scientific community. As a result, Drexlerian visions of nanotechnology still remain popular among science fiction authors and are present in the public understandings of nanotechnology.

Given the above, the position and skills of Drexler as an institutional entrepreneur did not serve the purpose of getting his agenda accepted at the governmental level, though he was able to generate some enthusiasm also among politicians. The Drexlerian visions did not fully materialize in the emergence of the nanotechnology field through the established political system. Nonetheless, the original futurist framing had an important influence on the emergence of the nanotechnology field because it created a principal cultural receptivity



towards nanotechnology. The cultural embeddedness of the Drexlerian frame allowed new actors to join and bring new resources to facilitate the expansion of the emerging field. However, once such dissemination takes place the frame of a technological field evolves out of the control of particular individual or organizational actors.



**Figure 6:** *Shifts in the framing of nanotechnology, 1986-2000*

The frame of nanotechnology the scientists promoted drew from the revolutionary potential and enthusiasm generated by the Drexlerian framing and, at the same time, trying to undermine the threats and dangers present in this frame. The frame the scientists promoted was much more ambiguous (cf. Rao & Georgi, 2006) than this previous frame, and for this reason the scientists were able to bundle a wide variety of academic research under the nanotechnology banner. The success of scientists to establish nanotechnology as a field of research at the governmental level was largely based on that they built on the cultural receptivity for the concept, while simultaneously altering its content. Using the vocabulary of Rao and Georgi (2006), the Drexlerians were outsiders who introduced an

imported logic to the social system of science, but who failed to obtain sufficient third-party support, which then allowed co-optation by the scientists. As a result, the Drexlerian insurgency did not succeed. Instead, the scientists' frame for nanotechnology served the contemporary needs and political interests of the scientific community, which was crucial in lobbying for novel material resources for nanotechnology, and in facilitating its acceptance in national level science policies. Figure 6 presents the main sequences in the process through which nanotechnology gradually moved from science fiction into science.

As a result of the above analyses, the present study extends the prevailing understanding on how framing may contribute to the emergence of new technological fields. The case of nanotechnology suggests that different forms and modifications of an initial frame may create opportunities for a new technological field to emerge. However, the extent to which this can happen draws on the skills, qualities, positions and strategies of entrepreneurial individuals promoting those frames. While the institutional entrepreneurship literature acknowledges the role of individual activities, it has largely omitted the contestation at the different stages and different levels of analysis in the emergence of technological fields. From the point of view of the social movement approach, mobilization always includes elements for counter-mobilization as activities towards a certain direction may lead to polarization and conflict between actors representing different views (Hirsch, 1990). However, such a conflict is a generative process in field emergence since the later adopters are able to define areas where they can exploit in the initial frame and at the same time make it more applicable (cf. Zald & Useem, 1987). Further, the case of nanotechnology suggests that counter-mobilization among scientists was triggered by the fact that the social system of science was being pervaded by outsiders. Marquis and Lounsbury (2007) provide corresponding observations on how the mergers and acquisitions initiated by national banks, but not regional banks, led to founding of new local banks. Such political conflicts have received only scant attention at the level of organizational fields (Morrill, Mayer & Rao, 2003), and their micro level foundations have gained even less attention in the previous literature.

The findings of the present study remind us that there is a lack of sufficient attention to the embeddedness of a field frame. The extent to which, but also the social structure in which, a frame is embedded may vary. A frame may be culturally, but not politically embedded as

was the case with the Drexlerian frame of nanotechnology. The nature of this embeddedness then influences how an organizational field may be built around this frame by activating certain actors, resources and beliefs that can be aligned with the frame. An important finding of this study is that the cultural embeddedness of a frame may be as influential in defining the persistence and impact of a frame as its political acceptance by the institutionalized funding institutions. Hence, a culturally embedded frame draws from and is capitalized through cultural resources such as beliefs and attitudes, which influence the actions and perceptions of individuals and communities. This means that, as is the case of social movements in general (e.g. Zald, 2005), the influence of this frame to the organizational bodies that provide resources for the field is largely indirect. However, cultural embeddedness of a frame is highly likely to produce effects also in more formally institutionalized systems. Consequently, the dissemination of an idea or a concept through popular culture may induce the emergence of such cultural resources, and result in the emergence of cognitive forms and functions that increase general receptivity towards novel technologies (cf. Garud & Karnoe, 2001).

The study also argues that the political and institutional capitalization of a frame depends on the activities of actors with certain skills and positions. Gaining acceptance in an institutionalized system draws from the established position in the institutionalized structures. Drawing from this discussion, the study suggests that, on the one hand, social movement type approach and agency related to mobilizing ideas and concepts may be highly influential in establishing a cultural embeddedness of a frame. On the other hand, the institutional entrepreneurship type approach and agency in terms of existing positions and skills may better explain why the frame becomes legitimated by formal institutions. There may not be one single dominant frame that will overcome all other frames, but a dominating frame may be some kind of a combination of the earlier frames (cf. Campbell, 2005). Furthermore, even though the initial frames may not be persistent over time in their totality, they still structure the understandings of a novel field (Lawrence & Phillips, 2004). As a result, different frames can draw from different types of resources and exist in parallel social and institutional structures.

## 6. CONCLUSION

We believe that the present study has extended previous literature in two directions. First, our investigation of the micro-level framing and counter-framing processes in the emergence of the nanotechnology field suggests that the formation of science and technology based fields is highly dependent on the framing activities of individual institutional entrepreneurs or social movement activists. This aspect has not been sufficiently addressed in previous literature, which has mainly approached the framing of new organizational fields as a predominantly collective endeavor. Even more importantly, previous literature has neglected the contested framing processes that follow the initial framing and structure the emergence of novel technological fields. With the present focus on both individual and collective entrepreneurial actors, however, we established the micro-level framing processes as a connecting point between the institutional entrepreneurship and social movement perspectives in the investigation of the emergence of technological fields. For this purpose, the study explored the interests of individual and collective actors, the frames they promoted, and the conflicts and combinations that resulted from the contestation between the frames. We suggest that a fruitful direction for future research is to further investigate the processes through which initial frames become culturally embedded, and the implications such embeddedness for the emergence of technological fields.

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## **ESSAY II**

### **Institutional Entrepreneurship in the Emergence of Science-Based Fields: Comparative Study of Functional Foods and Nanotechnology in Finland**

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**Abstract:** Previous literature on institutional entrepreneurship has neglected studying how new science-based fields come into existence, creating a blind spot in the current theory which this study explores. We investigate the processes through which institutional entrepreneurs contribute to field emergence drawing from their status and relational embeddedness, which we conceptualize as resources rather than positions. We look into how scientists and public policy actors, the institutional entrepreneurs, in the cases of functional foods and nanotechnology in Finland operate across three identified domains of activity: cognitive, organizational and spatial. The study puts forward a framework, which suggests, firstly, that institutional entrepreneurship in science-based fields is triggered by developments in science combined with local institutional needs, and secondly, that the possibilities for individual versus collective mobilization depends on the nature and scope of change required.

**Keywords:** Institutional entrepreneurship, science-based fields, status, relational embeddedness, individual and collective agency, functional foods, nanotechnology

## 1. INTRODUCTION

What role does agency play in how new science-based fields come into existence? The recent literature on institutional entrepreneurship has significantly contributed to our comprehension of agency and institutional change. The literature on the emergence of new organizational fields (Lawrence & Phillips, 2004; Maguire et al., 2004; Perkmann & Spicer, 2007) suggests that institutional entrepreneurs are the key actors in changing existing, and building and promoting, novel institutions. According to DiMaggio (1988), institutional entrepreneurs have an interest in particular institutional arrangements, such as standards and policies (Garud et al., 2002) that are aligned with their interests, and they leverage resources to create new institutions or to transform existing ones. Organizational field, on the other hand, refers to “a community of organizations that partakes of a common meaning system and whose participants interact more faithfully with one another than with actors outside the field” (Scott, 1995: 56). Regardless of theoretical and empirical contributions made within the institutional entrepreneurship approach, much remains to be done in understanding the origins and processes of institutional change (Lounsbury & Crumley, 2007; Perkmann & Spicer, 2007). Studies of institutional entrepreneurship also have a tendency to praise the activities of the most powerful actors in the later stages of emergence with the cost of “black-boxing” the early events and actors (Maguire et al., 2004; Lounsbury & Crumley, 2007). Consequently, this study draws its inspiration from the wish

to add to the few accounts on how, rather than why, new fields emerge (Lawrence & Phillips, 2004; Maguire et al., 2004; Dorado, 2005; Perkmann & Spicer, 2007).

The particular focus of this study is on the emergence of science-based fields, which has been curiously neglected in the previous inquiries. There is little understanding about who the institutional entrepreneurs in science-based fields are, and what they do to set a new field in motion. Recent work in institutional entrepreneurship has taken steps to consider the role of science in institutional change. Science is conceptualized as a vehicle for producing texts to build new institutions (Maguire & Hardy, 2006), or as a cultural resource to challenge old practices by means of analytical theories and tools to gain status for a new practice (Lounsbury & Ventresca, 2002; Lounsbury & Crumley, 2007). Hence, scientists are important agents of change in society. Public policy actors, on the other hand, hold an important role in validating the scientific agendas put forward by scientists. In this study we come to show that the agency of scientists and public policy actors is crucial in the emergence of new science-based fields. By so doing, we cast light on this under-explored topic in the institutional entrepreneurship literature.

This study further contributes to the debate on individual versus collective agency. Previous research both endorses (Lawrence & Phillips, 2004; Maguire et al., 2004; Battilana, 2006) and criticizes (Wijen & Ansari, 2006; Lounsbury & Crumley, 2007) the capacity of individuals to act as institutional entrepreneurs. To address these issues, the current study focuses on investigating the micro processes of emergence leading to a more collective adoption of the promoted practices and, hence, creates understanding on the succession of individual and collective activities and processes underlying institutional emergence. We further show how the capacity of individuals versus collective actors to induce change depends on type of field, and the nature and depth of the change they are aiming to put forward, as well as on their relational embeddedness and status. Our third area of contribution is the identification of the three domains of activity within and across which institutional entrepreneurs in emerging science-based fields bridge: cognitive, organizational and spatial. As a result of these analyses, we put forward a framework for institutional entrepreneurship in science-based fields. A comparative case study on functional foods and nanotechnology has enabled us to explore the above presented issues by revealing the significant micro dynamics from one case to another. Finland, a technologically advanced

North European country with 5.3 million inhabitants, provides an institutionally bounded 'laboratory' for such a comparative setting. Finland was among the first countries in the world to publicly legitimize the fields by forming technology programs around them. We limit our analysis to the finalization of the first technology programs in both fields in the end of the 1990s. Such methodological choices make it easier to track the complex process of emergence on both an institutional and a relational level.

The remainder of the paper consists of four sections. We begin by discussing relational embeddedness and status as the enabling factors of institutional entrepreneurship. Second, we investigate the domains of activity which the institutional entrepreneurs bridge in their endeavor to shape new institutions. After discussing the methodological choices of the study, we present the empirical case studies. Drawing both on the empirical data and conceptual discussion, we put forward our findings and build a framework for institutional entrepreneurship in science-based fields. Finally, we present the limitations of the research and the paths for further investigation we have identified during the study.

## **2. RELATIONAL EMBEDDEDNESS AND STATUS AS ENABLERS OF INSTITUTIONAL ENTREPRENEURSHIP**

Previous literature has addressed both position in networks and status as the enablers of institutional entrepreneurship (Leblebici et al., 1991; Campbell, 2004; Greenwood & Suddaby, 2006). Traditionally networks have been integrated in the institutional theory through the concept of isomorphism, where the fundamental institutional mechanisms driving organizational fields towards isomorphic adoption of ideas, practices, and beliefs are professionalization and social networks (Rogers, 1962; Meyer & Rowan, 1977; DiMaggio & Powell, 1983; Galaskiewicz & Burt, 1991; Davis & Greve, 1997; Guler et al. 2002). More recently, researchers have begun to incorporate the concept of structural holes (Burt, 1992) from social network theory into the institutional entrepreneurship approach by conceptualizing institutional entrepreneurs as bridging agents (Greenwood & Suddaby, 2006) and networks as opportunity structures (Dorado, 2005), rather than mere vehicles pressing for isomorphism.

However, we argue that this literature has not sufficiently problematized the inclusion of networks into the institutionalist literature. Network approaches tend to describe the interpersonal and organizational relations in rather structuralist terms. For example, the concept of structural holes refers to the absence of connection between separate networks, resulting in different flows of information in those networks (Burt, 1992). Incorporating such notions into institutionalist approaches comes with two major challenges. First, the approach assumes that once ‘created’ a connection exists, albeit weak or strong depending on the closeness and the amount of interaction between the actors (Granovetter, 1973). However, such an approach underplays the notion that the very perceptions of networks are socially constructed by actors in interaction with one another. Such perceptions are context dependent, and in each novel situation these relational connections require a process of activation and mobilization. Second, the ‘flows of information’ in these perceptual networks are not constant, but information and ideas are translated (Czarniawska & Joerges, 1996; Czarniawska & Sevón, 1996) and theorized (Greenwood et al., 2002; Maguire et al., 2004), and hence, transformed in interaction among actors. We suggest that rather than in structuralist terms, networks should be incorporated into institutionalist approaches through the notion of relational embeddedness. Sewell (1992: 19) defines *structure* as “sets of mutually sustaining schemas and resources that empower and constrain social action and that tend to be reproduced by that social action”. Drawing from this definition, we suggest that relational embeddedness is a far more complex construct than network approaches suggest by the mere network location (to some extent, also problematized by Battilana, 2006). No matter who the actor knows, in a novel situation she/he needs to engage in creating the new schemas and resources, and persuade the relevant individuals to adopt them. In this process, the very perception of networks limits or enables the activity of agents through their conceptions of the connections and relationships from which they can draw and on which they can depend.

The previous literature on the status of institutional entrepreneurs is quite equivocal. On the one hand, the literature suggests that in *emerging fields*, institutional entrepreneurs benefit from strong subject positions (Foucault, 1972; Lawrence, 1999; Maguire et al., 2004), which may draw from a formal, bureaucratic position, but also from other socially constructed and legitimate identities (Oakes et al., 1998). Such positions offer legitimacy and the ability to create new relationships with diverse stakeholders who participate in shaping an

emerging field. On the other hand, in *established fields* loose embeddedness and status marginality may be beneficial. Being a marginal actor (Leblebici et al., 1991; Dorado, 2005), “a partially autonomous actor” (Benson, 1977; Seo & Creed, 2002), or a member in lower status organizations and social groups (Battilana, 2006) results in higher likelihood of engaging in divergent organizational change. According to Greenwood and Suddaby (2006: 29), “new ideas occur at the margins of a field”, where the actors gain less benefits from the existing institutional arrangements and are more aware of their contradictions. They also show that in some cases actors in the centre of the field may act as institutional entrepreneurs, as they are more capable of identifying the need for change in their institutional context (Greenwood & Suddaby, 2006) or to compel others to change their practices or otherwise provide support for change (Hoffman, 1999).

Conceptualizing relational embeddedness and status as resources for the actors induces our first research question, *What role do relational embeddedness and status of scientists and public policy actors play in institutional entrepreneurship in emerging fields?*

### **3. DOMAINS OF ACTIVITY FOR INSTITUTIONAL ENTREPRENEURS**

Based on both the previous literature and our empirical findings, we argue that institutional entrepreneurs, drawing from their relational embeddedness and status, bridge gaps within and across three domains: cognitive, organizational and spatial. The previous literature relevant to these domains is reviewed below, and in the next section we investigate empirically the processes through which active agents engage in these bridging activities.

#### **3.1 Cognitive**

We suggest that there are three key ways in which institutional entrepreneurs participate in bridging cognitive gaps within and between institutional fields in order to induce the emergence of novel institutions. First, active agents engage in *framing* (Snow et al., 1986; Rao, 1998; Lounsbury et al., 2003; Zald, 2005; Khan et al., 2007), which is an “active, processual phenomenon that implies agency and contention at the level of reality construction” (Benford & Snow, 2000: 614). Framing is characterized by competition and

even a clashing of interpretive frames promoted by various actors and groups of actors (Benford & Snow, 2000), but also cooperation motivated by mutual identity and interests (Ansell, 1997). Second, institutional entrepreneurs engage in *theorization* (Greenwood et al., 2002; Maguire et al., 2004; Munir & Phillips, 2005), which refers to “the development and specification of abstract categories, and the formulation of patterned relationships such as chains of cause and effect” (Strang & Meyer, 1994: 104). Particularly sciences and professions have crucial roles in theorization by simplifying the phenomena at hand (Strang & Meyer, 1994). Indeed, ‘culturally legitimated theorists’ like scientists, intellectuals, and professionals, influence the spread of novel concepts by generating and promoting their theorizing (Zilber, 2006). Third, institutional entrepreneurs engage in the *translation* of ideas and practices from one context to another (Czarniawska & Joerges, 1996; Czarniawska & Sevón, 1996; Creed et al., 2002; Zilber, 2002; Czarniawska & Sevón, 2005). This concept challenges the idea that practices are transmitted intact by emphasizing their locally negotiated meaning (Garud et al., 2007; Lounsbury & Crumley, 2007). Hence, framing, theorization and translation refer to essentially related processes, where framing induces the creation of new meanings; theorization refers to shaping those meanings so that they accommodate the needs and perceptions of wider stakeholder groups, and help them become persistent; and translation refers to adaptation of a foreign idea or institution to a different institutional context (Sewell, 1992; Boxenbaum & Battilana, 2005). Institutional entrepreneurs may, accordingly, be seen as ‘transformers’ or editors of ideas.

Despite the relatively broad literature on the role of institutional entrepreneurs in such activities, there is little understanding on how scientists and policy makers engage in these activities, and thereby also build cognitive legitimation (Aldrich & Fiol, 1994) for the emerging field. From this we come to our second research question, *How do scientists and public policy actors bridge cognitive gaps for the emergence of science-based fields?*

### **3.2 Organizational**

Institutional entrepreneurs also contribute to bridging the gaps between dispersed organizations, which is a necessary act in order to mobilize and leverage (Dorado, 2005; Perkmann & Spicer, 2007) vital resources and credibility. Mobilization may take place, for instance, through political negotiation processes (Hoffman, 1999; Fligstein, 2001; Garud et



al., 2002; Maguire et al., 2004). Hence, bridging across organizational gaps stresses the role of institutional entrepreneurs as political actors, where agents strive to put forward new standards (Garud et al., 2002) and practices (Rao, 1998; Greenwood & Suddaby, 2006; Lounsbury & Crumley, 2007). A precursor for mobilization of resources is that a novel idea resonates with the prevailing normative sentiments and sensibilities of decision makers and their constituents, such as customers, voters and stockholders (Campbell, 2004). However, institutional theory has largely neglected the role of the material dimension in structuring fields (Levy & Scully, 2007). We argue that a profound understanding of field emergence necessitates the investigation of mobilization of both ideational (such as beliefs, legislation) and material (funding, personnel) resources. Since organizations with different functions, goals and priorities govern these resources, a bridging position or role between diverse stakeholders (Maguire et al., 2004; Greenwood & Suddaby, 2006) is a key asset in itself in institutional agency. Further, Zilber (2007) advances a polyphonic understanding of institutional entrepreneurship by arguing that institutional entrepreneurs may simultaneously both collaborate and compete with each other and, hence, maintain and disrupt institutional order. This means that successful mobilization of resources and bandwagons, underlying the adoption of an issue (Wijen & Ansari, 2006), are activated by organizations, which may act both as institutional entrepreneurs and 'institutional conservatives'. Child et al. (2007) propose that the wider the range of institutional entrepreneurs participating in an institutional entrepreneurial project the faster the institutionalization, further stressing the mobilization and collective aspect of institutional entrepreneurship.

In brief, if we are to advance a more comprehensive understanding of field emergence we need to further the knowledge on how institutional entrepreneurs, through benefiting from relational embeddedness and status, are able to mobilize dispersed material resources for developing the necessary field level support. We address this issue in our third research question, *How do scientists and public policy actors engage in bridging gaps within and among organizations, and with this activity mobilize resources for the emergence of science-based fields?*

### 3.3 Spatial

The third domain of activity within and across which institutional entrepreneurs bridge is spatial. Novel fields may rather simultaneously emerge across spatial scales, which refer to a socially produced (Lefebvre, 1991), nested hierarchy of bounded spaces of differing size, such as local, national and supranational (Leitner, 1997). Lounsbury and Crumley (2007) suggest that the spatially dispersed nature of emergence accounts for the disregard for studying the early emergence of new practices. Spatial scales have been largely neglected in the institutional entrepreneurship approach, excluding Lawrence and Phillips (2004) who investigate how globally disseminating macro cultural discourses enable the local projects of institutional entrepreneurs. Other streams of literature study agency, socially constructed nature of space, and cross-spatial links through the concepts of translation (Czarniawska & Sevón, 1996; Czarniawska & Sevón, 2005; Zilber, 2006); spatial scales (Bunnell & Coe, 2001; Coe & Bunnell, 2003; Spicer, 2006); and epistemic communities<sup>19</sup> (Bunnell & Coe, 2001; Amin, 2003; Amin & Cohendet, 2004; Håkanson, 2005). Translation, as discussed above, conceptualizes actors as translators of ideas and practices from one (spatial or other) context to a different one. Contrary to translation and macro-cultural discourse, the literature on spatial scales and epistemic communities has not been applied to the institutional entrepreneurship approach to any great extent. Yet, both spatial scales and epistemic communities have many implications for the agent's possibilities to induce the emergence of fields. For instance, the literature on spatial scales suggests that they are produced through three interconnected processes: capital accumulation, regulation, and articulation of discourse (Spicer, 2006), each of which in our conceptualization requires agency. According to Spicer (2006), interested social actors establish boundaries for a spatial scale through articulation of discourse, and by such activity define the appropriate logics of the scale. This comes very close to the above presented concepts of framing and local theorizing of macro-cultural discourses. In addition, the literature on epistemic communities identifies the individuals as embodiments and carriers of knowledge from one space or scale to another (Bunnell & Coe, 2001; Amin & Cohendet, 2004). Drawing from these literatures we suggest that more profound accounts for spatiality may be developed

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<sup>19</sup> Epistemic communities refer to groups of peers working explicitly on a common knowledge problem" Amin, A. (2003). Spaces of corporate learning. In J. Peck and H. W.-c. Yeung (Eds.), *Remaking the Global Economy* (pp. 114-129). London: Sage Publications..

within the institutional entrepreneurship approach. From here we come to our fourth research question, *How do scientists and public policy actors bridge spatial gaps for the emergence of science-based fields?*

#### **4. METHODS**

The study of institutional entrepreneurship necessitates detailed, interpretive analysis able to take the contextual factors into account (Garud et al., 2002; Maguire et al., 2004). The current research draws from a comparative case study of the emergence of two science-based fields in a single institutional context. This methodological choice responds to recent calls for comparative case studies to build “an adequate theory on institutional entrepreneurship and a more complete understanding of the paradox of embedded agency” (Greenwood and Suddaby 2006: 44; also Seo and Creed 2002; Dorado 2005). Our study also complements earlier single industry studies of field emergence (Van de Ven & Garud, 1993; Powell et al., 1996; Murtha et al., 2001; Garud et al., 2002). Further, a “two-case” case study (Yin, 2003, 53) combines contextual insight, i.e. the strength of rich descriptions of a single case study (Dyer & Wilkins, 1991), and more robust analysis of multiple case studies (Eisenhardt, 1989; Parkhe, 1993). We studied the emergence of functional foods and nanotechnology in Finland for their potential to elucidate theoretical similarities and differences in the emergence of varying science-based fields. Different number and type of actors, communities and institutions are involved in the two emergence processes. While functional foods is concerned with the institutionalized eating habits of people in general, nanotechnology mostly involves a limited group of scientists. Such differences are reflected in the speed of mobilization of necessary resources and in legitimation of the concepts. Finland holds an ‘avant-garde’ position in both fields, either in providing pioneering products or technology programs around these concepts. As a result of such a research setting, we could gain a broader understanding of the activities of institutional entrepreneurs in the emergence of science-based fields, which were partly context-specific and partly shared across the cases.

#### 4.1 Data collection and analysis

We collected two sets of data for this study. Altogether 53 interviews (30 for the functional foods case and 23 for the nanotechnology case) were conducted in Finland between November 2004 and June 2007. Interviews lasted between one and four hours, and they were recorded and transcribed before the analysis. Informants for both cases included top researchers from universities, representatives of public agencies conducting applied research or coordinating national and EU level programs, and informants from both small start-ups and large multinational firms. Such a broad scope of informants was covered so as to gain understanding of the possible actors contributing to the local emergence of these fields. In addition to the interviews, a variety of publicly and privately available data (such as applications to and reports of the technology programs, other reports and news stories) were used to map the real-time views on the critical events.

The data analysis was conducted in three stages. First, we identified the key events of emergence in both cases and created narratives which illustrate the chronologies of these events and their impact on the overall emergence. We also related these events to what happened in other countries at the same time so as to understand how the Finnish context was aligned with the global emergence of these fields. Both within-case sequence analysis and cross-case pattern search on the similarities and differences between the cases was conducted (Eisenhardt, 1989). Second, drawing from these analyses we identified the institutional entrepreneurs who had key roles in the emergence processes, and cross-checked these data with secondary written sources. To qualify as an institutional entrepreneur an individual must break with existing rules and practices associated with the dominant institutional logics (Garud et al., 2007) and must be systematically identified as a central actor by the interviewees. In the third stage we analyzed the activities of these institutional entrepreneurs and conducted comparative analyses between the cases. As a result of these analyses, together with studying the literature, we identified the three domains of activities (cognitive, organizational and spatial), and classified the activities accordingly. The categorization and the results of the analyses are presented below.

## 4.2 Research settings

We have adopted the following strategy for reporting the comparative case study. We start by presenting the research settings, which summarize the main actors and events for each case. After the case descriptions, we discuss the actors and events in relation to the three domains of activity that we have identified, and by so doing, elaborate the data contrasting it with both the cases and these analytical categories.

### *Functional foods*

The ancient philosophy of ‘food as medicine’ underlies the concept of functional foods, which refers to a broad category of foods with a positive health effect. Functional foods provides an intriguing setting to study institutional entrepreneurship at the intersection of institutional logics (Friedland & Alford, 1991; also Morrill, in press) of the food and pharmaceuticals industries. Even though the foundation for the strong Finnish competence in functional foods is built on the long-term research efforts of various research institutes, the actual emergence of the field required strong institutional entrepreneurs. The following case analyzes institutional and relational changes required in developing functional foods that aim to combat high blood cholesterol, the major causal risk factor for heart disease which is the leading cause of death both in high and low income countries (WHO, 2007). Cholesterol-lowering functional foods include clinically proven plant sterol based ingredients that block the absorption of cholesterol in the intestine. The pioneering Benecol margarine was developed in Finland in the late 1980s and early 1990s and it soon triggered the creation of a number of similar types of concepts (e.g. Flora/Becel pro.activ, HeartWise).

Already in the late 1960s, the international mortality statistics of research, undertaken in seven countries and led by Professor Ancel Keys at the University of Minnesota and his colleagues, triggered the theorization around the role of cholesterol in heart health in Finnish society. The results showed that Finnish men living in North Karelia in Eastern Finland suffered from the world’s highest heart disease mortality rate. A public health initiative called the North Karelia Project, coordinated by the National Public Health Institute and the World Health Organization (WHO), was launched in 1972. The most visible individual actor in the project was its leader Professor Pekka Puska, at the time a

young and ambitious medical scientist, who introduced the radically new ideas on the adverse effects of dairy fats on heart health to the conservative medical community. Puska successfully navigated between the taken-for-granted eating habits in the dairy farming region, the political pressure to lower high mortality figures, and the interests of the food industry. By drawing on the legitimation provided by the public health system and the WHO, he was able to build the early bridges between the contradictory interests of key stakeholders. The bridging mechanisms involved, for instance, participation of the local lay opinion leaders, an idea of Everett M. Rogers, who himself was involved in the project (see also Rogers, 1962, 2003). Later through the new found demand for healthier food, the food industry also became motivated to participate in this collective effort. Besides Puska acting as a 'guiding star', as formulated by an interviewee, a number of other scientists joined the theorization process. The North Karelia Project turned out to have direct implications for the legislation and agricultural policies, and indirectly induced the creation of low-fat products and fat alternatives. Yet, the process was strongly flavoured with contestations, negotiations and power games. These battles culminated in 'the great fat debate' in the leading Finnish newspaper Helsingin Sanomat in 1988 where the link between dietary fat and heart disease, the so-called cholesterol-hypothesis of professor Keys, was contested. This debate resembling 'institutional war' (Hoffman, 1999) was central to the construction of institutional order (Zilber, 2007), and was ongoing in a tempered form still in the early 2000s.

The actual trigger which led to the development of the first cholesterol-lowering functional foods concept Benecol came from the Kaukas chemical factory of the forest products company UPM Kymmene in the late 1980s. The factory was at the time searching for buyers for sitosterol, a surplus by-product of its milling process. The wood chemistry engineers became familiar with the medical science of human lipid metabolism and contacted the leading professor in this field of science, Tatu A. Miettinen at the Helsinki University Central Hospital (see also Lehenkari, 2003), who subsequently mobilized the industrial partner Raisio Margarine and provided the required scientific competence including later the early clinical trials. The research and development (R&D) manager of Raisio, Ingmar Wester, subsequently made a significant technological breakthrough in developing sitostanol ester, a fat soluble plant stanol derivative used in Benecol. After negotiations between Wester, Puska and Miettinen the cholesterol-lowering effect of

sitostanol was confirmed in a large clinical trial started in 1993 within the North Karelia Project, which already had an internationally recognized system for carrying out large-scale clinical trials. In brief, the emergence of the cholesterol-lowering functional foods in Finland can roughly be divided into two periods: the long period of rather global scientific development and ‘collective institutional entrepreneurship’ (Wijen & Ansari, 2006) within the North Karelia Project; and the serendipitous development of the pioneering cholesterol-lowering functional foods concept and the commercial market for it. Later we return to the acts of institutional entrepreneurship in the case with the help of the analytical categories.

### ***Nanotechnology***

Nanotechnology is a very broad and confusing concept typically used when referring to natural sciences (especially physics, chemistry and material sciences) and to a collection of related technologies with strong ties to research in both public and private research organizations. Nanotechnology has been defined by Wang (2004, 28) as “the construction and use of functional structures designed from atomic or molecular scale with at least one characteristic dimension measured in nanometers”, and the new scientific phenomena and characteristics of matter that are revealed, when operating on the size scale between 0.1 and 100 nanometers (Budworth, 1996; European Commission, 2004). Nanotechnology gained a legitimate status along with the launch of the National Nanotechnology Initiative in the USA in 2000, and established nanotechnology as a strategic focus area in Japan in 2001 and the EU in 2002. Despite its embeddedness in research, nanotechnology is increasingly moving into markets, the current products being nanomaterials and tools for diagnostics and production.

There has traditionally been a vast amount of research reaching into the atomic and molecular size scale in physics, chemistry, material sciences and biology, among others, in Finland. In the early 1990s, i.e. the time preceding the launch of the technology program, the Finnish research related to *nanotechnology* could be bundled into four areas: 1) *electronics*, including nanophysics and optical semiconductor devices; 2) *materials*, such as catalysts and powders; 3) *processes and tools*, such as Atomic Layering Epitaxy (ALE), a method for manufacturing nanometer thin layers; and aerosols, which is a method for producing small particles in gas; and 4) *biotechnology*, including diagnostics and immunochemistry. Much of

this research took place in separate research institutions dispersed across Finland<sup>20</sup> but initially was not labeled as nanotechnology. The launch of the Nanotechnology Research Programme in 1997 and the attached funding encouraged the scientists in the above domains of science to begin to label their research under this banner. The agency of a handful of researchers and public policy actors preceded the launch of the technology program, which facilitated such a shift in the labels and foci of the research.

Among the researchers, perhaps the most central actor creating acknowledgement for the concept of nanotechnology in the Finnish context was Professor Mikko Paalanen, who drew both from his sociable character and the legitimacy given by 15 years of experience working at Bell Labs in the USA as a colleague of Dolan and Fulton, the inventors of the single electron transistor<sup>21</sup>. In 1992, Paalanen returned to Finland and became Professor of Applied Physics at the University of Jyväskylä, where he and his group concentrated on quantum electronics, and 1994 he continued with similar activities in the Low Temperature Laboratory of Helsinki University of Technology.

On the public funding side, around the mid-1990s, there was a growing awareness of a gap between the public research funding institutions: The Finnish Funding Agency for Technology and Innovations (Tekes) takes decisions on strategic activity to ensure the adoption of technologies important to Finnish industries, which are close to commercialization; whereas The Academy of Finland is the organization that supervises the quality of science in Finland, and finances purely scientific endeavors. The division of responsibilities of the two organizations was not clear-cut, and there had been a tendency for competition for resources. In the autumn of 1995 Oiva Knuuttila, a technology expert of Tekes, discussed with his colleagues Juha Vapaavuori and Jussi Kivikoski the importance of the two organizations in providing long-term investments in emerging fields, such as nanotechnology, without immediate expectations of commercialization. Knuuttila had a background in nuclear physics and a personal interest in nanotechnology, and both Vapaavuori and Kivikoski were chemists by education, which made them all conscious of both the scientific and political leverage of nanotechnology.

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<sup>20</sup> However, there has been collaborative research projects among some of these research groups in the projects funded by the Academy of Finland and European Commission.

<sup>21</sup> An important innovation in the development of nanoelectronics



The discussions within Tekes coincided with the ESPRIT Workshop “Long Term Research” organized in Finland in the autumn of 1995 by the European Commission. The focus was on “future emerging technologies”, which also touched upon nanotechnology. The workshop encouraged a small group of individuals within Tekes to investigate further the prospects for establishing a program around nanotechnology. With the lead of Jorma Hattula, the new Director of Research at The Academy of Finland, and with the active participation of Oiva Knuutila from Tekes, this gap in the Finnish science funding structures was construed as an issue, which required cooperation between the two organizations. Consequently, drawing on the negotiations in Finland, the encouragement from the EU workshop, a benchmarking exercise to Japan by Paalanen, Knuutila and Juhani Keinonen (the head of the Research Council for Natural Sciences at the Academy of Finland), and the embeddedness in global research networks of the Finnish researchers, the Nanotechnology Research Programme was established in 1997.

## **5. COMPARATIVE CASE ANALYSIS**

As the case descriptions illustrate, the depth and time required for institutional emergence between the cases is very different, which gives rise to different requirements for and representations of agency between the cases. This is an important theoretical difference, which will be analyzed in more detail in this section. Table 1 presents the illustrative quotes of the institutional entrepreneurs by the identified domains of activity.

### **5.1 Bridging cognitive gaps for shared understanding**

Our fieldwork data show that in the early emergence stage bridging of different cognitive schemas or perceptual frames, which tend to limit the perceived alternatives for action (e.g. research, cooperation, funding), is crucial. Indeed, *creating the meaning for the concepts of functional foods and nanotechnology, and theorizing their significance for different parties* across disciplines and sectors was the most important task of the institutional entrepreneurs in both cases. Driven by the issue of high mortality in heart disease and a major change in thinking towards preventing rather than treating the disease underlined the emergence of functional foods. A key strategy followed by Puska’s team was framing of the transfer of

fat consumption as a necessity for heart health and as a national project. Since food consumption is culturally embedded and eating patterns change only slowly, robust scientific evidence, or ‘sound science’ (Maguire & Hardy, 2006) was required to provide legitimacy for the novel concept. Scientists also played a crucial role in starting and directing a mass media discourse, which was a way to disseminate the debate to wider audiences.

Driven by a vision of a handful of public policy actors, the emergence of the Finnish nanotechnology field was largely about creating a sense of what benefits and novelty nanotechnology, as an area of scientific research and public investment, could bring to the table. At the time of the preparation for the first nanotechnology program, nanotechnology was becoming a better understood concept among scientists and public policy actors. However, as it was among the first nanotechnology programs in the world, the challenge for the representatives of Finnish public funding organizations was to define the meanings and boundaries of the nanotechnology concept. The scientists aimed to promote such a definition that was not only understandable from their point of view, but also inclusive. From the point of view of Tekes, more research could be included with a more relaxed definition for the new concept. As an outcome, a very broad and inclusive definition for nanotechnology was adopted. While in both cases the framing and creating of initial meanings for both concepts was crucial, a much broader group of actors and a longer time for theorizing was required for functional foods, whereas the nanotechnology program, targeting a narrow and specialized group of scientist, was set up within a relatively short period of preparation and with the engagement of fewer parties. This reflects the different drivers of early theorization from one case to another.

While the functional foods field is an issue-driven field (Hoffman, 1999) formed around a major collective problem, nanotechnology in Finland represents a vision-driven field. An issue-driven field necessitates framing an issue and a possible solution to it in such a way that it appeals to a wide range of affected parties from the grass-roots level to legislators and other political decision makers. A vision-driven field, as in the case of nanotechnology, requires a much smaller number of supporters as the changes addressed are far less constitutive and target a more focused group of actors.

Gap & Acts of IE	Functional Foods Quotations	Nanotechnology Quotations
<p><b>Cognitive</b></p> <p>Framing Theorizing Translating</p>	<p>[...] Then we [medical doctors] came and said that the diet should be changed and quit smoking - it was quite a strange message...This was a national movement that we need to reduce [the use of] dairy fats and increase [the use of] vegetable fats. – <i>Director General of the National Public Health Institute</i></p> <p>The underlying radical change in this case is treatment versus prevention of heart disease - the same applies to many other issues in the society. – <i>Regional Sales Director</i></p>	<p>It took an enormous amount of energy, when we discussed how to define this: in one or two or three dimensions that we could talk about nano, and what is the right size scale. – <i>Senior Technology Expert at Tekes</i></p> <p>Latest during the program [...] they [firms] recognized nano and then they begun to ask what this means for us, or should we be interested in this, and what this brings along. It was a little like thinking aloud [for us] and of course the firms that scan the world and future anyway could have come up with it also without the program. However, it is likely that the program and the communications and discussions that came with it turned it faster and clearer into shared knowledge. – <i>Technology Expert at Tekes</i></p>
<p><b>Organizational</b></p> <p>Mobilizing</p>	<p>It is interesting how you get the political decisions made and decision makers involved, also on the firm management level... It is not by saying ‘do this’, but it is a process of getting people involved - it is the key question. – <i>Director General of the National Public Health Institute</i></p> <p>[...] and inter-sectoral [cooperation]...of course our medical work is the basis, but just the basis, the reason that people have been able to change [their eating habits] is that the business side has come along. – <i>Research Professor at the National Public Health Institute</i></p>	<p>As both organizations are bureaus run by chief executives, in such an organization you do what the chief executive tells you to do. It was of course the underlying starting point that the chief executives of The Academy of Finland and Tekes supported this [nano program]. – <i>Technology expert at Tekes</i></p> <p>Finland is a small country. Here things are taken care of through direct personal relationships. And of course people who have something to do with research, we are in contact with. If you think about Tekes, its officers are in contact with [...] researchers and communicate with them. – <i>Head of a Research Council at the Academy of Finland</i></p>
<p><b>Spatial</b></p> <p>Migrating Evangelizing Transferring/ Translating</p>	<p>I worked for the Rockefeller Institute during 1963-65 and it was there where the research [on plant sterols] was primarily done. – <i>Professor Emeritus in Medicine</i></p> <p>They [key scientists] participated in the annual meetings of the American Heart Association and held lectures etc...They are also well-known in the world. – <i>R &amp; D manager, Chemist</i></p> <p>The other side is that we have transferred all sort of ideas around the globe to Finland, no person could ever have invented all these things what we’ve done in Finland. The nice thing in working in public health or medical sciences is that if someone gets an idea one can carelessly steal it - and we are glad if someone will utilize it. – <i>Research Professor at the National Public Health Institute</i></p>	<p>I worked from 1977 to 1992 at AT&amp;T Bell Laboratories as a colleague of Dolan and Fulton [inventors of single electron transistor, SET]. In 1992 I brought the SET idea to Finland when founding the Applied Physics Group in University of Jyväskylä. The first Finnish SET was produced in Jyväskylä in 1993. – <i>Professor Mikko Paalanen [in the Final Report of the Technology Program]</i></p> <p>During [2001] I was continuously asked to travel across Europe to tell about the Finnish nanotechnology program [...] in various panels, think tanks and so on.” – <i>Senior Technology Expert at Tekes</i></p>

**Table 1:** Illustrations of institutional entrepreneurship by the domains of activity

Creating *interdisciplinary understanding* was another domain, where institutional entrepreneurs were very active. For functional foods, developing Benecol ingredient brought together scientists from diverse disciplines such as chemistry (food and wood) and medicine. Such boundary spanning activity necessitated a high status of actors and content expertise as well as an ability to see beyond disciplinary boundaries; this was a challenge solved by building new professional relationships. This novel constellation of scientists enabled innovation in the interface between nutrition and pharmaceuticals. Similarly, in the nanotechnology case, the goal of starting a technology program was harnessing the interdisciplinary mindset between physicists, chemists and bioscientists. Though, arguably, the only commonality between the scientists from different disciplines at the beginning of the program was that they all dealt with nano or ‘near nano’ size phenomena, by the end of the program the scientists gradually began to see where their research could converge. This resulted in some research collaboration between physicists and chemists, in particular, during the program. Consequently, in both cases creating new interfaces between the sciences and encouraging collaboration was another important task performed by the institutional entrepreneurs. This required a shared goal, such as improvement in heart health for functional foods and the identified gap between funding institutions for nanotechnology. The differences between the cases in the interdisciplinary domain stem from the fact that for functional foods a multidisciplinary approach was required to find a solution to health problems and practical business problems, whereas in the nanotechnology case the collaboration was mostly enforced by the public funding body and motivated by the research funding it offered. Hence, the depth and attachment to multidisciplinary approach varies across the cases.

Finally, institutional entrepreneurs enabled the *bridging of cognitive gaps across different sectors* in both cases, but to a different extent. In the functional foods case, actors from four rather unrelated sectors of the economy (forest industry, food industry, medical science and the public health system) were involved in the development process of Benecol. Relationships of individual scientists, i.e. the identified institutional entrepreneurs, strongly contributed to coupling the emerging system. However, for nanotechnology there was still a major sectoral gap between research and businesses. In the first nanotechnology program there are hardly any industrial connections. During the program Finnish businesses with R&D in the area came to understand more what nanotechnology could mean for them and how it

could benefit their research and development activities. Hence, while both cases stress the importance of high status actors creating the early connections, in the functional foods case the field emergence was triggered by inter-sectoral interest and dependence, whereas in the nanotechnology no such natural needs or dependencies were easy to identify, but were rather an outcome of the national research program and the exposure and visibility it was able to generate.

## **5.2 Bridging of local financial and policy organizations for mobilization of material resources**

As discussed briefly in the case introductions, the Finnish context of public financing is centered around two organizations. Tekes (The Finnish Funding Agency for Technology and Innovations) is essentially a networking organization, and it finances projects where industry is also represented. One central instrument to deliver financing is technology programs. Through the programs Tekes also encourages collaboration between scientists. While the Academy of Finland programs create the strengths in the basic science, Tekes programs aim to create business out of them. The role of these public financing institutions is crucial in the early stages of field emergence. As the introductions to the cases illustrate, individuals particularly within Tekes acted as institutional entrepreneurs who enabled the investments into both new concepts.

In the functional foods case, Tekes financing was crucial for the development of the pioneering Benecol concept. Also the requirement for at least two industrial partners for obtaining Tekes financing induced a closer cooperation between Raisio and the UPM Kymmene Kaukas mill, and directed the project towards being technology oriented. In the end, however, Tekes financing was crucial for financing the expensive clinical trials. A major challenge, however, was that Tekes had not previously financed clinical trials. Later in 1997 the first ever technology program in foods (1997-2000) in Finland was launched by Tekes, signifying a form of institutionalized belief in functional foods.

In the mid 1990s, nanotechnology, on the other hand, could be characterized as basic research with long-term commercial potential. Central individuals in Tekes and the Academy of Finland identified the gap in the Finnish science funding structures for such

technologies. Nanotechnology was construed as an issue that illustrated the need to build cooperation, rather than competition, between the two institutions. Such collaboration was preceded by a change in top management at the Academy of Finland, and the consequent search for new operating modes. The case of nanotechnology clearly established that when it comes to public funding organizations in a small country context, individuals leading those organizations can leverage power over an emerging domain of activity according to their preferences, aptitudes and beliefs. A handful of technology experts decided upon the founding and funding of the technology program, and hence, held powerful positions over the local emergence and institutionalization of a novel field. Further, changes in the leadership of these organizations may result in changes of the focus areas and practices of the funding they allocate.

Consequently, both cases have shown that the entire institutional context may be developed when a few individuals in management positions in strong institutions decide to cooperate. Individual level brokering was enabled by the small population of the country and the homogeneity of the institutional context. This strongly contributed to the emergence of communities around both functional foods and nanotechnology. However, the cases differed from one another, again, in the extent of the amount and type of organizations and communities that needed to be bridged, and the number of actors orchestrating those activities. Functional foods dealt with a major societal change bringing together various institutions around health and food, whereas nanotechnology represented a smaller-scale initiative that engaged a relatively close-knit community of scientists and representatives of public funding organizations.

### **5.3 Bridging the gap between spatial scales for local emergence and global influence**

An interesting issue emerging from both case studies is that the identified institutional entrepreneurs possessed an extraordinary ability to work across spatial scales. This is also a specific feature of scientists, as scientific communities tend to be global and findings of research and scientific knowledge are published to serve and to be validated by that community. In the functional foods case the bridging of spatial gaps was crucial in two key phases: in the early development and in the later commercialization phase of the concept.

In the beginning, Professor Miettinen had a significant role in transferring plant sterol analytics competence from the prestigious Rockefeller Institute for Medical Research in New York. The roles of high status scientists from respected institutions were crucial also in evangelizing the benefits of the novel concept in reducing high cholesterol and the consequent risk of heart disease, and raising the visibility of the topic in the global scientific community. Such backing by scientists and scientific publications supported negotiations with both national and supranational authorities and health care professionals and, hence, was crucial for commercialization of the concept. Later individual Finnish scientists played an important role in affecting the emerging regulation for functional foods at the EU level. Due to the complex nature of the science behind the concept, scientists translated it into a language understood by the political decision makers at the supranational level. However, it would be misleading to argue that international translation of the concept was easy. Occasionally there were serious breaks or even nonspread (Ferlie et al., 2005) of the concept due to e.g. rigid institutionalized eating habits and orientation toward treatment, rather than prevention of diseases.

As with the functional foods, in the nanotechnology case the central Finnish scientists had spent extensive times abroad, where they had gained relevant experience and worked with prominent scientists in domains such as single electron transistors (Mikko Paalanen at Bell Labs in the USA) and compound semiconductor quantum-dots (Jouni Ahopelto at NEC in Japan), among others. Such a transfer of scientific knowledge, and the high legitimacy of these organizations enabled the development of various domains of science related to nanotechnology in Finland. Legitimacy for the nanotechnology program was also increased through benchmarking during the time when nanotechnology as a concept was used in hardly any other technology program. During the preparation phase of the program, a Finnish delegation consisting of Oiva Knuutila from Tekes, Juhani Keinonen from the Academy of Finland, and Professor Mikko Paalanen traveled to Japan for benchmarking. They studied the organization of the Japanese 10-year technology program taking place under the banner ‘mesoscale physics’, which was a more legitimate concept at the time. The Finnish technology program had an excellent timing: by the ‘hype year’ 2000, Finland had become a similar benchmarking case for many countries in Europe, and elsewhere, that were only about to establish their first nanotechnology programs. Oiva Knuutila was invited to a number of conferences, seminars and think tanks in Europe to advise on and

discuss issues related to nanotechnology. Consequently, the Finnish actors contributed to the construction of nanotechnology as a field of activity also in the European and global context.

To conclude, while the same individual level processes linking the “global” to the “local” were salient across the cases (migrating and translating scientists), the feedback loops from local to global varied reflecting the different stages of development of the fields. In the functional foods case, specific concepts and commercial products became disseminated and translated globally. In the case of nanotechnology, the very institutional arrangement (technology program) became the object of transfer and translation. Table 2 summarizes the theoretical similarities and differences of the cases by the domains of activity.

<b>DOMAIN</b>	<b>FUNCTIONAL FOODS</b>	<b>NANOTECHNOLOGY</b>
<b>Cognitive</b>		
Domain of initial framing and theorization	diet-disease link	meaning, boundaries and benefits of nanotechnology
Extent of cognitive change required	major	minor
No. of identified IEs	relatively small	very small
No. of communities affected	large	small
Driver of theorization	issue	vision
<b>Organizational</b>		
Mobilization	collective	individual, arms-length
Legitimizing organizations	prestigious medical science institutes and journals, public funding organizations	public funding organizations
<b>Spatial</b>		
Spatial connectors	migrating scientists in public and private organizations, public policy actors	migrating scientists in public organizations, public policy actors
Objects of translation from local to global	concepts, patents, products	concepts, institutional arrangements

**Table 2:** *Theoretical comparison of the functional food and nanotechnology cases*



## 6. DISCUSSION

In this section we return to our research questions and articulate the contribution of the study in the form of propositions. At the end of the section we present the framework for institutional entrepreneurship in science-based fields.

### 6.1 Relational embeddedness and status as enablers for scientists and public policy actors for institutional entrepreneurship

Previous research is equivocal about whether institutional entrepreneurs benefit from centrality and embeddedness (Maguire et al., 2004; Greenwood & Suddaby, 2006) or marginality and disembeddedness (Leblebici et al., 1991; Battilana, 2006); and whether agency is individual (Campbell, 2004; Lawrence & Phillips, 2004; Battilana, 2006) or collective (Wijen & Ansari, 2006; Lounsbury & Crumley, 2007). For the first debate, our study showed that scientists and public policy actors, i.e. the identified institutional entrepreneurs, held central positions in prominent organizations. Hence, our study suggests that the existing institutions define the source of legitimacy also for a new field. This further indicates that in science-based fields people associated with prominent institutions may more readily act as institutional entrepreneurs, which supports the findings of Maguire et al. (2004) and Greenwood and Suddaby (2006). Hence, we come to our first proposition:

**Proposition 1a:** *Institutional entrepreneurship in science-based fields is enabled by relational embeddedness and high status in renowned research and public policy institutions.*

Regarding the second debate, our study indicates that the possibility for individual versus collective entrepreneurship is context dependent. In both cases a handful of scientists and public policy actors firstly, initiated, and secondly, mobilized the support for the field. For both cases we found that by having an influential position in an organization or a specific domain of interest, an individual had better chances in redefining the goals and orientations of that organization. Such a process is political and, again, depends on the relational embeddedness and status of an individual in the organization. However, the capacity of an individual to induce change varied between the two fields, as did also the societal level

impact of the emergence of the respective fields. From the analysis of the comparative case study we come to our second and third propositions:

**Proposition 1b:** *The deeper the social and institutional change required, the broader the institutional context, the larger amount and the more dispersed communities involved, and the less identifiable the leading organizations; the more institutional entrepreneurship is about collective mobilization.*

**Proposition 1c:** *The more incremental the institutional change required, the more bounded the institutional context, the smaller amount and the more specialized the communities involved, and the more identifiable the leading organizations; the more institutional entrepreneurship is about individual orchestration.*

## 6.2 Institutional entrepreneurs bridging cognitive gaps in science-based fields

Previous literature on the framing of meaning (Snow et al., 1986; Rao, 1998; Lounsbury et al., 2003), theorization (Greenwood et al., 2002; Maguire et al., 2004), and translation (Czarniawska & Sevón, 1996; Creed et al., 2002; Zilber, 2002; Czarniawska & Sevón, 2005) places a focus on the meaning of work in which institutional entrepreneurs are engaged. In contrast to this extant literature, our study focused on how scientists and public policy actors engage in bridging cognitive gaps in emerging science-based fields, and our particular contribution addresses the meaning work in this context. First, the central actors were conceptual agents, and framed the meaning and boundaries of the novel concepts in question. In the context of scientific fields in particular, scientists are required to articulate the meaning of scientific results to public policy actors and other audiences. This is similar to social issue driven fields, where the language and goals of a certain community need to be transferred into the language and priorities for other stakeholders (Rao, 1998; Hoffman, 1999; Maguire et al., 2004). The empirical case also showed that in some cases local public policy actors play a significant role as identifiers and translators of new concepts into local funding schemes, which motivates other actors to redirect or relabel their activities accordingly. This aspect has gained little attention in the previous literature on institutional agency. Second, the central actors, through their engagement in framing and translation, were able to bring together the actors across sectors and disciplines. What was found to be

special in the fields under investigation is that they both are cross-disciplinary and cross-sectoral, and the conceptual bridging of these cognitive domains was crucial in order to release ideational resources. However, the actions and strategies of the actors were rather emergent and serendipitous; an observation, which is in line with Lawrence and Phillips (2004). Further, social and conceptual skills combined with an understanding of the political environment were critical in bridging the cognitive gaps between disciplines and sectors.

**Proposition 2a:** *Scientists, to act as institutional entrepreneurs, need to be able to frame the novel scientific concepts and findings into a locally significant form in order to create understanding of and support for the local emergence of a science-based field.*

**Proposition 2b:** *Public policy actors select and theorize around certain scientific and technological concepts, influenced by scientists, and create resources for them. By this activity they advance cognitive shifts among the scientists by encouraging redirection and relabeling of the existing activities.*

### **6.3 Institutional entrepreneurs bridging gaps within and among institutionalized organizations**

According to Gould (1980, in Garud et al, 2002), agents shape the selection mechanisms that then govern their functioning. By so doing, the agents secure their inclusion in those mechanisms which define access to legitimacy and resources, such as standards and funding. Our cases show that, especially in the small country context, relational embeddedness of institutional entrepreneurs acts as a significant enabler of both institutional agency and change. Political and social skills combined with relational embeddedness contribute to individuals' capacity to engage in negotiation with the parties that control necessary material and/or ideational resources. Scientists may be conceptualized as having control over the ideational resources, from which a national economy benefits over a longer time period. Public policy actors, together with firm-level actors, on the other hand, control the material resources, which enable the development and dissemination of the ideational resources. Negotiation among individuals in high positions in research and public policy organizations induced the emergence of novel fields in both fields in question. Consequently, our study contributes to the call of Levy and

Scully (2007) to investigate the material structuring of fields in the context of institutional entrepreneurship. The study shows how status and relational embeddedness contributed to the creation and mobilization of resources for functional foods and nanotechnology.

**Proposition 3a:** *Scientists control the ideational and public policy actors the material resources which enable the emergence of a novel science-based field.*

In both cases, public financing provided a springboard for institutional entrepreneurs, and in itself constituted a form of institutional entrepreneurship. Most crucially, Tekes acted as a ‘field switcher’ (cf. Perkmann & Spicer, 2007) in identifying promising funding areas; and as an institutional entrepreneur in signaling an official or collective belief in the novel concepts. These programs, which provided funding but also legitimation for the new fields, provided platforms that brought together disconnected actors and enhanced local knowledge sharing and mutual alignment. Through financial support these platforms created a stepping stone for smaller actors to enter the field. Consequently, institutionally created platforms, although orchestrated by their leading individuals, strongly contributed to the emergence of new relational connections and local and global recognition for both fields. The global emergence of a strong hype, or widely shared macro-cultural discourses (Berger & Luckmann, 1967; Lawrence & Phillips, 2004), around both functional foods and nanotechnology in the late 1990s and early 2000s was crucial in directing public financing towards these fields, which stimulated organizational cooperation locally and globally.

**Proposition 3b:** *Public funding organizations, by providing funding and legitimacy, provide institutionalized platforms that bring together actors, bridge organizational gaps and, hence, support emerging science-based fields.*

#### **6.4 Institutional entrepreneurs bridging across spatial scales**

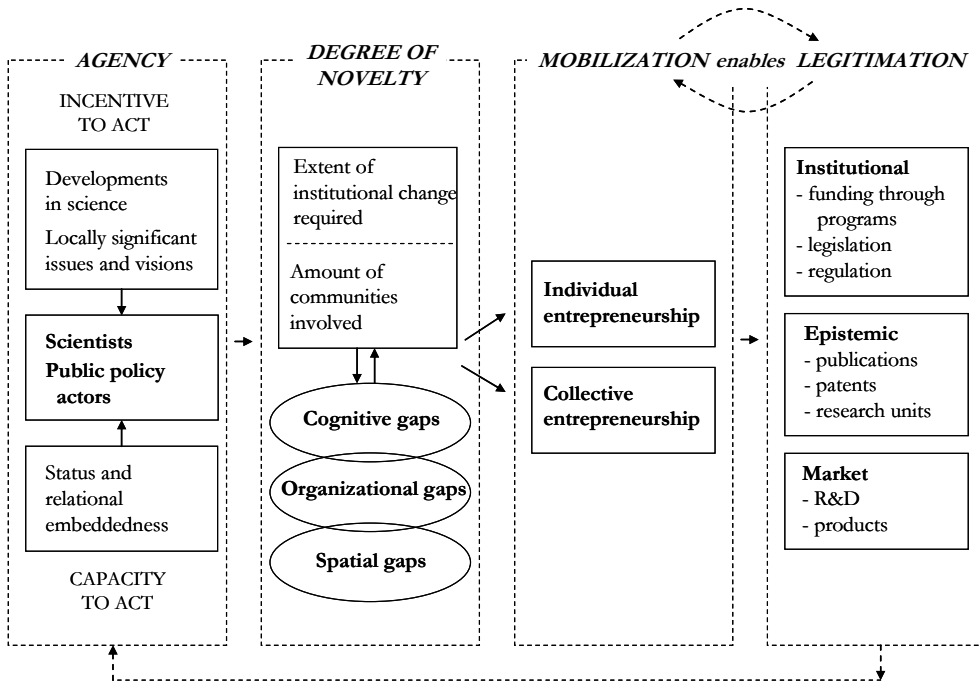
Our cases suggest that the capacity of actors to operate across spatial scales, and link local and global levels of activity to one another, may in fact be one important capability that defines the possibilities for institutional entrepreneurship in science-based fields. Scientists are by their formal training and activities in scientific communities particularly capable of working across spatial scales. Public policy actors, on the other hand, often form part of

intergovernmental policy organizations. In the empirical cases, particularly scientists connected across spatial scales, not only as content-specialists but also as legitimators of the concepts. This activity was backed by both their personal status in the research community and the prestige of their current and previous organizations. Similarly, public policy actors enacted locally the trends that were identifiable in global policy networks and built locally funded schemes and regulation around them. Thus, our findings extend the discussion of Spicer (2006) on spatial scales in that we show that scientists and public policy actors as institutional entrepreneurs are in central positions to affect all the three processes of producing spatial scales: capital accumulation, discourses and regulation. Such conceptualization brings institutional entrepreneurship into interaction with the current theorizing on the network position crossing national borders (Bunnell & Coe, 2001; Spencer, 2003; Amin & Cohendet, 2004), with the introduction of new organizational forms or practices (Campbell, 2004; Boxenbaum & Battilana, 2005; Greenwood & Suddaby, 2006), and with the notion of spatial scale (Spicer, 2006). In so doing, our study addresses what we consider as one of the central weaknesses of the current institutional entrepreneurship literature, namely that of focus on projective agency within a limited spatial scale.

**Proposition 4:** *In science-based fields, the capacity of an actor to operate across spatial scales is an important capability that defines his/her possibilities for institutional entrepreneurship.*

Figure 1 summarizes the above insights, and presents a framework for how institutional entrepreneurs in science-based fields bridge gaps in the cognitive, organizational and spatial domains by drawing from their relational embeddedness and status. Our empirical data suggest that developments in science and locally created visions and identified needs, often structured by institutional entrepreneurs, create the motivation for change. Due to scientific substantiation scientists may be advantageously positioned to tackle the paradox of embedded agency. The comparison of two emerging science-based fields portrayed two emergence paths necessitating different mobilization processes. This suggests that field emergence is highly context-specific. The deeper and wider the extent of institutional change required and the number of communities involved, the stronger the collective aspect of institutional entrepreneurship. Legitimacy is both a medium and an outcome of mobilization, and results in institutionalization of the novel field reflected through

institutional, epistemic and market artefacts. Such legitimation supports further development of ideas which may provide seeds for the emergence of further novel science and technology driven fields.



**Figure 1:** Framework for institutional entrepreneurship in science-based fields

## 7. CONCLUSION

The study investigates how new science-based fields come into existence, which is a gap in the current institutional entrepreneurship literature. We conceptualize institutional entrepreneurs, particularly scientists and public policy actors, as operating across three identified domains of activity: cognitive, organizational and spatial. To do this, these agents draw from their relational embeddedness and status in the existing institutions. The study puts forward a framework, which suggests, firstly, that institutional entrepreneurship in science-based fields is triggered by developments in science combined with local institutional needs; and secondly, that the possibilities for individual versus collective mobilization depends on the nature and scope of change required. The study makes several

contributions to the institutional entrepreneurship literature. It develops the theory through the investigation of individual and collective mobilization in the comparative setting. The study also extends the boundaries of institutional entrepreneurship by e.g. bringing new types of fields under investigation, and by incorporating the notion of spatial scales (Spicer, 2006) into the approach.

There are naturally limitations in this paper. First, both fields under investigation are particularly cross-disciplinary by nature, which may limit the applicability of our findings to similar types of field. Second, we studied field emergence in the Finnish context, which restricts the generalizability of the results to similar institutional contexts, i.e. small countries characterized by relatively permeable sectoral boundaries, high role of public financing of innovation, and close connections between individuals. Yet, the focus on a spatially and culturally limited setting provided an institutionally homogeneous environment for the investigation, and made it possible to study such a complex topic in a comparative case setting. Further comparative studies of field emergence in other institutional contexts are needed to investigate the role which national and field contexts play in emergence. More work is also required to capture the dynamics of individual versus collective institutional entrepreneurship in emerging science-based fields to study our propositions on the effect of scope and depth of change. Finally, we suggest that research on how institutional entrepreneurs operate across spatial scales would provide important understanding on the domains of institutional agency.

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**ESSAY III**

**Institutional Entrepreneurs as Mediators  
between Global Discourses and Local Institutions  
– Emergence of Functional Foods and Nanotechnology in Finland**

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**Abstract:** Investigating the emergence of new fields at the intersection of local institutions and global influences is necessary for further development of the institutional entrepreneurship approach. We draw on complementary insights from the literature on institutional entrepreneurship and Scandinavian Institutionalism to study the activities of agents within and across localities. Building on a comparative case study on the emergence of functional foods and nanotechnology, we develop a framework suggesting that institutional entrepreneurs in science-based fields are actors who are able to operate across spatial scales, and who create and mobilize counter discourses to prevalent discourses and embed them locally. The paper concludes by emphasizing the need to further investigate the interaction between spatial scales and institutional agency in emergence of fields.

**Keywords:** Institutional entrepreneurship, science-based fields, translation, spatial scales, functional foods, nanotechnology

## 1. INTRODUCTION

The institutional entrepreneurship approach incorporates agency to the neoinstitutionalist tradition and investigates the role of active agents in shaping their institutional context (DiMaggio, 1988; Fligstein, 1997; Beckert, 1999). A particular focus has been on the emergence of novel fields, where scholars have studied, firstly, how the position and activities of institutional entrepreneurs contribute to the emergence (Maguire et al., 2004; Perkmann & Spicer, 2007); secondly, how institutional entrepreneurs participate in the meaning making and shaping understandings of a field (Rao, 1998; Maguire et al., 2004; Munir & Phillips, 2005) and in the creation of novel standards, policies (Garud et al., 2002; Wijen & Ansari, 2007) and practices (Lounsbury & Crumley, 2007); and thirdly, how macro-cultural discourses enable the activities of local actors to shape a new field (Lawrence & Phillips, 2004). Field refers to “a community of organizations that partakes of a common meaning system and whose participants interact more faithfully with one another than with actors outside the field” (Scott, 1995: 56). The literature on institutional entrepreneurship provides understanding on various aspects of the ways in which individual and organizational agency contribute to field emergence. However, besides omitting how early emergence unfolds as a process, previous studies tend to concentrate on narrow geographical settings, neglecting the interaction between the local and the global in the process (DiMaggio, 1991; Scott, 2001; Morrill, in press), and the role and activities of mediating agents in this context. Also, Lounsbury and Crumley (2007) suggest that the

spatially dispersed nature of emergence accounts for the disregard for studying the early emergence of new practices.

A further gap in the institutional entrepreneurship literature is the curious neglect of science-based fields as objects of empirical inquiries. There is a scarce understanding of who the institutional entrepreneurs in science-based fields are, and through which activities they institute novel fields. Science-based fields are a particularly interesting case for the investigation of agency and mediation of influences between different spatial scales, which refer to a socially produced (Lefebvre, 1991), nested hierarchy of bounded spaces of differing size, such as the local, national and supranational (Leitner, 1997). In science-based fields actors form part of these scales through a variety of epistemic communities, i.e. “groups of peers working explicitly on a common knowledge problem” (Amin, 2003, 119). It is often in epistemic communities where actors, such as scientists and public policy actors, are subject to counter discourses, which challenge the institutionalized macro-cultural discourses, or “broad discourses and associated sets of institutions that extend beyond the boundaries of an institutional field and are widely understood and broadly accepted in a society” (Lawrence & Phillips, 2004: 691; also Berger & Luckmann, 1966). According to Lawrence and Phillips (2004), macro-cultural discourses enable local emergence but the creation of novel institutional components is always tied to local institutional environments and active agents crafting them. Whereas these authors have created a good foundation for the discussion on how discourses enable institutional entrepreneurship in local contexts, their study did not investigate how institutional entrepreneurs act as mediating agents of discourses between different institutional contexts, or how they participate in their creation.

Consequently, the research question that motivates this study is *How do institutional entrepreneurs in science-based fields mediate between globally circulating discourses and the local institutions and competencies?* For such an investigation, we develop the institutional entrepreneurship approach by merging conceptual ideas from the streams of literature stressing the role of cross-spatial links in institutional change and emergence. These include the theory of translation in Scandinavian Institutionalism (Czarniawska & Sevón, 1996, 2005), the literature on spatial scales (Lefebvre, 1991; Leitner, 1997), and the concept of macro-cultural discourse. We conceptualize institutional entrepreneurs as translating agents, who



bridge spatial scales and are central actors in the identification and theorizing of local issues to which these discourses then become embedded. Empirically, we examine the emergence of two science-based fields in Finland in a comparative case setting. Cholesterol-lowering functional foods represents a field, in the development of which Finnish researchers and commercial actors were the global pioneers and have significantly influenced the forms and functions of the field globally. Nanotechnology, on the other hand, was already established as a domain of activity in some countries before it became institutionalized in Finland, though the Finnish actors were among the early adopters and established a pioneering technology program on nanotechnology. In the local construction of the nanotechnology field the Finnish agents were able to draw legitimacy from other institutional contexts, whereas in functional foods they had to build both the credibility and understanding of the field from scratch. Finland provides us with both an institutionally bounded and technologically advanced “laboratory” for such an investigation.

Our findings contribute in several ways to management and organization literature, and above all, to the institutional entrepreneurship approach. Firstly, the study complements the understandings on the interaction between macro level emergence and micro level agency by discussing how local agents contribute to the macro-cultural discourses rather than merely using them as a resource. Secondly, we develop institutional entrepreneurship literature by investigating agency across spatial scales to address a weakness of the institutional entrepreneurship literature, namely the concentration on geographically distinct and delimited areas. Thirdly, our comparative setting as such is a contribution, as is our particular focus to study the emergence of science-based fields, which are curiously understudied contexts for institutional entrepreneurship. The remainder of the paper begins with a discussion on macro-cultural and counter discourses as means to mediate influences across spatial scales, after which it elaborates the activities of institutional entrepreneurs to bridge these scales and embed the influences in local contexts. After having presented the methodology, we put forward the comparative case study, followed by an analytical discussion on the key findings and contributions as well as ideas for further inquiries.

## 2. MACRO-CULTURAL DISCOURSES AS MEDIATORS OF INFLUENCES GLOBALLY

The inclusion of discourse (Lawrence & Phillips, 2004; Phillips et al., 2004; Hardy et al., 2005) to institutional accounts has provided novel means to tackle change and emergence. These approaches discuss how new discourses become institutionalized, and how they change the existing institutions and institutional logics that shape the actors' frameworks for reason and belief. According to Phillips et al. (2004), institutional theorists have tended to define the concept of institutions in terms of patterns of action. However, action *per se* does not travel over distance and shape the beliefs and attitudes of others, whereas texts and discourse do (Phillips et al., 2004). Consequently, Phillips et al. (2004: 635) argue that "institutions can be understood as products of the discursive activity that influence actions".

The highest level at which such influences circulate is macro-cultural discourse (Berger & Luckmann, 1966; Lawrence & Phillips, 2004). Examples of such discourses are portraying killer whales with human-like sympathetic characters in the press and popular media (Lawrence & Phillips, 2004); or labelling genetically modified food as 'Frankenfood'. Both of these have implications to the wider institutionalization and activity within the domain of whale-watching or genetically modified organisms. Zilber (2007) divides discourses into well-accepted macro-cultural discourses (Lawrence & Phillips, 2004) and competing discourses (Maguire et al., 2004; Zilber, 2007). The media in particular plays a central role in transmitting and legitimating various discourses by shaping understandings and opinions, which influence the emergence and adoption of global trends that are products of macro-cultural discourses. According to Gamson and Wolfsfeld (1993), the media regulates which actors are given standing, and which ideas and language are presented, journalists and editors being the major gatekeepers (Rao et al., 2003). The media voices issues that individuals and organizations promote or disagree over and, hence, plays a strong role in creating 'public opinions', which become embedded in macro-cultural discourses.

In science-based fields counter discourses typically have origins in epistemic communities (Amin, 2003) that are subject to global influence and action (Boli & Thomas, 1997; Meyer et al., 2006). Science is conceptualized as a means for producing texts to build new institutions (Maguire & Hardy, 2006); or as a cultural resource challenging old practices by undermining them through new analytical theories and tools, which then institutionalize a new practice (Lounsbury & Ventresca, 2002; Greenwood & Suddaby, 2006; Lounsbury & Crumley, 2007). While epistemic communities typically emerge in local contexts, over time they tend to become transnational as the community's ideas spread through conferences, journals, research collaboration and informal communications (Haas, 1992). As epistemic communities stretch across time and place (Bunnell & Coe, 2001), and scientific discourse is global by nature, we argue that epistemic communities create a mediating layer between local institutions and global discourses. Scientists draw from the trends and discourses present in their epistemic communities, and embed them locally through their research, teaching, and policy activities. Further, intergovernmental organizations (IGOs) and international non-governmental organizations (INGOs) (Boli & Thomas, 1997; Inoue & Drori, 2006; Meyer et al., 2006) function in a similar manner to epistemic communities, as people are brought together either by their formal position or interest in a specific issue. IGOs and INGOs create and mediate discourses across sciences, industries, states and localities, and may create cultural frames integrating local and global levels of activity (Boli & Thomas, 1997).

From the above discussion on macro-cultural and counter discourses and their mediation to local contexts we come to our first research question:

***Question 1:** Through which processes do macro-cultural and counter discourses enable the local emergence of science-based fields?*

### 3. INSTITUTIONAL ENTREPRENEURS AS TRANSLATORS ACROSS SPATIAL SCALES

As discussed above, the literature on macro-cultural discourses casts light on the emergence of fields and the dissemination of novel frames of action. However, it gives few implications on the role and activities of mediating actors. Scandinavian Institutionalism with its notion of translation (Czarniawska & Joerges, 1996; Czarniawska & Sevón, 1996, 2005; Lindberg & Czarniawska, 2006), on the other hand, has produced detailed narratives on adaptations of foreign ideas and institutions to local contexts. Embedding an idea or macro-cultural discourse requires local agency, as ideas or discourses need to be translated into a locally meaningful form. As a result, the form ideas take is different from forms elsewhere as they reflect specific local institutions (Lawrence & Phillips, 2004) and issues. According to Hoffman (1999: 352), a field is formed “around issues that bring together various field constituents with disparate purposes”. In science-based fields such issues may be construed in the intersection of breakthroughs in science and the social and political aims present in the local science policy. Translating agents, often scientists and public policy actors, localize ideas by strategically and collectively reframing novel ideas to fit local circumstances to facilitate resource mobilization, implementation and transfer (Boxenbaum, 2006).

In line with this discussion, we argue that issue construction begins by framing an issue, which refers to an “active, processual phenomenon that implies agency and contention at the level of reality construction” (Benford & Snow, 2000: 614). Framing is characterized by competition and a clashing of interpretive frames promoted by different actors and communities (Benford & Snow, 2000), but also cooperation motivated by shared identity and interests (Ansell, 1997). Institutional entrepreneurs also engage in *theorization* (Greenwood et al., 2002; Maguire et al., 2004), referring to a process where agents construct the significance, scope and relevance of events (Munir, 2005) or discourses that justify an issue and enable the emergence of a field. Whereas translation refers to the adaptation of a foreign idea or institution into a different context (Sewell, 1992; Czarniawska & Joerges, 1996), framing induces the local creation of new meanings, and theorization shapes those meanings so that they reflect the needs and perceptions of a

wider group of stakeholders, and make them persistent. According to Lippi (2000), the role and influence of these socializing agents, who locate at local rather than at macro level, are perhaps more important than the actual idea to be transposed.

By shaping and creating institutions, actors contribute to the particular and disparate development of new fields locally. In this task, the ability of scientists in particular to carry knowledge (Bunnell & Coe, 2001; Amin & Cohendet, 2004) and articulate discourses (Spicer, 2006) from one space or scale to another is crucial. Spicer (2006) discusses how actors rescale struggles on certain issues within a spatial scale by connecting them to discourses on the same, lower or higher scales. In a similar manner, actors in epistemic communities are subject to discourses applicable to different scales, and may rescale them to address the local context and issues. The interaction between agents and macro-cultural discourses across spatial scales remains an understudied area in the institutional entrepreneurship approach. Theory advancement necessitates a profound understanding of how field-level characteristics affect such mediating and rescaling processes. Hence, this study puts forward a comparative setting of agency in two fields that depend to a varying extent on local issues and global discourses and represent a varying scope of institutional change required. The above presented conceptual approaches cast light on how the local embedding takes place, but have more or less taken for granted where the idea or discourse originates from and, more importantly, how it is mediated to the local context. Also, so far the Scandinavian Institutionalism has neglected the comparisons of translation in different types of local fields. From here we come to our second research question:

***Question 2:** How do translation processes and media employed by institutional entrepreneurs differ in pioneering and adopting science-based fields?*

#### **4. METHODS AND DATA**

Lawrence et al. (2002) recommend qualitative approaches for examining the localized dynamics of field level institutional change. Understanding the interaction between local and global in field emergence necessitates detailed, interpretive analyses taking into account the specific contexts in which the interaction occurs (cf. Garud et al., 2002; Maguire et al.,

2004). To do this, we have adopted the case study approach (Eisenhardt, 1989; Yin, 2003). According to Stake (2005), the case study is not a choice of method but a choice of what is studied, allowing the use of various sources of real time and retrospective data (Yin, 2003). We studied emergence as it unfolded over time employing the idea of systematic combining (Dubois & Gadde, 2002), where theoretical framework, empirical framework and case analysis coevolve. Our research setting responds to recent calls for comparative case studies to build “an adequate theory on institutional entrepreneurship and a more complete understanding of the paradox of embedded agency” (Greenwood & Suddaby 2006: 44; also Seo & Creed 2002; Dorado 2005). It also complements earlier single industry studies of field emergence (Van de Ven & Garud, 1993; Powell et al., 1996; Murtha et al., 2001; Garud et al., 2002).

#### **4.1 Data sources and data collection**

Both cases are longitudinal and draw mostly from retrospective data, as our study extends until the year 2000, the end of the first technology programs. Altogether 89 interviews form the key source of the empirical data: 32 for functional foods and 57 for nanotechnology. Interviews lasted between 30 minutes and four hours, the median being 1.5 hours. The interviews were recorded, transcribed and coded in NVivo before the analysis. Informants for both cases included top researchers from universities, representatives of public agencies, informants from small start-ups and large multinational firms, and private financiers such as angel investors and venture capitalists. In nanotechnology the interviews were conducted in four countries: Finland, Sweden, Denmark and the U.S., and in functional foods in Finland and the U.S. While the interviews conducted in Finland provided information of local emergence, the other interviews offered important contextual information of the respective processes in other countries. The identified institutional entrepreneurs were asked to describe in detail in what activities they engaged, and what type of mediators in their view connect the different spaces to enable the local emergence. For identifying an institutional entrepreneur we followed Garud et al. (2007: 962) who argue, “to qualify as an institutional entrepreneur an individual must break with existing rules and practices associated with the dominant institutional logic(s) and institutionalize the alternative rules, practices or logics they are championing.” Empirically, institutional entrepreneurs were individuals, who were

considered by a wider group of informants as central to setting the emergence in motion. Also, a range of actors other than institutional entrepreneurs were interviewed in order to investigate the “institutional work” (Lawrence & Suddaby, 2006) in which they participated. For both cases also a variety of public and non-public documents were used, such as final reports of the technology programs, articles in academic journals, and news stories in the press and trade journals.

## **4.2 Data analysis**

The data analysis is comprised of four main stages. First, we traced the development of the fields both globally as well as in the local context. Table 1 provides chronologies of the main events characterizing the emergence of both fields in Finland and elsewhere. This first stage of analysis was conducted by collecting such events from the primary (interviews) and secondary (documents) data that triggered issue construction. Events were considered as discrete units which are unique, time bound, enacted and context-bound (Pauwels & Matthyssens, 2004). In the second stage, we identified the key actors who mediated between spatial scales in the local emergence process and investigated possible mediators used by them. Third, we conducted a cross-case pattern search between case similarities and differences (Eisenhardt, 1989). In comparing the cases, events, macro-cultural discourses, and mediating actors and activities between spatial scales formed our units of analysis. In the fourth stage, these categories formed the building blocks for our theorized storyline (Golden-Biddle & Locke, 2006) on the interaction between macro-cultural discourse, institutional entrepreneurs and spatial scales in the emergence of science-based fields. Such contextualist analysis of emergence stresses how the context is a product of action and action produces the context, and where change is neither linear or singular but takes place at multiple interconnected levels (Pettigrew, 1990; also Seo & Creed, 2002). In the following we present the synopses of empirical cases, and in the next section we discuss the actions and events in further detail through comparative analysis of the functional foods and nanotechnology cases.

Year	Functional Foods Events	Year	Nanotechnology Events
<b>G L O B A L</b>			
1950s	Link between dietary fats and heart disease identified	1959	Feynman's speech There is Plenty of Room at the Bottom
1953	Relationship between the use of sterols and reduced serum cholesterol-level proved (Pollak 1953)	1978	Launch of supramolecular chemistry
1958	Seven Countries Study on the epidemiology and causes of coronary heart disease begin at the Minnesota University.	1981	Invention of scanning tunneling microscope by IBM in Switzerland
1969	US White House Conference on Food, Nutrition and Health draws public attention to diet-disease link	1986	Drexler publishes Engines of Creation, the Coming Era of Nanotechnology, and establishes Foresight Institute
1970s	Sitosterol esterified with fatty acids to fat-soluble form by the researchers of Procter and Gamble Inc.	1987	Launch of the first single electron transistor at Bell Laboratory; establishment of MEMS as a field
		1990	The first academic journal Nanotechnology
		1992–	Joint Research Center for Atom Technology program on meso scale physics in Japan
		2001	Technology program on meso scale physics in Japan
		1994–	Transnational research projects on nanotechnology in EU
		2002	nanotechnology in EU
<b>F I N L A N D</b>			
1972	Community level intervention (North-Karelia Project) initiated to reduce the high heart disease mortality rate	1980s	Research reaching into atomic and molecular scale in e.g. physics, chemistry, material sciences and biology
1986	Medical inquiry and search for the possible applications for sitosterol started	1992	Introduction of nanoelectronics as a research area in University of Jyväskylä
1988	Great Fat Debate begun at the main Finnish newspaper Helsingin Sanomat	1995	Identification of the gap in public funding structures
1989	Technological breakthrough in converting plant stanols into a fat-soluble form by Wester at Raisio Margarine		ESPRIT workshop on Long-term research Benchmarking to Japan
1991	Patent application for sitostanol ester filed at the Finnish Patent Office by Raisio Margarine	1997–	Nanotechnology Research Program by Tekes
1995	Launch of Benecol margarine by Raisio	1999	
1997–	Technology program on foods by Tekes		
2000			
<b>G L O B A L</b>			
1991	Early experiments with Benecol released at the scientific meeting of the American Heart Association	2000	Clinton announces the National Nanotechnology Initiative (NNI) in the USA
1995	New England Journal of Medicine publishes results that Benecol lowers blood (LDL) cholesterol by 14%	2002	Establishment of Nanotechnology as a strategic priority area in EU
1999	Launch of Benecol and Unilever's competing plant sterol ester margarine in USA		

**Table 1:** *Chronology of the key events in functional foods and nanotechnology*

### 4.3 Research settings

The data for the comparative case study were collected in two separate research projects focusing on investigating the dynamics of the emergence of science-based fields. The



comparative setting is justified by the important theoretical and empirical differences between the cases. Yet, they are similar enough to make the comparison worthwhile. Functional foods and nanotechnology in Finland are both science-based fields by virtue of their origins. Interestingly, these fields draw rather differently from local issues versus global macro-cultural discourses, and also have different feedback loops to the global emergence of the respective fields. In the cholesterol-lowering functional foods, the Finnish actors were the pioneers who shaped and also created the forms and functions of the field globally, and had a major impact on the discourses on food and health. In the local construction of nanotechnology, the Finnish agents were able to draw legitimacy from other institutional contexts for establishing the local form of the field. These differences enabled us to uncover the means and activities of institutional entrepreneurs in mediating influences across spatial scales, and embedding them into the Finnish context in both fields. Finland, an institutionally homogeneous Nordic country with 5.3 million inhabitants commands the ‘*avant-garde*’ role in both fields in terms of science or technology, pioneering either in technology development or institutional templates around these concepts. Focus on a distinctive spatial setting is necessary for investigating mediators and mechanisms of translation in the emergence of science-based fields. Table 2 presents quotes from the interviews illustrating the various processes of mediation of influences across the spatial scales.

The ancient “food as medicine” philosophy of Hippocrates underlies the concept of functional foods, which refers to a broad category of foods with a positive health effect. In the 1950s a research agenda on the relationship between nutrition and degenerative disease was established. Forty years later in the 1990s, an equally ground-breaking nutrition agenda on functional foods came about (Heasman & Mellentin, 2001). The emergence of functional foods required strong institutional entrepreneurship in addition to scientific and technological advancement. The concept is controversial in that it suggests that food can have medicinal effects and be used to prevent and to some degree also treat degenerative diseases. Our case concentrates on functional foods that aim to combat high blood cholesterol, the major causal risk factor for heart disease which is the leading cause of death both in high and low income countries (WHO, 2007). Cholesterol-lowering functional foods contain plant sterols that block the absorption of cholesterol in the intestine. The pioneering Benecol margarine was developed and launched in Finland in

1995 as a part of the public health initiative called the North Karelia Project, which aimed to lower the cholesterol levels in the nation. Professor Pekka Puska, Director General of Finland's National Public Health Institute describes Benecol as the 'pearl in the crown'<sup>22</sup> of the initiative. The launch of Benecol triggered the creation of a number of similar types of concepts (e.g. Flora/Becel pro.activ, HeartWise). By the turn of the millennium, Finland was considered the world leader in the development of health-enhancing foods and was called "the Silicon Valley of Functional Foods".

Nanotechnology has been defined by Wang (2004, 28) as "the construction and use of functional structures designed from an atomic or molecular scale with at least one characteristic dimension measured in nanometers", i.e. on a size scale between 0.1 and 100 nanometers (Budworth, 1996; European Commission, 2004). The roots of nanotechnology are twofold. Nanotechnology is driven by scientific and technological development, which enables the manipulation of individual atoms and the investigation of phenomena revealed by the "nanoscale" size scale. Miniaturization in science is widely considered to have its inspiration in the 1959 speech of a Nobel Prize winner, physicist Richard Feynman, who stated "there is plenty of room at the bottom". The first major steps toward "nanotechnology" were the establishment of the field of supramolecular chemistry in 1978, and the launch of tools such as the scanning tunneling microscope in 1981 and atomic force microscope in 1986. Further, the development of microelectromechanical systems was a hot domain in the late 1980s in all industrialized countries. In Finland in the 1980s and early 1990s there was research reaching into the nano-scale in electronics, materials, processes and tools, and biotechnology. However, almost none of this research was labeled as nanotechnology before the local technology program on nanotechnology began in 1997. Consequently, in addition to the developments in science and technology, nanotechnology draws from the emergence of the very concept, as will be discussed in more detail in the comparative case analysis.

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<sup>22</sup> <http://www.benecol.co.uk/new/benecol-history.htm>

	Functional foods quotations	Mediators across scales	Nanotechnology quotations	Mediators across scales
<b>Translation and mediation to local context</b>	<p>I worked for the Rockefeller Institute during 1963-65 and it was there where the research [on plant sterols] was primarily done. – <i>Emeritus Professor in Medicine</i></p> <p>We've been working with the guru of innovation-diffusion theory Rogers over the years. I visited Stanford with him and he visited our cottage and we wrote together about the use of lay opinion leaders (Puska et al. 1986). – <i>Director General of the National Public Health Institute</i></p> <p>The sterol representing Benecol was synthesized only in the mid-70s by the Japanese, but those experiments were made only with rats and chickens, none with man. – <i>Emeritus Professor in Medicine</i></p>	<p>Migrating scientists</p> <p>Scientific publications</p>	<p>The research on nanostructures at VTT Microelectronics Centre [...] was initiated in 1991 by sending a visiting researcher to Japan to join a group at NEC in this field. [...] This work was continued in Finland in 1993. – <i>Jouni Ahopelto [in the Final Report of the Technology Programme]</i></p> <p>What happens in Finland is mainstreams. We follow what happens elsewhere. How much we can do things ourselves depends on the situation. – <i>Professor of Applied Physics</i></p> <p>We organized a networking visit to Japan in 1996. [...] At the time they didn't talk about nano but it was mesoscale physics or something. Nano was a bit of an ugly word, due to Drexler perhaps. – <i>Senior Technology Expert at Tekes</i></p>	<p>Migrating scientists</p> <p>Trends, mainstream</p> <p>Benchmarking</p>
<b>Translation from local to global</b>	<p>We conducted the security tests in the best international research institutes...Every country has its own protocols and legislation. – <i>MNC Director Asia &amp; Oceania</i></p> <p>We released the first clinical tests in an enormous meeting of the American Heart Association in 1991 – and ever since the sales and production of plant sterol have diffused and grown exponentially. – <i>Emeritus Professor in Medicine</i></p> <p>It is even amusing sometimes when I listen to ministers from the [most distant] countries at the WHO meetings talk about the North-Karelia Project. – <i>Director General of the National Public Health Institute</i></p>	<p>Clinical tests</p> <p>Conference presentations</p> <p>Evangelizing public policy actors</p>	<p>Even though it wasn't an enormous program on the global scale, it was one of the first organized as a program in the whole world. In addition for it to be recognized in Finland, it was also recognized elsewhere. Especially Oiva [Knuutila] [...] traveled even more than usual just to tell about nano. It brought into global knowledge what we were doing in an entirely different manner than without the program. – <i>Technology Expert at Tekes</i></p> <p>The international visibility was achieved in a sense that [...] during [2001] I was continuously asked to travel all across Europe to tell about the Finnish nanotechnology program in various panels, what should be done where, participate in think tanks and the like. – <i>Senior Technology Expert at Tekes</i></p>	<p>Evangelizing public policy actors</p> <p>Object of translation: institutional arrangement</p>

**Table 2:** Illustrations of the interview data on mediating actors, activities and artifacts

## 5. COMPARATIVE CASE ANALYSIS

### 5.1 Scientific and popular discourses and epistemic communities in science

In both functional foods and nanotechnology macro-cultural discourses played a central role in the construction of novel cognitive frames that enabled the emergence. These macro-level developments are described below.

**Functional foods.** After the food shortages of World War II, dietary habits and values favoured foods high in saturated fat. However, the scientific and policy discourse on the link between dietary intake of fat and heart disease was initiated in the U.S. in the 1950s, which challenged such values. Within the medical community Professor Ancel Keys at the University of Minnesota started the Seven Countries Study in 1958 to investigate cross-country variation in epidemiology and causes of coronary heart disease. A decade later President Nixon convened the landmark Conference on Food, Nutrition and Health. The conference stressed the role of consumer protection and education programs and prompted the introduction of dietary guidelines for certain classes of food. Identification of the relationship between dietary intake of fat and occurrence of heart disease enabled two decades later the “interstitial emergence” (Morrill, in press) of cholesterol-lowering functional foods in the transitory area between foods and pharmaceuticals. Functional foods have aroused considerable public and policy interest. Functional foods have been framed either positively as an opportunity to maintain national competitiveness of food manufacturers in the rapidly globalizing food industry and a way to reduce health care costs of ageing western populations; or the concept has evoked public concern over the safety of functional foods which are often associated with genetically modified food. A more specific discourse on cholesterol-lowering functional foods emerged in Finland in the 1990s, along with the development of the world’s first cholesterol-lowering functional food, the margarine called Benecol®. The relationship between dietary fat and heart disease rose to the top of the local political agenda along with the study of Professor Keys, which showed that men living in North Karelia in Eastern Finland suffered from world’s highest heart disease mortality rate. As discussed, the North Karelia Project, coordinated by the National Public Health Institute and the World Health Organization (WHO), was

launched in 1972. During the period of its existence, 1972-1997, the project was led by Professor Pekka Puska. His team challenged the eating habits of the farming region (rich in dairy fats and salt) and the opinion of the conservative medical community where some members considered heart disease as a “*normal age related phenomenon, which can’t nor even should be tackled*”, as recalled by a Research Professor who was at the time a member of the project team. The relationship between dairy fat and the risk of heart disease was strongly contested, and the backlash of the previously dominant discourse in form of “the great fat debate” took place in the leading Finnish newspaper Helsingin Sanomat in 1988, resembling an “institutional war” (Hoffman, 1999). Even though this debate was initiated as an open attack against the relationship between dietary fats and heart disease, the outcome was a rapid increase of cholesterol awareness by the general public.

**Nanotechnology.** As stated above, the trend of miniaturization in science is widely considered to have its inspiration from Feynman’s words “there is plenty of room at the bottom”. In the technology domain, the so-called Moore’s Law has become a powerful guideline for the IT industry, suggesting that the number of chips on a transistor doubles every year. The size of the smallest components in computers already reaches into the nanoscale. Yet, probably none of the science and technology would be called nanotechnology if it had not been for futurist Dr. Eric Drexler. Inspired by miniaturization in science, combined with his enthusiasm for science fiction, Drexler introduced the novel concept of nanotechnology in his book “*Engines of Creation: the Coming Era of Nanotechnology*” in 1986. The book gained a lot of attention due to the provocative claims about molecular machines that create minuscule copies of themselves. Compelling visions inspired many and generated a considerable following for Drexler’s ideas among futurists. The rhetoric became adopted and embedded especially in the cyber punk genre of science fiction in the U.S.<sup>23</sup> by the early 1990s. As a result, the concept “nanotechnology” became initially regarded as science fiction by the scientific community. However, despite, or owing to, the discursive embeddedness of nanotechnology in science fiction, the concept was able to capture the attention of science lobbyists and political decision-makers toward the mid-1990s in the U.S. In Europe the concept was plagued less by the connotations to science

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<sup>23</sup> The books with reference to nanotechnology include *Science Fiction in the Real World*, *Great Mambo Chicken and the Transhuman Condition*, *Summer Queen*, *Aristoi*, *Virtual Light*, *Terminal Café*, *Queen City Jazz*, *The Diamond Age*, *Idoru*, *Distress*, *Slant*, *A King of Infinite Space*, *The Hacker Crackdown*, *Clone*, *Brown Girl in the Ring*, *Bloom*, *All Tomorrow’s Parties*; and movies *Virtuosity* and *Infinity*.

fiction though Drexlerian ideas were also known. Common to both continents, nanotechnology was used as a means for tilting the balance of public funding from biotechnology and medical sciences to physical sciences and engineering. Consequently, by the mid 1990s the notion of nanotechnology had begun to gain significant ground also in scientific discourses, through which it became disseminated to Finland, along with the popular cultural “Drexlerian” discourses. Interestingly, the key innovations were relabeled as ‘nanotechnology’ in science and media only after Drexler had introduced the concept, and even more so after the legitimation by public policy makers and scientists, although stripped - as much as possible - from its Drexlerian meaning. By 2002, nanotechnology had been framed as a strategic domain of research in most industrialized countries.

**Comparative remarks.** Both fields benefited from the emergence of new discourses in global epistemic communities, which challenged or complemented certain institutionalized frames of understanding. For the case of cholesterol-lowering functional foods the concept emerged as a kind of counter discourse to the prevailing discourse stressing taste and pleasure of traditional foods. Changing such views clearly lies beneath the emergence of functional foods as a field. In the nanotechnology case, the creation of the concept, on the other hand, directed the imagination of a wider public to technology development on a very small size scale. First established in science fiction, science lobbyists and policy makers later mobilized counter discourses, which aimed to abolish such connotations. This change of frames enabled the creation of national technology programs, such as the one, among the first, in Finland. In both cases, certain field-related activities pre-existed these discourses, such as rigorous medical studies of the diet-disease link in functional foods, and miniaturization in research and technology in nanotechnology, which triggered and enabled the emergence of the novel discourses in epistemic communities.

There are also several differences between the cases. Counter discourses in functional foods represented such a fundamental change in conventional understanding on food and health that the institutionalization of these discourses was a major task and posed a challenge, or even threat, to many existing organizations. As a result, the link between heart health and consumption of dairy fat was later contested by individuals, organizations and various activist groups. Mobilization of the novel discourse required a grass-roots level change of attitudes, and the involvement of a variety of communities. However, the

nanotechnology discourse in science fiction interestingly created opportunities for actors in science and policy domains to gain access to new resources, and did not require such a major change in the existing institutionalized discourses within the scientific community. The communities the discourses affected were few and represented the scientific elite. The major threat for organizations was not to be included in the nano-domain and the new resources it offered, which resulted in opportunism in the form of ‘nano-labeling’ of research and development activities in the 2000s.

## 5.2 Migrating scientists and local translation of ideas and technology

As is typical for science-based fields, migrating scientists played crucial roles in building local competences that enabled the identification and adoption of the novel concepts. The main task of the central scientists, but also of public policy actors, was to translate the scientific discourse within epistemic communities into issues that were understood and accepted by other stakeholders in the local context. While we cannot describe these links from global to local exhaustively, we give some examples of some of the most important connections below.

**Functional foods.** In the 1950s and 1960s Finnish researchers were active in international research collaboration particularly with U.S. scientists. Within the North Karelia Project, the migration of scientists and the transfer and translation of existing theories to health promotion was crucial. Most importantly, the project team applied the innovation-diffusion model by Everett M. Rogers, the key member of the project team (see also Rogers, 2003), to translate the novel understandings of risk-reducing lifestyles present in the research community to individuals through normal community networks. Reciprocal research visits and co-authoring took place between Rogers and Puska in Finland and Stanford, U.S. during the project. Later in 2000, a co-principal investigator of the project, Professor Erkki Vartiainen, spent one year in Scotland to implement a similar heart disease prevention scheme. Likewise, migration and the import of the state-of-the-art medical science were central in developing the pioneering cholesterol-lowering functional foods concept in Finland. The leading scientist of the human lipid metabolism, Professor Tatu A. Miettinen from the Helsinki University Central Hospital in Finland, had worked for the prestigious Rockefeller Institute for Medical Research in New York during 1963-65. The

competence that Miettinen imported from the pioneering research institute on plant sterols to Finland became central in the development of the plant stanol ester used in Benecol.

**Nanotechnology.** There were many scientists in various domains of science studying atomic and molecular scale phenomena in the 1980s and early 1990s. However, very few of them were politically active in promoting the concept of nanotechnology. The most central actor among the scientists was arguably Professor Mikko Paalanen. After gaining his PhD from the renowned Low Temperature Laboratory (LTL) at Helsinki University of Technology in the mid-1970s, he worked for 15 years at Bell Laboratories in the U.S. At Bell, Paalanen was involved in the research of single electron transistors (SET)<sup>24</sup>. In 1992, he returned to Finland and became Professor of Applied Physics at the University of Jyväskylä, where the first Finnish SET was produced in 1993. In the mid-1990s, as the Director of LTL he, along with his team, extended the existing competences around a sensitive magnetometer called SQUID (Superconducting Quantum Interference Device), which had interesting similarities of application to SET. During the early 1990s in the domain of nanoelectronics, other migrating researchers included Jukka Pekola visiting the University of California in Berkeley; Jouni Ahopelto visiting at NEC in Japan; and Olli Ikkala who in general was an internationally known researcher in the domain of self-organized polymer nanostructures. However, Paalanen was the one among the scientists of all domains of nanotechnology, who recognized the need to actively promote nanotechnology in the wider academic and political arenas in Finland and participated in the translation of nanotechnology as a science into nanotechnology as a policy.

**Comparative remarks.** The migrating scientists were important embodiments and carriers of novel research into the Finnish context, and acted as central mediators between spatial scales. These scientists imported competencies and novel discourses but, most significantly, engaged in the local translation of new concepts, both scientifically and politically. There are two levels of activity in which agents are embedded and from which they draw: the scientific development and discourses; and the popular discourses. Both functional foods and nanotechnology fields were strongly embedded in scientific research during their early stage of emergence. However, popular trends and discourses sensitized

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<sup>24</sup> An important innovation in the development of nanoelectronics based on Coulomb blockade and quantum tunneling.



scientists and actors in public funding organizations to interpret the science through a novel lens, which enabled the local emergence of these science-based fields. For functional foods, what started as a local public health initiative, ended as a specific cholesterol lowering product aimed for the global market place. In the case of nanotechnology, the emergence took place by directing the focus of existing institutions to nanotechnology and developing the related technology and competence base. However, the cases differed from one another to the extent of the field being a product of local creation versus local translation. In the functional foods case the local agents merged research results from their epistemic communities with local scientific and technological competences and raw materials to solve a serious health issue. In this process they significantly shaped and developed the concept and created a central innovation in the domain. In nanotechnology, the ideas were imported to and adopted in science in a fairly similar form to what was already happening elsewhere, but embedding them into the individual and local competence base resulted also in modified foci of research. In the next section we discuss the local translation and embedding in more detail.

### **5.3 Legitimizing organizations and links back to global development of the fields**

In both cases, the agency of certain individuals, enabled and enforced by their formal organizations, formed the basis for the local emergence of the fields. Also, in their dissemination from Finland to other countries, various organizations played an important role, especially so in the functional foods case.

**Functional foods.** While the severe local health issue and the high level competence in cholesterol metabolism were important in the local development of the pioneering plant sterol margarine, the actual trigger for developing the Benecol concept came from a Finnish forest products company that was at the time searching for buyers for sitosterol, a surplus by-product of its milling process. After a potential application area was identified from scientific publications, where the cholesterol-lowering property of plant sterols was known since the 1950s (Peterson, 1951; Pollack, 1953), Professor Miettinen was contacted. He suggested the use of fat soluble sitostanol ester in food products to Raisio Margarine, the leading Finnish vegetable-fat producer. The positive results of the early experiments with Benecol were released at the American Heart Association Scientific meeting in 1991.

This resulted in a radical change in the way of thinking about the potential of plant sterols both in Finland and in foreign research laboratories, reflected in patenting and scientific publication activity around sitostanols. Even though Benecol was ready for a launch in 1992, the management of Raisio requested long-term clinical trials. The delay of the market launch was probably the right decision also due to the view of the medical community at that time that low blood cholesterol level may be linked to violent behaviour. An extensive clinical trial with Benecol was thereafter carried out within the North Karelia Project which already had an internationally recognized system for clinical trials. The trial documented a 14 percent reduction in the 'bad' cholesterol level (low-density-lipoprotein, LDL) and was published in 1995 in the flagship journal *New England Journal of Medicine*, the same day Benecol was launched in Finland. Later, the involvement of Professors Puska and Miettinen in the marketing of Benecol built a sound base for negotiations with regulative authorities and the marketing of Benecol both nationally and internationally.

In sum, both the local heart disease prevention program in North Karelia and the concept of cholesterol-lowering functional foods were pioneers in the endeavor to find the connection between nutrition and heart health. The ideas behind these innovations have circulated globally through scientific articles and patents. The success of the North Karelia Project (by 2002 the age-adjusted coronary heart disease mortality rate had fallen over 80 percent in North Karelia from the pre-program years) is documented in over 400 international medical articles and the project is frequently cited as the model for other national and international prevention trials. Since the early 80s, up to 2,000 guests from more than 100 countries have participated an "International Visitors' Programme" organized twice a year in Finland. Also developing countries, which are today struggling under the dual burden of both chronic and infectious diseases, are launching similar types of projects, the North Karelia Project being the "spiritual father" of the later projects. Professor Puska became recognized for his local achievements and was invited to build the WHO Global Strategy on Diet, Physical Activity and Health (2001-2003) and was appointed as President Elect of the non-governmental organization World Heart Federation in 2006. Hence, a wide range of organizational actors from local heart associations and other NGOs to rather global MNCs, IGOs and INGOs have participated in constructing the heart-health issue and in legitimating the cholesterol-lowering functional foods.

**Nanotechnology.** Regardless of the research competence present in Finland during the early 1990s, the reason why one of the first nanotechnology programs in the world was established there lies in the agency and competence of a handful of individuals in public policy organizations. Tekes, the Finnish Funding Agency for Technology and Innovations, had typically financed projects forming part of the strategic activity to ensure the adoption of new technologies, which are close to commercialization and important to Finnish industries. The task of the Academy of Finland has traditionally been the funding of projects in basic research. However, the division of labor between the funding organizations was not clear-cut, and a need for cooperation existed. In the autumn of 1995, Oiva Knuutila, a technology expert of Tekes, discussed with his colleagues, Juha Vapaavuori and Jussi Kivikoski, the importance of the organization to allow long-term investments on emerging fields, such as nanotechnology, without an immediate expectation for commercialization. Knuutila had a background in nuclear physics, and Vapaavuori and Kivikoski were chemists by education. Their task in Tekes was to identify new potential areas of applied research and commercial development. Their education made them able to see both the scientific and political opportunities provided by nanotechnology, and their tasks in the organization offered a true leverage on the technology policy issues. These discussions within Tekes coincided with the ESPRIT Workshop “Long Term Research” organized in Finland by the European Commission. The focus was on “Future Emerging Technologies”, which also touched upon nanotechnology. The workshop encouraged a small group of individuals within Tekes to investigate further the prospects for establishing a program around nanotechnology. As a result, a delegation including Oiva Knuutila from Tekes, Juhani Keinonen, the Head of the Research Council for Natural Sciences from the Academy of Finland, and Professor Paalanen, visited Japan in 1996 to benchmark<sup>25</sup>.

With the lead of Jorma Hattula, the new Director of Research at The Academy of Finland, and Oiva Knuutila, the gap in the Finnish science funding structures was construed into an issue which, together with encouragement from the ESPRIT workshop and the benchmarking exercise, enabled the founding of the Nanotechnology Research Programme in cooperation with the two institutions. The program, lasting from 1997 to 1999, was

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<sup>25</sup> Japan had started in 1992 with a 10-year technology program on “meso scale physics”, a more legitimate concept at the time representing, however, a significant investment to nano-related research.

among the first nanotechnology research initiatives in the world to be organized in the form of a program and also to employ the concept of nanotechnology. The timing of the program was interesting: by the 'hype year' 2000, Finland had become a benchmarking case for many countries in Europe that were about to establish their first nanotechnology programs. After the program was finished, the central actors and researchers contributing to it became the promoters of the institutionalization of nanotechnology in the European context. For example, Oiva Knuutila was invited to a number of conferences and seminars in Europe to advise on and discuss various nanotechnology programs. Consequently, the Finnish actors contributed to the construction of nanotechnology as a field of activity also in the European context.

**Comparative remarks.** In both emergence paths *kairos* or “right or opportune moment”<sup>26</sup> played an important role as the favorable timing of the market launch of Benecol and the Finnish nanotechnology program indicated. Moreover, in both cases high status organizations acted as legitimators of the activities of the central agents, and the public financing channeled for instance through Tekes was crucial for both fields. However, the legitimizing organizations and media were different across the cases. In functional foods, the involvement and commitment of commercial firms, as well as health related NGOs and INGOs in the later legitimation were necessary. In the relevant epistemic communities, scientific publications and patents were used both to protect intellectual property as well as to evangelize and legitimize the novel concepts. As functional food represents a more fundamental institutional change, a greater variety of organizations was necessary in its legitimation. In the nanotechnology case, emergence was a far more contained process addressing but a few scientific elites, and the major roles were played by the local research and public policy organizations. The central actors greatly benefited from a suitable education for recognizing nanotechnology as an interesting area of public investment, as well as from their task in a formal public organization to identify potential local seeds for nationally important technologies. Consequently, their actions were supported by their work tasks and organization. Since nanotechnology hardly existed in the national policy agendas at the time of the launch of the program, the legitimation from the European Commission and benchmarking from Japan were crucial for starting a local

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<sup>26</sup> [<http://en.wikipedia.org/wiki/Kairos>]

program. As a result, the timing of the launch of the Benecol ingredient and the Finnish nanotechnology program resulted in their becoming benchmarking cases for other countries initiating similar activities.

## 6. FINDINGS AND DISCUSSION

### 6.1 Macro-cultural discourses and institutional entrepreneurship

In our first question we asked, *Through which processes do macro-cultural and counter discourses enable the local emergence of science-based fields?* The notion of macro-cultural discourses has scarcely been developed in the institutional entrepreneurship literature and in the context of field emergence. For this discussion our study gives two contributions. Firstly, our cases not only show the enabling property of macro-cultural discourses (Lawrence & Phillips, 2004), but highlight that parallel and counter discourses fundamentally underlie institutional entrepreneurship. Agency is needed to change the prevalent discourses. If institutions are characterized “as products of discursive activity that influence actions” (Phillips et al., 2004: 635), then institutional entrepreneurs must be such actors who create and disseminate parallel and counter discourses. Hence, contributing to the work of Lawrence and Phillips (2004), institutional entrepreneurs participate in the creation of entirely new discourses, rather than merely capitalize on existing macro-cultural discourses.

***Proposition 1:** Institutional entrepreneurs are agents who are active in identifying, creating and mobilizing parallel and counter discourses to prevailing institutionalized discourses.*

Our second contribution to the discussion on macro-cultural discourse in field emergence concerns the special nature of science-based fields and the types of discourses and activities present in their construction. The empirical study showed that the developments in science need to be translated across spatial scales, as well as popularized, which is another form of translation, across community boundaries in order for a local field to emerge. This process is regulated by the local public and policy institutions as well as ‘public opinions’. For such a task the identification and construction of a local issue, which is important from the public policy point of view, was crucial in both cases.

**Proposition 2a:** *Local construction of a scientific discourse requires the identification of an issue which is significant from the local policy point of view, and is supported by a critical mass of significant communities.*

**Proposition 2b:** *The more profound the institutional change required and the more and greater variety of communities involved, the more fundamental the construed issue and better justified the accompanying discourses need to be.*

## 6.2 Institutional Entrepreneurs Translating across Spatial Scales

Our second research question was, *How do translation processes and media employed by institutional entrepreneurs differ in pioneering and adopting science-based fields?* Besides suggesting answers to this question, our empirical data contribute to discussing the common and divergent aspects of institutional entrepreneurship across spatial scales in field emergence.

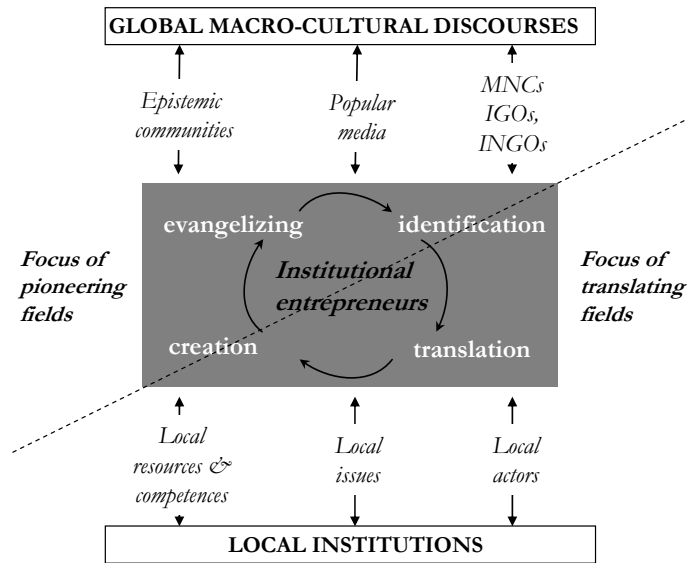
The empirical study suggests that the capacity of actors to operate across spatial scales, and link local institutions and global discourses to one another, may in fact be one important capability that defines the possibilities for institutional entrepreneurship in science-based fields. The role of this capability is naturally emphasized in the context of a small and open society, where scientific communities are rarely self-sustaining. Scientists are by their formal training and activities particularly capable of working across spatial scales, and linking a global body of research into local competences and funding institutions by acting as local legitimators and lobbyists. Such activity is backed by both their personal status in the research community and the prestige of their current and previous organizations. Public policy actors, on the other hand, are gate keepers to what is financed by policy institutions. In the empirical cases, public policy actors enacted locally the trends that were identifiable in global epistemic and policy communities, built funding schemes and regulation around them, and hence, played an important role in institutional innovation. The study casts light on mediating activities and artefacts between local institutions and macro-cultural discourses, to which Lawrence and Phillips (2004) give some early implications. Our focus on migrating scientists complements the idea that membership of a transnational community (Portes, 1996) or international technical community (Saxenian & Hsu, 2005) may act as a mediator between otherwise disconnected knowledge bases.

Moreover, our findings extend the discussion of Spicer (2006) on spatial scales by elaborating the ways in which institutional entrepreneurs participate in the local production of capital accumulation, discourses and regulation. As a result, the study addresses what we consider to be one of the central weaknesses of the current institutional entrepreneurship literature, namely that of concentration on projective agency (Dorado, 2005) within a limited spatial scale.

***Proposition 3:** In science-based fields, the capacity of an actor to capitalize on, create and translate material and discursive practices across spatial scales defines his/her possibilities for institutional entrepreneurship.*

The third contribution to the embedding agency discussion addresses the second research question on how agency and translation differs depending on the nature of the field. Timing, or *kairos*, largely defined the extent to which local projects became noticed in global communities. Timing was also reflected in the extent of change and mobilization which the agents needed to induce. Functional foods in the cholesterol-lowering category represents a truly *pioneering* field. Our study shows that even in pioneering science-based fields, the seeds for activity are present in discourses of global epistemic communities, from which they are translated and sometimes greatly modified to address local issues. The task of local actors was to articulate and mobilize counter-discourses to the prevailing institutionalized understandings of the link between dairy fats and heart health based on ground-breaking research results. This was a project of creating cognitive legitimacy for a novel conception of food, and to engage in profound cultural change. Consequently, pioneers of new fields have an important role in building templates and counter discourse locally and later disseminating them by theorizing the local successes across national boundaries within their epistemic communities, also reaching toward other audiences. Though pioneering is tied to a specific institutional context, in science-based fields the necessary legitimation and institution building takes place at the level of global communities, as pioneering is typically characterized by references to certain scientific publications and patents. These present one type of feedback loop between local institutions and global discourses.

**Proposition 4:** *In pioneering science-based fields, high status individuals and organizations act as institutional entrepreneurs by creating and mobilizing novel discourses locally, and legitimize them in the global epistemic community through publishing, patenting and evangelizing.*



**Figure 1:** *Institutional entrepreneurs as the mediators between local institutions and global influences in the emergence of science-based fields*

The emergence of nanotechnology in Finland, on the other hand, represents an *adopting* field. Similar to functional foods, the emergence of nanotechnology was enabled by developments in science and macro-cultural discourses elsewhere. When ‘nanotechnology’ started to gain momentum in science and political discourse, it was construed as means for changing the existing division of tasks between established funding institutions in Finland. The novel technology program was legitimated through benchmarking and referencing activities in relation to the pioneers in the domain. Hence, rather than mobilizing counter discourses, the main task of the local institutional entrepreneurs was to modify the discourses and practices from a different institutional environment suitable to the local context, and construct the need for local activity. However, the local form, a nanotechnology program, was new at least in the European context, and became a template for other institutional actors in the later stages.



***Proposition 5:*** *In adopting science-based fields, institutional entrepreneurs draw from somewhat institutionalized discourses and benchmark existing templates present elsewhere, and through theorizing and mobilizing create local versions of them.*

Figure 1 summarizes the conceptual and empirical discussion and presents the framework for institutional entrepreneurs as mediating and translating agents at the intersection of global discourses and local institutions. These actors form part of various communities and organizations through which they are able to modify the prevalent macro-cultural discourses. On the other hand, institutional entrepreneurs are aware of and hold some power over local resources, competences, issues and actors. To conclude, our study strongly suggests that institutional entrepreneurs play a central role in the local embedding of novel institutional fields.

## **7. CONCLUSIONS**

In this study, we investigate the role and the ways in which institutional entrepreneurs utilize macro-cultural discourses in building or redirecting local institutions, and thereby contribute to the local emergence of a new field. While the institutional entrepreneurship approach brought focus to the role of the ground breaking activities of individual actors in bounded spatial localities (Lawrence & Phillips, 2004; Maguire et al., 2004), Scandinavian Institutionalism stressed imitation as a motor of agency and translation as a vehicle to appreciate spatial differences (Czarniawska & Sevón, 2005). The notion of spatial scales (Spicer, 2006) focused further attention into interactions across the geographic scales.

Empirically the study drew from two cases, functional foods representing the global pioneer and nanotechnology a local adopter. Through such a comparative setting we were able to contrast the activities of the central actors in constructing local fields. The focus on the complex interaction between macro-cultural discourses and institutional entrepreneurship across spatial scales both conceptually and empirically allows this study to make several contributions to the literature on field emergence. Firstly, it complements the work of Lawrence and Phillips (2004) by discussing how micro-level agency may contribute to macro-cultural discourses, rather than merely using them as a resource.

Secondly, our study finds that, depending on the field, translation may result in such a great modification of the original idea that a novel, pioneering innovation may be the result. This finding brings Scandinavian Institutionalism into interaction with innovation literature by suggesting that local translations are important seeds for local technological and institutional innovation, which creates a further link to the literature on the social construction of technology (Constant, 1980; Bijker et al., 1987; Garud & Karnoe, 2003). Thirdly, we identify that a major task for institutional entrepreneurs in the emergence of institutions is to create parallel and counter discourses to prevalent institutionalized discourses, representing a contribution to Phillips et al. (2004). Thus, the study advances a view according to which institutionalization is not only a top-down phenomenon of institutional isomorphism, but rather, it works also from the micro to the macro, from the local to the global (Barley & Tolbert, 1997; Lippi, 2000).

Naturally, the study has several limitations. The division to local agents and institutions and global macro-cultural discourses is analytic at best. Local and global influences are intertwined in complex ways across the various phases of field emergence and it is very difficult to track in detail the role of the individual agency in connecting between these levels. Also, our cases can hardly be generalized to other fields and, consequently, more studies are called for on the role of the individual agency in different kinds of emerging fields in multiple contexts. Whereas our research setting offers a novel perspective to study field emergence, it also raises some further topics to be covered. Firstly, the effects and implications of macro-cultural discourses and agency to field emergence require further investigation. For example, language presents barriers for the dissemination of macro-cultural discourses, and investigating the development and influences of macro-cultural discourses to field emergence across different language areas might provide a fruitful path for further research. Secondly, the relationship between individual relational embeddedness and organizational formal status as an enabler for the creation and mobilization of novel macro-cultural discourses is another interesting topic to cover. Finally, more investigation on how cultural and social movements and consumer behavior promote or inhibit the emergence of new fields would also contribute to understanding their dynamics.

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## **ESSAY IV**

### **Nanotechnology and Nanolabeling – Identity, Projected Image, and the Construction of New Organizational Forms**

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**Abstract:** This study investigates the emergence of the nanotechnology business as a potential new organizational form by exploring the interplay between form identity and organizational identity in form emergence. By drawing on both ecological and constructionist literature the study aims to create further understanding of the origins of form level identity notions, and to investigate the processes through which such identity notions influence form emergence in nanotechnology business. The study draws on 25 interviews with top managers of 22 nanotechnology companies in Northern Europe and the US as well as from the analysis of their websites and nanotechnology business directories. Nanotechnology is characterized by two important contextual factors: a major demand for the nanolabel due to an “armaments race” between different nations, as well as a great ambiguity of the boundaries of nanotechnology for both internal and external observers. Such factors have resulted in business managers being able to successfully signal nanotechnology even though their core technologies or activities are not in line with the widely accepted definition of nanotechnology. The study indicates that the initial business activity, in novel forms with high rewards for participation, is largely a result of labeling activities and transmutations, where existing practices and identities are provided with new meaning and content.

**Keywords:** Labeling, image, identity, nanotechnology

## 1. INTRODUCTION

We have been laughing that this current nanowave [...] is like a tsunami has hit over us, and we have to run somewhere safe. [...] this nanowave is very strong. In every country and city you have local nanoinitiatives. – *Interview with a physicist, and a pioneer of nanotechnology*

The above excerpt from an interview conducted for the current study represents the “armament race” in funding and activities for nanotechnology between different countries and regions. Indeed, nanotechnology has been the centre of major attention and interest by governments, researchers and businesses alike ever since the millennium, when it became established as a strategic focus area for the EU, Japan and the US. Such priority statements became manifested through competing budgets and comparative statistics, which resulted in the demand for activity in nanotechnology. Consequently, various actors had major incentives to be associated with the field: to access funding, to establish a reputation of being at the forefront of the technological innovation, and to gain visibility in local and

global media. As a result of such drivers of nanotechnology, the reported activity in the field in both research and business has grown tremendously since the late 1990s.

The current study focuses on investigating the emergence of the nanotechnology business as a potential new organizational form resulting from the above described incentives. The study contributes to the ongoing investigation into the birth of new organizational forms, which has gained increasing interest among management scholars during recent years. More specifically, the study focuses on the interplay between form identity and organizational identity in form membership, as these notions are considered central to the emergence and development of novel forms in the extant literature. Hsu and Hannan (2005) define an organizational form as a named category to which an audience applies membership standards. Form is subcategory of a field, i.e. “those organizations that, in the aggregate, constitute a recognized area of institutional life: key suppliers, resource and product consumers, regulatory agencies, and other organizations that produce similar services or products” (DiMaggio & Powell, 1983: 143). Hence, an organizational field typically consists of many organizational forms (Scott, 2001). Previous ecological studies establish that identity is a main signifier of being a member of a form (Ruef, 2000; McKendrick & Carroll, 2001; Pólos et al., 2002; McKendrick et al., 2003; Hsu & Hannan, 2005), and that identity can be “usefully regarded as codes (or rules) that audience members hold as defaults for organization” (Hsu & Hannan, 2005: 476). Further, McKendrick et al. (2003) argue that form establishment is essentially about identity formation, and that form is an external identity code. For this reason, the perceptions and opinions of outsiders play a major role in defining the form and the form membership (McKendrick et al., 2003). However, while these studies elaborate on the consequences of identities for form emergence, they have not to any large extent investigated how both the form and organizational level identity notions emerge in the first place, and through which processes they contribute to the form emergence. This is a significant gap in the literature and in our understanding of how novel forms come into being.

This study addresses this identified gap by exploring *how externally validated form identities emerge*; and *how opportunistic actors take advantage of those identities during form emergence*. To answer the research question, the study employs the following research strategies. Firstly, the study investigates how new form identities emerge as an outcome of cognitive and discursive

framing of meaning, which are contested processes defining the boundaries of an emerging form. Such investigation arguably extends beyond the comfort zone of the ecological approaches, and therefore constructionist literature on framing and social movements is employed for this purpose. According to Rao (1998: 917), “frames are theories that justify an organizational form – an incarnation of goals, authority, technology, and clients, as dispensable, valid, and appropriate”. Consequently, the frames shape the acceptable cultural resources that the actors can draw from (also Rao, 1998), and define the range of possible identities that may be perceived as belonging to the form. To my knowledge the interrelationship between framing of meaning and form identity have not been explicitly addressed in the previous literature.

Secondly, after having established the relationship between form identity and frames, the study investigates how actors opportunistically exploit the form identity notions by signaling certain identities to external evaluators. In the previous literature on identity and image, the role of top management has been stressed in such signaling activity (Albert & Whetten, 1985; Alvesson, 1990; Gioia et al. 2000; Pratt & Foreman, 2000). Despite the focus on identity in form emergence, it may be argued that in emerging fields the “true” identity of an organization does not play as important a role as the projected image of the identity they signal (Gioia & Thomas, 1996; Gioia et al., 2000). According to Whetten et al. (1992, in Gioia et al. 2000), image represents the way in which ‘organizational elites’ would like outsiders to see the organization. Consequently, image tends to become loosely coupled with reality, and image can be affected in itself without directly affecting the identity or activities of a company (Alvesson, 1990). Particularly in the emerging domains of activity, management has a greater leverage to engage in the impression management activities, because “the more the ambiguity, the greater the material and perceptual space for images” (Alvesson, 1990: 391). Such behavior is beneficial, because an organization belonging to a legitimated organizational form profits from improved access to resources, more protection from authorities, and higher visibility (McKendrick et al., 2003).

Following this conceptual discussion, I present the methods used in this study. Subsequently, I describe the empirical case of nanotechnology which represents a powerful example of how opportunistic signaling behaviors of top management of organizations contribute to the emergence of commercial activity in nanotechnology. An empirical case is

conducted by analyzing the notions of identity by the firms that manifest nanotechnology, as well as considering their degree of engagement in signaling activity. The emergence and institutionalization of the field level identities and resources in nanotechnology have had a strong impact on the way in which form level activity in nanotechnology business organizations has taken shape. Finally, I discuss the findings and suggest some directions for further research.

This study has several implications for the literature investigating the role of identity in form emergence. Firstly, the study challenges and complements the ecological understandings on the role of identity in form emergence by investigating the processes that precede any such notions. The findings suggest that the cognitive frames of the external evaluators are initially shaped by field or form internally contested processes. Secondly, the study empirically challenges the existing notions of the emergence of business activity in novel science-based fields by establishing that a major part of the perceived novel business activity is a result of strategic and opportunistic impression management activities orchestrated by the top managers of form-related companies. By engaging in signaling activity, the managers also participate in the construction of nanotechnology companies as a novel organizational form. The study opens important avenues for further inquiries into the emergence of business activity in novel organizational forms.

## **2. ORIGINS AND DISSEMINATION OF FORM IDENTITY**

According to ecologists, the origins of novel form identities stem from the existing forms (Ruef, 2000; McKendrick et al., 2003). New organizational forms are considered as hybrids of the existing forms, and borrow from their legitimacy and resources (Haveman & Rao, 2006). Dobrev et al. (2006: 580) argue that “a new organizational form emerges when a set of entities possesses an identity ‘sharper than’ that of any other set of existing organizations”. Despite its potential to explain the some aspects of categorization, the ecological approach offers a limited understanding of the processes through which new form identities are born and become dominant. On the other hand, extant constructionist literature argues that identities are social constructions, which are constituted in interaction

with individual and organizational actors (Gergen & Davis, 1985; Weick, 1995; Gioia et al., 2000; Patriotta & Lanzara, 2006; Strandgaard Pedersen & Dobbin, 2006). Castells (1997: 7) describes this process in more detail:

*individuals, social groups, and societies process all these [cultural] materials, and rearrange their meaning, according to social determinations and cultural projects that are rooted in their social structure, and in their space/time framework. [...] who constructs collective identity, and for what, largely determines the symbolic content of this identity, and its meaning for those identifying with it or placing themselves outside of it.*

Consequently, collective identities, which are also form identities, are by definition constructed by multiple actors in specific social contexts in relation to some purpose and drawing from certain underlying assumptions (however, see also the views presented by Dobrev et al., 2006). Further, recent ecological theory argues that an organizational population emerges only if an audience is able to cognitively identify categorical similarities and differences within a set of organizations (Hannan et al., 2007). Again, how those cognitive categories come into being is given less attention in this approach. Recent studies on social movements and framing of meaning, on the other hand, have established that the early stage of field and form emergence is impregnated by battles of meaning between frames promoted by competing groups of actors (Rao, 1998; Granqvist & Laurila, 2007). Goffman (1974, in Benford and Snow 2000: 614) defines frames as “schemata of interpretation that enable individuals to locate, perceive, identify, and label occurrences within their life space and the world at large”. Like the construction of collective identities, the process of framing is a collective and contested process where meaning is shaped among the involved actors. As a result of the framing processes, a shared *field frame* may emerge, referring to “political constructions that provide order and meaning to fields of activity by creating a status ordering for practices that deem some practices more appropriate than others” (Lounsbury et al., 2003: 76-77). Hence, framing activities shape also the cognitive categories for external audiences to evaluate and categorize organizations. Indeed, this very framing activity, by defining the meaning and boundaries of the field or form, and eventually resulting in a dominant field frame, also defines the range of possible identities or projected images for its members.

To signal membership and associate their organizations with a form, actors employ various discursive and other strategies. Lounsbury et al. (2003) describe field frame as a component of discourse, which can be influenced through political activity. The concept could also be analytically extended to cover other social and discursive activity that result in field or form level changes of meaning. Also, McKendrick and Carroll (2001) argue that once established, a form identity becomes part of other societal institutions such as languages, directories, and public labels. Labels play an important role as signifiers of organizational forms and as differentiators between them (Hsu & Hannan, 2005). Ashforth and Humphrey (1997: 43) also contend that “labels have a profound effect on how organizational members conceive of social objects and how they act towards those objects”. Labels establish one set of discursive means for organizations to attach themselves to a form.

Further discursive links that mediate between field frames, form identities and organizational identities can be conceptualized through definitions and descriptions. Explicit definitions and descriptions, attached to certain labels, disseminate the dominant frames in a discursive form. Descriptions are able to transmit some aspects of cognitive frames across time and place. Their wordings represent some collectively accepted framing by wider audiences, but hardly exhaustively describe the frame. Rao (1998) stresses the role of opportunistic agents in form emergence as the constructors of resources from prevalent cultural materials, which labels and descriptions also represent. Through rhetoric and labels, top managers are able to signal the identity of their organization to external parties, and to borrow from the label’s legitimacy and embedded meanings. Such activity also contributes to embedding the form and the label in discourses, which become institutionalized (Phillips et al., 2004), and provide further cultural materials that opportunistic actors are able to exploit (Rao, 1998) while constructing their specific identities. The following section investigates in more detail signaling activities of top managers, and the implications of this activity to form emergence.



### 3. TOP MANAGEMENT, IDENTITY AND IMAGES

Ecological approaches posit that the key aspect of an identity code of an organizational form is that it is *externally* recognized and constrained by sanctions of *external* agents (Pólos et al., 2002). The very perceptions of external actors regulate how the form identities emerge and persist (McKendrick et al., 2003). Within these actors McKendrick et al. (2003) include financial analysts, bankers, suppliers, distributors, potential employees and customers; but also governmental level actors and regulatory agents form part of this group. McKendrick et al. (2003) further stress that such perceptually focused identities aim to identify some common features across potential form members. These statements leave room to argue that organizations, simply by plausibly signaling a certain identity, may gain the benefits of being associated with a form. This may be true especially during the form emergence, which is characterized by ambiguity over what the form is about and what the 'rules' are of being part of the form.

From an individual or organizational point of view, success and status are closely linked to the actors' abilities to construct and draw from identities that are regarded and rewarded by others (Schlenker, 1995). During form emergence, through the contestation of frames, certain labels or symbols become more popular than others, and rewards become associated with them. As a consequence, various organizations consider it as strategically beneficial to claim these labels and adopt certain discourses to establish a perceived relationship between their organization and the form. This identity management activity is crucial to an organization's success and survival and, hence, a critical task for the top management to engage in (Pratt & Foreman, 2000). By controlling the external perceptions of an organization's identity, top management shapes an image of an organization (Bernstein, 1984). Image may be a projection of a desired status in the future, and communicates to internal and external stakeholders a vision to be achieved (Gioia & Thomas, 1996). Such a projected image is a result of impression management activities, where a socially desirable, manufactured image hides and misrepresents the actual identity of an organization by emphasizing its selected aspects (Gioia et al., 2000). Further, image is primarily transmitted through "coincidental, infrequent, superficial and/or mediated information, through mass media, public appearances, from second hand sources etc., not

through our own direct, lasting experiences and perceptions of the ‘core’ of the object” (Alvesson, 1990: 377). Such coincidental and mediated information form the components of reputation (Fombrun, 1996), which again may be decoupled from the identities shared by the organizational actors.

Consequently, external observers cannot directly evaluate the ‘true’ identity of an organization, but rather, are inclined to adopt the signaled images of organizational identity. This is especially the case when the form level identity notions are in flux. Emergent fields are characterized by an uncertainty of what the field is about and who should be included as its members, as external actors lack a comparative base for making judgments on the features of an organization. Hence, business managers have good opportunities to engage in the strategic labeling activity. They can merely signal that their companies are active in the domain by projecting an image complemented with activities that support the image. For this reason, the emergence of a novel field or form may begin with the emergence of *an image* of the form projected by a multitude of organizations, which have varying levels of attachment to the form.

Further, according to Ashforth and Humphrey (1997: 54), “by projecting desirable labels an organization stakes a claim to a status that might be difficult [and risky] to establish by other means”. Once an organization has gained a status as a form member, the audience applies the membership standard to it as a default (Hsu & Hannan, 2005). Being a member of a novel form may provide access to invaluable resources, which further encourages the top management of organizations to engage in labeling activity. Business managers also have a strong potential to influence the discourse and the emerging patterns of meaning and action in an emerging form. This is especially the case when there is a strong demand for the label due to field or governmental level pressures, as is the case for nanotechnology in industrialized countries. In the longer run, these processes may result in shared identities and common meaning systems and goals.

Owing to firms’ systematic efforts to affect impressions (Alvesson, 1990), intentional and opportunistic image building and signaling is also likely to have an important impact on how novel institutions and organizational forms emerge. The availability and adoption of labels that communicate categorical classifications facilitate their institutionalization as a

cognitive category (Hsu & Hannan, 2005), an argument similar to Phillips et al. (2004). Strong macro-cultural acceptance around a label may turn it into a movement, where “meaning-making, the mobilization of collective action, and the construction of social identity are intertwined” (Creed et al., 2002, 479). In line with these notions, the study argues that by being involved in labeling activities in novel fields, top managers both validate and participate in the institutionalization of labels and emergent cognitive categories.

Following this conceptual discussion, I present a detailed analysis of the means through which firms manifesting nanotechnology draw from the existing understandings and meanings of nanotechnology, and establish a position which is aligned with the expectations these frames of action induce. In this account, I focus on top management level perceptions, on their identities, or non-identities, as nanotechnology companies, and their activities to endorse the association of their organizations with nanotechnology. However, prior to this, the data collection and data analysis methods are presented in detail.

## **4. METHODOLOGY**

### **4.1 Research context**

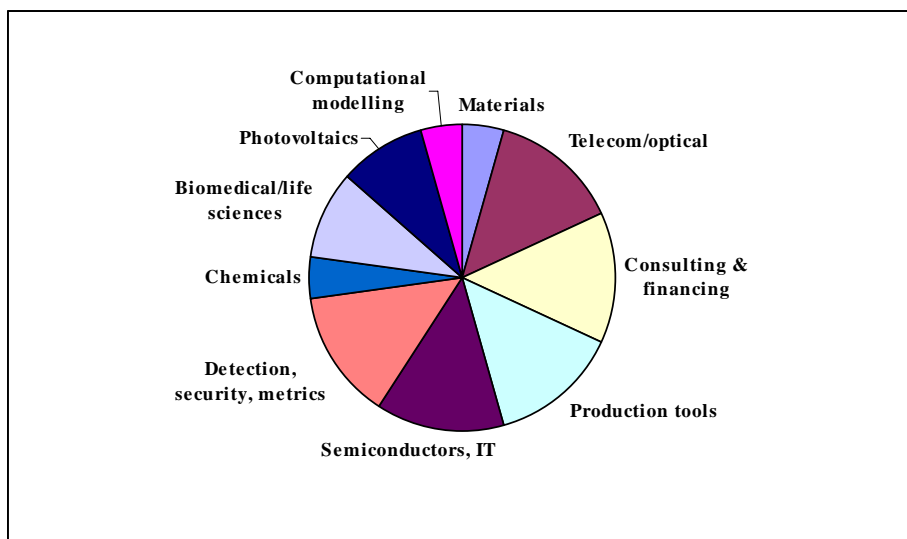
Nanotechnology provides an interesting context in which to investigate the birth of business activity in novel fields, because it is technologically emergent but yet an institutionally established domain of activity. The broadly accepted definition of nanotechnology is one where the dimension of operations takes place on the size scale between 1-100 nanometers (European Commission, 2004; President's Council of Advisors in Science and Technology, 2005). However, such definition still leaves room for ambiguity on what can be regarded as nanotechnology and what should be excluded, as will be discussed in greater detail in Section 4.1. Nanotechnology draws from both the scientific development of various technologies and tools, but also from the emergence, dissemination and popularization of the very concept itself. The concept does not refer to a homogenous set of science and technology; rather, it is used as an umbrella concept, under

which various organizations position their activities, which take place in nano or a ‘near nano’ size scale. As a result of such incentives, nanotechnology has become strongly institutionalized in society, forming part of languages, directories and labels, and has been institutionalized in a variety of national and interregional programs.

Although nanotechnology is still largely in basic and applied research, a myriad of ‘nanotechnology companies’ have surfaced during recent years. However, these companies tend to have their primary industries elsewhere, meaning that involved organizations engage in their respective industries, and in addition to that they are associated with nanotechnology. This infers that nanotechnology is too young and not yet established or definite enough as a field to be the only reference base for most organizations. Over a future period of time, the recent focus on nanotechnology may result in the surfacing of a more coherent and unified field of nanotechnology and emergence of further field-specific resources and shared identities. However, to date nanotechnology remains, at least, as an ambiguous domain of action. As a consequence, nanotechnology business represents a potential new organizational form rather than an established and definite form (cf. McKendrick et al., 2003).

## 4.2 Data collection

***Sampling the companies.*** The study draws from 25 interviews of top managers from 22 nanotechnology companies. Of the interviewees, 15 informants, representing 13 companies, are from Northern Europe (Finland, Sweden and Denmark, all technologically and institutionally advanced countries in nanotechnology), and 10 informants, from 9 companies, are from the San Francisco Bay Area of the US. Of the firms, 18 were chosen by the recommendation of well-connected individuals representing public administration or research in each region, and 4 were selected from web-based nanotechnology company directories (see below). Membership in the nanotechnology directories is based on the self-assessment of the actors, and establishes what the actors want to signal to external audiences. Hence, the selection of the companies drew heavily on their reputation as well as their projected image as nanotechnology companies. Figure 1 presents the distribution of companies by their target industries.



**Figure 1:** Distribution of the companies by target industries

**Interviews and websites.** After having identified the companies, their top managers were contacted and asked for an interview. In the end, of the informants, 88% (or 22) represented the top management of the companies holding titles such as CEO, CTO, VP and managing director. The remaining 12% (3) had the title of manager, project coordinator or founder. Semi-structured exploratory interviews permitted me to cover a pattern of questions, but also allowed the informants to influence the direction of the interviews. In each interview, the informants were asked to describe *what is new and significant in nanotechnology from their point of view* and *to explain their core technologies and activities related to nanotechnology*. This provided an understanding of the technologies and the context in which the top management was embedded. The interviews lasted an average of 54 minutes. All the interviews were recorded and transcribed verbatim with the exception of one, where extensive notes were taken.

In addition, data consisting of the content of the companies' websites was examined. Websites are a powerful tool for firms to manage their external image and to inform about their activities. Analysis of the website content helped to reveal what the companies aim to signal to interested external parties. For each company the following websites were examined: Homepage; Company or About us; and Products or Services or Technology. All

these three websites were present in 81 % of the company websites, and all the companies had at least their home page in the Internet. Finally, the companies' presence on three Internet-based nanotechnology directories was examined: [www.nanovip.com], [www.nanotechwire.com], and [www.nanotechnology.com]. Being listed on these websites is yet another means for the companies to signal their participation in nanotechnology. The directories function as a reference base for interested external parties, and hence, shape the perceptions of the nanotechnology business. The results of this analysis are presented in the empirical description.

***Secondary data sets.*** The study forms a part of a larger whole with altogether 54 interviews (37 in Northern Europe, 17 in California) of informants from the following groups: researchers, representatives of different types of nanotechnology companies, and representatives of public funding agencies and lobbying organizations. The interviews took place between November 2004 and May 2006. The interviews in each region typically started with a meeting with the representatives of public administration and researchers, who suggested the suitable informants. These interviews lasted an average of 70 minutes, and they were transcribed verbatim.

Further, I have gathered publicly available data on nanotechnology since August 2004, including books and book chapters, academic research publications, professional journal articles, and a variety of reports as well as newspaper and magazine articles. I have also participated in many seminars, conferences, workshops and networking events to gain understanding of this complex emerging field. Also, non-publicly available data such as presentations and reports were received during the course of the interviews, which gave further insights to the emergence of business activity in nanotechnology.

### **4.3 Data analysis**

Qualitative, interpretive methods are especially suitable when the aim is to explore the emergence of new domains of social reality (see also Lee, 1991). The aim of the grounded analysis (Glaser & Strauss, 1967; Charmaz, 1983) was to investigate the emergence of identity notions in the context of novel organizational forms. The data analysis all through the study has followed what Dubois and Gadde (2002) call systematic combining: I have

made several forays into the data and then consulted the literature regarding the potential meaning and interpretations of the observed phenomena. Hence, the theoretical framework, and the empirical framework and analysis have coevolved hand in hand (Dubois & Gadde, 2002). Data analysis had started already while conducting the interviews as an iterative and partly subconscious process of categorizing data and finding commonalities. Eisenhardt (1989) suggests that overlapping data analysis and data collection allow the researcher to be flexible during the data collection and make adjustments accordingly. The learning during the data collection period was also reflected in the attitudes and the repertoire of supplementary questions of the researcher during the interviews. The second round of immersion took place while transcribing the interviews, which provided further familiarization with the data and contributed to the identification of the emergent categories.

As the company data form part of a larger whole, the actual data analysis was conducted in two rounds. Firstly, all 54 interviews were coded using computer assisted software. The interview data was categorized during some two and one-third rounds of analysis into emergent categories. This initial round of analysis of all the interview data was crucial for the later analysis, because it formed a strong base for understandings and interpretations of nanotechnology. Thereafter, a further two rounds of analysis of the subset of the data for the current study, i.e. the top management interviews, were conducted. From this data, categories emerged representing the perceptions, uses, drivers and challenges of nanotechnology. The interrelationships between, and the significance of, the categories was investigated carefully. However, by far the most loaded category was that related to the discursive nature of nanotechnology, which described the ways in which various actors benefited from and exploited the emergence of the very label of nanotechnology. The current study focused on the further analysis of this overarching theme in the context of nanotechnology businesses.

Already during the interviews, and more so during the data analysis, it became obvious that the interviewed 'nanotechnology companies' had different levels of involvement with nanotechnology. The level of involvement was identified from the top management accounts of their core technologies and their own perceptions on whether what they do is actually nanotechnology or not. The interview data were triangulated with other sources of

data, which helped to reveal whether their technology actually fitted the broadly accepted definition of nanotechnology as the size scale of between 1-100 nanometers. The analysis revealed that of the 22 companies manifesting themselves as nanotechnology firms, 11 were *quasi nanotechnology* and only 11 *true nanotechnology* firms. In the following section, the reasons for and implications of this claiming of nanotechnology label are discussed in more detail.

***Analysis of websites.*** The selected pages of company websites as described above were analyzed by rating each company with a number from 1 to 4. When the website presented no reference to nanotechnology at all, 1 was assigned to the company; number 2 was assigned to the company when one, very few or only subtle references were made to the nano size scale, for example a reference to nanometers; 3 was employed when websites had abundant explicit references to nanotechnology, but nanotechnology was not described as the main driver of the company and was not present in its mission statement presented on the website; and 4 was employed when nanotechnology was used as the core concept to define the company's technologies and missions. In the analysis, 1 and 2 were categorized as not signaling nanotechnology on the website; and 3 and 4 referred to the presence of signaling on the company website.

Inconclusive evidence was found regarding the signaling of nanotechnology on the company websites which contrasted with the basic assumptions of the study. Of the quasi nanotechnology companies only 55%, and of the true nanotechnology companies 64%, signaled nanotechnology on their websites. The reasons for this are elaborated in the next section by looking closer into the type and nature of the companies in question.

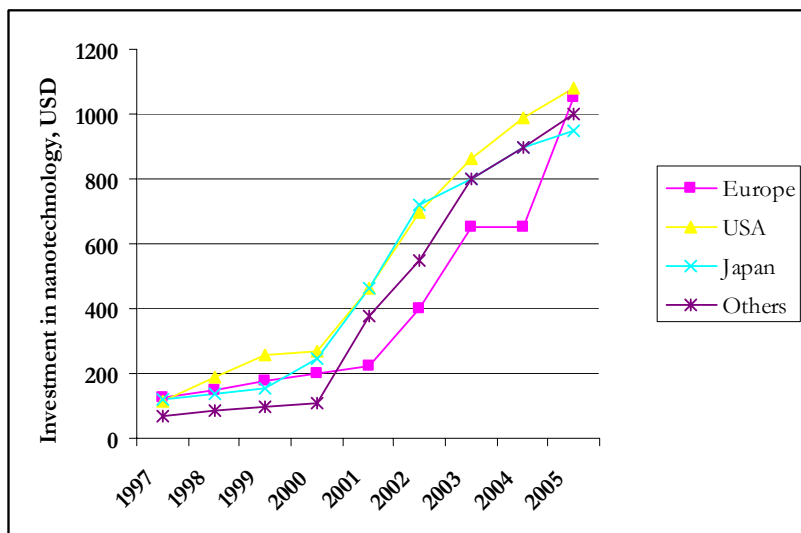
## **5. LABELING ACTIVITY OF NANOTECHNOLOGY FIRMS**

### **5.1 Field level drivers of nanotechnology labeling: definitions and frames**

As described above, owing to the major interest and investments into nanotechnology by the European Union, Japan and the US alike (see Figure 2), a demand for the activity in nanotechnology has emerged since the late 1990s. This strong focus and attention to the



field have created a sense of urgency to create return on the invested public and private capital. Consequently, there is an overall public pressure to move nanotechnology from science to commercial applications. Owing to the incentives to collect data on the nanotechnology business, thousands of nanotechnology firms worldwide have been identified by various public and private organizations. This data has been used in cross-governmental rankings and comparisons of local activities. The definition of nanotechnology adopted in the EU and US, i.e. referring to one dimension of operations taking place on the size scale between 1-100 nanometers (European Commission, 2004; President's Council of Advisors in Science and Technology, 2005), has had an impact on which firms have been included in the nanotechnology business category. However, the overall publicity around nanotechnology, as well as the ambiguity of the concept, have contributed to the fact that when firms manifest nanotechnology, governments, the wider public and the media are eager to accept such examples. This has resulted in bundling 'small' (micro) and 'even smaller' (nano) under the umbrella expression of 'nanotechnology', as revealed by and reflected by the collected data.



**Figure 2:** *Estimated public investments in nanotechnology (Source: President's Council of Advisors in Science and Technology, 2005)*

Further, though the definition for nanotechnology as a size scale may be very useful and apparently clear-cut, very large parts of some existing industries, such as the chemical, pharmaceutical, biotechnology and electronics industries, fit well into this definition. This

has caused some ambiguity among researchers, governmental actors and business managers in deciding where the boundaries of nanotechnology should be drawn. Table 1 presents the National Nanotechnology Initiative formulation of the definition adopted in the US, which is very similar to the European Union formulations. The table also presents some consequences of the definition for business organizations. The broad definition of nanotechnology has given rise to ambiguity among many actors in established industries, such as the chemical industry, leaving them puzzled about the value of such an all-accommodating concept.

<b>Definition adopted for National Nanotechnology Initiative (USA, 2000)</b>	<b>Consequences of the definition</b>
<p>Nanotechnology is the understanding and control of matter at dimensions of roughly 1 to 100 nanometers, where unique phenomena enable novel applications.</p> <p>Encompassing nanoscale science, engineering and technology, nanotechnology involves imaging, measuring, modeling, and manipulating matter at this length scale.</p>	<p>Such a definition is adopted that it covers all the topics on earth from love-making of elephants to ship building, everything fits in. That is beneficial to no one. This has taken place even in the European Union level. Nanotechnology has too wide a definition  <i>– Chief Scientist of a consumer electronics MNC (quasi nano)</i></p> <p>In chemistry, what is nano? It doesn't really make sense in chemistry because everything is nano. If you think about atoms, it is nano. If you make an organic molecule, you can say it is nanotechnology. We put hydrogen atom here rather than here, it is nanotechnology. But chemists don't think of it as nanotechnology. [...] Five years ago that was biotechnology, everything had to be biotechnology. Of course we didn't like that because we don't do anything which has to do with bio. It is much better now, but the problem is that biotechnology is relatively well-defined and nanotechnology is not defined that well.  <i>– Chief scientist of a chemical MNC (true nano)</i></p>

**Table 1:** *Definition of nanotechnology and its consequences for business actors*

As will be presented later in this study and has already been discussed in the conceptual section, the definition is not the only way for the external evaluators to define what companies should form part of the nanotechnology business category. Cognitive frames regulate what is perceived as belonging to the form. Table 2 presents an articulation of important components of the nanotechnology frame identified in a previous study (Granqvist & Laurila, 2007) and some of its consequences for the involved organizations. Granqvist and Laurila (2007), in their study on the emergence of, and competition between, different nanotechnology frames promoted by various protagonists, establish that there is an important duality present in the currently dominant nanotechnology frame. On

the one hand, it includes the definition of nanotechnology as the mere size scale. This represents the view promoted by the US scientists in their attempts to gain access and to create novel resources for physical sciences and engineering in the late 1990s. Similar activity has also taken place in the European Union context. On the other hand, the Drexlerian understandings of nanotechnology are also present in this frame. Eric Drexler, a futurist and the initial creator of the concept, suggested that nanotechnology is the future of manufacturing, where molecular assemblers can manufacture anything synthetically, atom up through self-replication. Nanotechnologies would result in endless riches and abundance, but also great threats were associated with nanotechnology should the self-replication of assemblers get out of control. Such views became embedded in popular culture and contributed to the controversial meanings of nanotechnology and the overly positive expectations of it as a “miracle wonder technology”<sup>27</sup> shared among the wider public. These views are present in the frame of nanotechnology in that it is new, very revolutionary, hazardous, and close to science. Hence, these perceptions are also reflected upon the companies that are included in the nanotechnology category.

<b>Frame of nanotechnology, socially shared and culturally embedded understandings</b>	<b>Consequences of the frame</b>
Definition of nanotechnology as activities on the size scale of 1-100 nanometers combined with the Drexlerian ideas of self-replicating machines building anything synthetically, atom up.	<p>It suits me fine that people imagine technology as being small features on integrated circuits or microrobots, because it just means that there is a longer period of time when people, who see the world in a different way, can develop a better intellectual property position, better business position with less competition. – <i>Vice president, photovoltaics company (true nano, materials)</i></p> <p>In many cases we’ve been part of [EU project] applications, which has some nanoheading, which is of course fine with us, because it is exactly what we are interested in. But to some extent it has been, it is maybe not so... You should say what we are interested [is] not maybe as new as some others, and maybe that is why funding has been so difficult. – <i>Chief scientist of a chemical MNC (true nano)</i></p>

**Table 2:** *Frame of nanotechnology and its consequences for business actors*

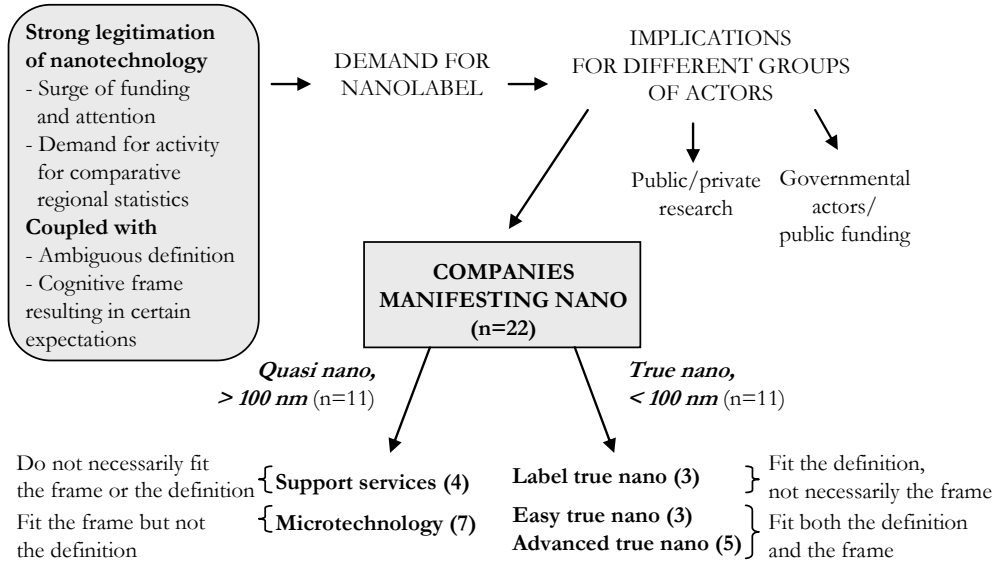
Such duality of understandings (mere size scale vs. dangerous wonder technology) has contributed to the ambiguity in the understanding of what nanotechnology is. This has

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<sup>27</sup> As phrased by an informant, a physicist

resulted in major difficulties in defining the boundaries of the field, also in reflecting upon the emerging forms such as nanotechnology business. The part of the frame of nanotechnology that suggests that it is something new, revolutionary and exciting, poses a challenge for the participation of companies in established industries, which otherwise fully match the definition. On the other hand, such a frame provides opportunities for firms that fit the frame of being radical and advanced to participate, though they would operate outside the nanometer size scale.

In the next section, I discuss these identity notions through the two identified categories of firms, *quasi nanotechnology* and *true nanotechnology*. I elaborate the reasons for and the strategies of the top management to signal nanotechnology in each category. While the formal definition of nanotechnology as a size scale has been employed to distribute the companies into these two categories, the understandings related to the nanotechnology frame are investigated within and across both categories of companies. Figure 3 presents the empirical framework for the categorization and nature of the companies present in the study.



**Figure 3:** Categorization of the companies present in the study

## 5.2 Quasi nanotechnology

Of the 22 companies present in the study, 11 companies were identified as ‘quasi nanotechnology’ firms. Though associated with the field, these companies fail to match the size-driven definition of nanotechnology. As discussed above, of the quasi nanotechnology companies 55%, or 6, did and 45%, or 5 companies, did not signal nanotechnology on their websites. The reasons for this are elaborated further in this section by examining more closely the nature of the companies. Table 3 presents more detailed information of the quasi nanotechnology firms.

QUASI NANOTECHNOLOGY				Signaling nano on		Country
ID	Category	Industry	Type of company	directories	websites	
1	Support services	Consulting & financing	small and new VC	1 of 3	yes	Finland
2	Support services	Consulting & financing	small and new VC	no	no	Sweden
3	Support services	Consulting & financing	established VC	1 of 3	yes	USA
4	Support services	Computational modeling	technology start-up	3 of 3	yes	USA
5	Microtechnology	Telecom/optical	MNC	no	no	Finland
6	Microtechnology	Telecom/optical	university spin off	no	no	Finland
7	Microtechnology	Telecom/optical	university spin off	2 of 3	yes	Finland
8	Microtechnology	Production tools	MNC	2 of 3	no	USA
9	Microtechnology	Production tools	MNC	2 of 3	no	USA
10	Microtechnology	Semiconductors/IT	university spin off	2 of 3	yes	Denmark
11	Microtechnology	Detection, security, metrics	university spin off	2 of 3	yes	Denmark

**Table 3:** Information of the quasi nanotechnology firms

In a closer investigation of the nature of the quasi nanotechnology firms I identified two further subcategories. Three of the quasi nanotechnology firms were consulting and financing companies and one was a company specializing in the computer modeling of atomic and molecular structures. Given their activities, I label these four firms as *support services firms*. The managers of financing and consulting firms had a commercial rather than scientific background with previous experience on the commercialization of new technologies predominantly from the ICT sector. However, these firms had grasped an opportunity to become involved with this novel field of activity by focusing part or all of their activities on nanotechnology. The computer modeling companies, on the other hand, tend to draw from both scientific and computing skills, but like consulting and financing, these skills can also be positioned to various domains of activity. The support services

firms do not necessarily fit the definition or the frame of nanotechnology, but they are expected to have special knowledge on nanotechnology and to act as service providers for the other involved organizations. Also, these companies actively signal an image of themselves as nanotechnology businesses, and hence, participate in the construction of the nanotechnology business as an organizational form. Three out of the four support services firms signaled nanotechnology on their websites. The one that did not had an overall limited presence in the Internet, and was not present either in any of the nanotechnology directories.

The remaining seven quasi nanotechnology firms could be characterized rather as *microtechnology* than nanotechnology firms as they are engaged in the micron scale structures. These firms may have some aspect of their activity in nanoscale; for example their devices may measure nanoscale changes, or they are able to produce layers that are nanometers thick. However, their core competence and technologies as such unarguably reach the micron scale (also according to the informants) and hence, these companies also fall outside the size-scale driven definition of nanotechnology. Nevertheless, these companies fit the frame of nanotechnology as novel, radical, innovative, and close to research. All the firms in this category are engaged with new technologies, which are likely to have an important impact on the existing industries. Four out of the seven firms are newly established science-based companies, and three of these companies signal nanotechnology on their website. Enforcing their association to nanotechnology had increased their chances of access to funding and other resources that are associated with nanotechnology, such as reputation and media coverage. The remaining firm, still in the incubation phase, focuses on a narrow customer base. In its core business, nanotechnology plays no role, and the company website and the lack of presence in any of the nanotechnology directories reflect this. However, the company endorses and benefits from the association to nanotechnology in its local incubation environment.

The remaining three firms in the microtechnology subcategory are established multinational companies (MNCs) with some R&D activities in domains which are relevant to nanotechnology. None of these companies signaled nanotechnology on their websites. This is because these large established companies have primary identities in their established industries, and the image they like to signal to external parties is necessarily in

alignment with those primary industries. These companies have also become drawn to the 'nanotechnology movement' as visible and legitimate examples of the nanotechnology business. Two of the three MNCs were also listed in the nanotechnology directories though they would not otherwise actively endorse the connection to nanotechnology. Due to the presence of such established and well-known companies, this association has contributed to legitimating the nanotechnology business as a novel organizational form.

Common for all companies in this category is that despite the quasi nanotechnology companies failing to fit the size-driven definition for nanotechnology, they develop or deliver products and services for new or emerging markets, and some aspect of their operations takes place on a small size scale. The ambiguity present in the nanotechnology business form has enabled the quasi nanotechnology companies to build or draw from an image as nanotechnology companies. Table 4 presents some illustrative quotations of their top managers regarding the external demand for nanotechnology and the resulting shifts in the labels and identity. The reasons for the nanolabeling for quasi nanotechnology firms, as identified by the informants, are related to the demand for the label. Firstly, because people like to hear it, and secondly, because there are so few nanotechnology companies that even remotely related ones are included in the category by external evaluators. These statements show that the overall demand for the nanotechnology label has enabled these firms to climb on the bandwagon. A further reason for the adoption of the nano-label was related to the strategic positioning and differentiation from technologically less advanced competitors. Overall, during the interviews many references were made for various actors in the business community using nanotechnology as a synonym for 'advanced'.

The analysis of the company websites and three Internet directories showed that established firms signaled less nanotechnology than novel growth firms did. Established firms have less incentive to do so due to their position and identities in their existing markets, whereas growth firms have various incentives to climb on the nano-bandwagon to gain access to the resources it has to offer. Similar results were also found for the firms in the true nanotechnology category and will be discussed in more detail in the end of the next section.

<b>EXTERNAL DEMAND FOR NANOTECHNOLOGY LABEL</b>	
<b>Quasi nanotechnology</b>	<p>We are claiming nano, just because people want to hear that. – <i>CTO of a sensor start-up</i></p> <p>I think because there are so few start-up nanotech companies we are called a nanotech company. [...] amongst our customers it doesn't make sense because they all are working on the same scale we are. We don't go around saying to each other: "oh, we are working in nano!" – <i>CEO of a chip designer company</i></p>
<b>True nanotechnology</b>	<p>[<i>Question about the reasons why the company is labeled as nanotechnology company</i>] Um I think we got lucky [laughter]. Everybody in the industry does this. – <i>Manager of a pharmaceutical MNC</i></p> <p>You can say that we have been, without knowing it by ourselves, one of the leading companies in nanotechnology. – <i>CTO of a medical diagnostics company</i></p>
<b>SHIFTS IN THE LABELS AND IDENTITY</b>	
<b>Quasi nanotechnology</b>	<p>In the late 1990s, the concept micro-optics became suddenly very popular, and that was clearly because it was commercially interesting. There was the problem that [...] when you went into an optics exhibition, there may have been up to 10 firms in the category 'micro-optics', but when you took a closer look, it wasn't that at all. So at some stage we thought that we should label what we do as 'true micro optics', because our production technology is completely different from how you produce traditional optical components. [...] We wanted to distinguish ourselves from that. [...] If someone, who according to our standards makes millimeter optics, and says that they do micro-optics, then we can label what we do as nano-optics. – <i>CEO of an optical components company</i></p> <p>Nanotechnology has existed for ages. I was first time concretely involved with it in 1983. [...] According to webanalyses [...] an amazing amount of nanotechnology firms have been established, the explosion of the use of nano-word. It doesn't reflect at all how the activities in this domain have evolved. Old companies have adopted nano-label, or the name of the company has changed, or they have new nano departments. Before they called their technology with another name, and now they have added that with nano. – <i>Chief Scientist of a consumer electronics MNC</i></p>
<b>True nanotechnology</b>	<p>Actually we are very different from some of the other nanotechnology companies in that we are a 50 year old company and have been doing this kind of products for 50 years. [...] you just do what you do, and then recently, within the last 10 years of course nanotechnology has come up as a separate field of research and business and then we could say that that is exactly what we do. [...] And that is actually the way it has come into the company. So we still do more or less the same things that we always have done, but now we got a new name, which doesn't really matter for us, but then the good thing for us is that now there is all this focus on nanotechnology at the universities, in the public funding sector. It is easier for us to collaborate with the universities and to get funding for some of the things we do. – <i>Chief scientist of a chemical MNC</i></p> <p>While our name is [Nanocompany], and our email is [www.nanocompany.com], we are excited about some of the publicity and enthusiasm and in some cases hype that nanotech can generate. [...] I think it has been an advantage in terms of profile and sort of separating us from a lot of other companies that are out there. – <i>Vice president of a sensor start-up</i></p> <p>When we invented this in 1992, we never referred to it as nanotechnology. Only when we founded [Company] and looked for a more sexy name for this technology, we named it [Advanced Nanoparticle Layering Method], and that way entered the nanoworld. – <i>CEO of a materials start-up</i></p>

**Table 4:** Views of top managers regarding the drivers and consequences of nanolabeling



### 5.3 True nanotechnology

Of the 22 firms present in the study, I identified 11 firms as ‘true nanotechnology’ companies. Of these companies 64%, or 7, signaled nanotechnology on their websites whereas 27%, or 3 companies, did not. Table 4 presents illustrative quotations related to relabeling and repositioning also for this category of companies. Table 5 presents the subcategories of the true nanotechnology firms.

TRUE NANOTECHNOLOGY				Signaling nano on		Country
ID	Category	Industry	Type of company	directories	websites	
12	Label true nanotech	Biomedical/life sciences	large, established	no	no	Finland
13	Label true nanotech	Biomedical/life sciences	MNC	1 of 3	no	USA
14	Label true nanotech	Chemicals	MNC	2 of 3	no	Denmark
15	Easy true nanotech	Photovoltaics	technology start-up	3 of 3	yes	USA
16	Easy true nanotech	Photovoltaics	university spin off	2 of 3	yes	USA
17	Easy true nanotech	Materials	university spin off	1 of 3	yes	Finland
18	Advanced true nanotech	Semiconductors/IT	university spin off	no	yes	Sweden
19	Advanced true nanotech	Semiconductors/IT	university spin off	1 of 3	yes	USA
20	Advanced true nanotech	Detection, security, metrics	university spin off	2 of 3	n.a.	Finland
21	Advanced true nanotech	Detection, security, metrics	university spin off	3 of 3	yes	USA
22	Advanced true nanotech	Production tools	medium-sized, established	2 of 3	yes	Sweden

**Table 5:** Information of the true nanotechnology firms

Three of the companies in this category are established chemical and pharmaceutical companies, which are almost by definition engaged in the nanometer size scale activities. However, although they have been active in this work for many years, not until recently have they been drawn into the domain of nanotechnology simply by doing what they have been doing previously. I describe these companies as *label true nanotechnology*. The association of these companies to the nano-label has been driven by the need of external parties to identify and represent the well known firms belonging to the domain of activity so as to further legitimate the nanotechnology business. None of these three companies actively signals nanotechnology on their websites, but two of them are present in the nanotechnology directories. Again, similarly to the established companies in the quasi nanotechnology category, these firms rather identify themselves with their established industries. As illustrated by the quotations in Table 4, these companies have, however, benefited from the major demand for the nano-label. This has allowed the companies to be

associated with such a novel field, which may have refreshed their image, and provided them with access to public funding and to develop collaborative relationships with universities. This has required the companies to develop secondary identities and images for specific purposes, such as gaining media attention or participating in publicly funded technology programs.

Though the established organizations in the existing industries fit the definition of nanotechnology, they may not fit the frame of nanotechnology as novel, exciting or revolutionary. The case in point presented in Table 2 is that of a chemical company, which by definition is engaged in nanosized structures and molecules, but suffers from that the frame of nanotechnology is seen as something new and radical, which their offering necessarily is not. Some industries have an image that is less of a burden for the companies wanting to be associated with nanotechnology, such as pharmaceuticals and biotechnology. Nanolabeling of some established pharmaceutical companies may be merely a result of a chance, as stated by one informant (Table 4). For another pharmaceutical company the demand for the label has resulted in a shift in their organizational identity, where the managers have come to realize that they are a nanotechnology company just by doing what they have been doing for a long while. In cultural theory this is referred to as transmutation, where existing forms and practices are provided with new meaning and content (Strandgaard Pedersen & Dobbin, 2006). Many quotes in Table 4 provide examples of transmutations of companies' activities.

Three of the companies in the true nanotechnology category deal with nanoparticulate materials. They can be characterized as *easy true nanotechnology*, because although producing and manipulating nanosized particles is advanced technology, it is not necessarily very difficult or new. Examples of using nanomaterials are dyeing glass red with gold particles, which is a technique that has been used since the Middle Ages (Ratner & Ratner, 2003), or using titaniumdioxide particles in sun screens. Therefore, these companies are comparatively low tech. However, nanomaterials and their production techniques and application areas develop all the time, and some of the outcomes of using nanoparticles may have relatively profound and visible implications for some existing industries. As a result, these companies generally fit well with both the definition and the frame of nanotechnology. In the interviews their top managers stressed that nanomaterials make

using existing technologies cheaper, more efficient and easier to produce; and in general, they remove some important bottlenecks of technological innovation and have made certain applications commercially viable for the first time. However, as in the case of label true nanotechnology firms, some of these companies may have already been active in this development for a long time, and only relatively recently have labeled either the technology or the company in a way which associates it with this field of activity. This is a further example of a transmutation (Strandgaard Pedersen & Dobbin, 2006). All the companies in this subcategory signaled nanotechnology on their websites and were present in the Internet directories. Hence, the easy true nanotechnology companies are engaged in strongly manifesting nanotechnology.

Surprisingly, of the 22 companies that signaled nanotechnology, only five can be categorized by what I describe as *advanced true nanotechnology*. One of these companies is involved with developing advanced nanoscale mass production technology, two are working on carbon nanotubes, and the two remaining firms are engaged in complex quantum effects in electronics. These companies fit both the definition and the frame of nanotechnology: they develop technologies that are advanced, science-based and their implications for existing industries may be radical. Further, they represent the leading edge of nanotechnology, are engaged in novel research in the field, and are at a fairly early stage of their commercialization. All the true nano companies signaled nanotechnology on their website, except for one company which had its website under construction and so the data could not be accessed in its totality. Also, all the companies except one were present in the nanotechnology directories. For these companies it is natural and highly beneficial to adopt the nanolabel to describe their activities, since it is the focus of their research and development activities, and their products draw from nanotechnologies. In the interviews the top manager of all the *true nanotechnology* companies stressed nanotechnology as the most important technological driver for the firm. Nanotechnology was perceived as a way to make something cheaper, more efficient, faster, or even possible in the first place. The actors were nanotechnology driven, but they also stressed the role of nanotechnology as a way to manage images and gain attention.

To conclude, across both categories of 'nanotechnology companies' none of the incumbent firms associated with nanotechnology did signal it on the main pages of their websites,

whether they actually fitted the size-driven definition of nanotechnology or not. On the other hand, of the technology start-ups or university spin-off companies with websites all but one, or 92%, signaled nanotechnology on their websites. In this distinction it did not matter whether or not they were a quasi or true nanotechnology firm, which implies that the true identity of the organizations had little impact on how they signaled themselves as nanotechnology companies. The driver from signaling rather tended to be the opportunity and potential for gain. Smaller firms had more to win through this association by accessing the vast resources available for nanotechnology firms, whereas incumbents were mostly 'piggybacking' on nanotechnology identities. All these companies also constructed nanotechnology as a field of activity. The presented empirical evidence is reflected with the conceptual discussion in the next section.

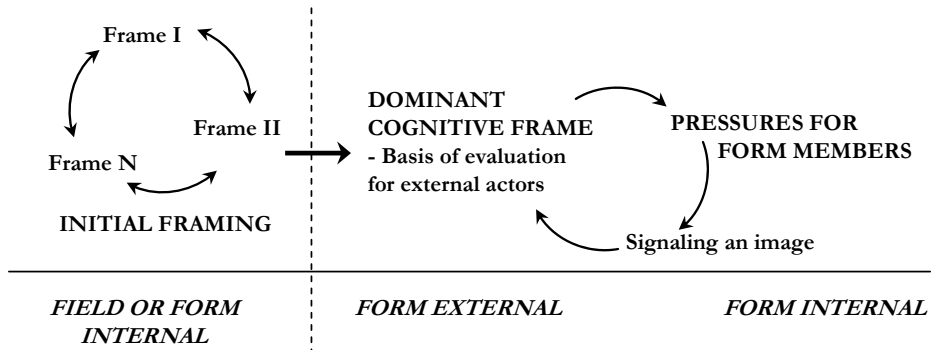
## **6. DISCUSSION**

The study aimed to answer the two research questions: *How did externally validated form identities emerge?*; and *How did opportunistic actors take advantage of these identities during form emergence?* This section presents some findings for these research questions and elaborates the theoretical contributions of the study.

### ***6.1 Origins of externally validated form identities in the nanotechnology business***

The first research question investigated the notions presented in the previous literature on organizational and form identities and, hence, it was mostly addressed in the conceptual section of the paper. However, the empirical part of the paper also provides some implications for this question, which are presented below. Extant ecological research stresses that the key aspect of an organizational form is a shared identity code, which is externally recognized and constrained by the sanctions of the external agents (e.g. Pólos et al., 2002; McKendrick et al., 2003; e.g. Hsu & Hannan, 2005). Nevertheless, this approach gives few implications for the origins of the form identities. The current study deepens the notion of form identity, and shows that these identity notions are initially shaped in the processes of framing of meaning, characterized by contestation of various interpretations by different actors of what a form should be about. Framing, hence, shapes the range of

possible identities for the actors in the fields. Further, a previous study on the framing of nanotechnology establishes that the initial framing of meaning was a field level process, where predominantly only interested and involved actors took part (Granqvist & Laurila, 2007). The framing processes resulted in more widely disseminating discourses and labels mediated by, for example, media and public hearings and presentations, which then shaped the initial cognitive schemata of evaluation of nanotechnology for the involved actors (Granqvist & Laurila, 2007), and also for external evaluators.



**Figure 4:** *Origin and impact of form level identity notions*

Therefore, the cognitive basis of evaluation for external agents, as stressed by ecologists, is largely shaped by earlier field or form internal processes (see Figure 4). Through exposure to these frames, external actors gradually internalize them as cognitive schemata of evaluation and the form level identity notions come into existence and become objectified (also Berger & Luckmann, 1966). As a result of such processes, the frames begin to control and direct the actors' actions by rewarding those who fit the schemata of the external actors, and sanctioning those who are not aligned with it. Though the initial frames tend to be highly influential and persistent, the actors in the field or form, together with external evaluators, continuously structure the cognitive frames of interpretation during the later stages of field development. Indeed, cognitive identification and categorization of forms are only possible after some level of framing of meaning has taken place (Granqvist & Laurila, 2007). Consequently, the framing of meaning has significant implications for ecological studies in terms of the origins of macro-level notions of form identities and the basis of evaluation for external agents.

Extant ecological literature further stresses that the identities the organizations “possess” should be aligned with the form level identity codes. However, the current empirical study provides us with evidence that merely by signaling an identity, an organization may gain the benefits of being included into a novel field or form, and the ‘true’ identity of an organization is of less importance, especially during the form emergence. This finding is somewhat opposite to Scott (1998) and McKendrick et al. (2003), who argue that organizations with the same core features belong to the same form. However, from an external evaluator’s point of view a projected, managed image can emerge as such a core feature for categorization purposes. Hence, this notion may be reformulated so that organizations in the same emerging form are characterized by similar projected images, which signal a particular identity to the external evaluators.

## ***6.2 Actors, identities and images in nanotechnology business***

The conceptual part of this study has built an argument that the signaling activity of firms may be enough for companies to be associated with an emergent form, owing to the ambiguity of what the form should be about. Indeed, the empirical study provided evidence that validated such views. Of the 22 firms with a reputation of being nanotechnology companies that form part of this study, only 11 fitted the widely accepted definition, i.e. where one dimension of the operations takes place on the size scale between 1-100 nanometers (European Commission, 2004; President's Council of Advisors in Science and Technology, 2005). As discussed, this was driven firstly by the “armaments race” that created a favorable environment for nanolabeling; and secondly, by the ambiguity surrounding the notion of nanotechnology. The frame of nanotechnology as radical, innovative and potentially dangerous competes with the merely size-related definitions, and provides an opportunity for a certain type of organization, fitting either the frame or the definition, to climb on the bandwagon. Such tension between the frame and the definition of nanotechnology has resulted in a much broader range of companies being included in the nanotechnology business form, also from existing industries.

Another interesting and related finding, challenging some notions of the origins of business activity in novel technological fields, is that a major part of the companies included in the nanotechnology category were in existence long before the nanolabel. Just by doing the

same things as before, they became adopted under the nanotechnology banner. In cultural theory and studies of religious symbols this is referred to as transmutation, where existing practices are provided with new meaning and content (Strandgaard Pedersen & Dobbin, 2006). The empirical study suggests that a major part of the business activity in novel fields is a result of transmutation of existing companies, i.e. changed perceptions on what the companies are doing and which industries they serve. Hence, transmutations refer to a changed image for an organization, decoupled from the identity shared within the organization. For ecological approaches, where the amount of firms is stressed in the emergence of a form rather than from their visibility and impact, such a finding suggests that the signaling activity is beneficial for the establishment of a form by increasing the perceived number of the companies.

However, the results are somewhat inconclusive in what it comes to the assumption that “nanotechnology companies” engage in signaling activity. Of all the companies with websites only 62% signaled nanotechnology. A closer look at the nature of the firms revealed that of the companies that did not signal nanotechnology, 75% were multinational companies and well established firms. This suggests that the established companies signal their core industries as their primary identities, a finding similar to that of McKendrick and Carroll (2001) and McKendrick et al. (2003). Signaling nanotechnology may reflect unfavorably in and be sanctioned by the customers in their main industries. On the other hand, all but one, or 92% of the technology start-ups or university spin-off companies did signal nanotechnology. Small companies have engaged more actively in signaling nanotechnology because for them it has provided them with access to novel financial, reputational and human resources. It appears that new actors are more likely to engage in labeling early on, whereas established organizations gain fewer benefits from such action. In previous studies, the investigation of such labeling processes in emerging forms has indeed been given little attention.

## 7. CONCLUSIONS

Previous ecological studies argue that organizational identity is the key component in defining the membership in a form. However, the current study challenges and extends such a view by investigating the origins of form identity notions as well as exploring the ways in which the top managers of business organizations exploit such notions in emerging fields. The study establishes that field and form internal processes of the framing of meaning are the underlying processes behind any externally endorsed form identities. The study also challenges the identity notions suggested by ecological studies, and provides evidence that a mere signaled image may be sufficient to establish membership in a form, especially in emerging domains of activity. The special contextual factors of nanotechnology have allowed and encouraged business managers to engage in repositioning and relabeling their existing activity to gain access to novel resources. The study provides evidence that transmutations (Strandgaard Pedersen & Dobbin, 2006) of the existing firms form a major part of the business activity in novel field with high rewards for participation. By signaling nanotechnology, the business managers also contribute to the construction of a new organizational form, nanotechnology firms.

There are naturally some limitations for this study, which also suggest directions for further research. The sample of the firms was fairly small, which sets a limit for the generalizability of the results of the study. Also, the contextual factors characterizing nanotechnology are somewhat unique. A quantitative study examining a wider sample of “nanotechnology firms” would help to investigate whether the suggested distribution between *true* and *label nanotechnology* is valid. Such a study would also cast light on the origins of business activity in novel technological fields and forms in general. A further inquiry on how business managers employ the labels to gain access to the resources provided by the novel form would also deepen the understanding of the emergence of business activity in novel fields. The overall question remains whether nanotechnology companies will create a novel organizational form, or whether the firms are only opportunistically piggybacking on the label i.e. holding their primary identities and interests elsewhere (cf. McKendrick et al., 2003). A longitudinal inquiry on the development of nanotechnology business would provide answers to this issue.



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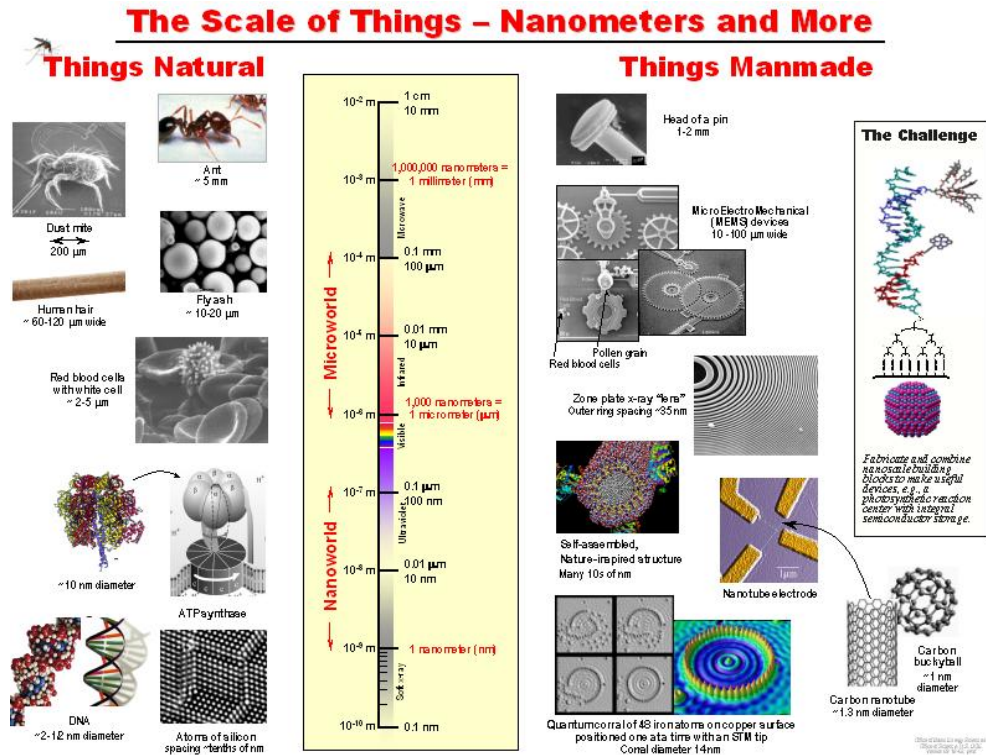
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## **APPENDICES**



# APPENDIX 1

## The Scale of Things



Source: Richard E. Smalley Institute for Nanoscale Science and Technology  
[\[http://cnst.rice.edu/nano.cfm\]](http://cnst.rice.edu/nano.cfm)

## APPENDIX 2

### **Near-, mid- and long-term areas, where nanotechnology is likely to have a major impact**

Source: US President's Council of Advisors in Science and Technology (2005: 22)

#### Near-term (1-5 years)

- Nanocomposites with greatly improved strength-to-weight ratio, toughness, and other characteristics
- Nanomembranes and filters for water purification, desalination, and other applications
- Improved catalysts with one or more orders of magnitude less precious metal
- Sensitive, selective, reliable solid-state chemical and biological sensors
- Point-of-care medical diagnostic devices
- Long-lasting rechargeable batteries

#### Mid-term (5-10 years)

- Targeted drug therapies
- Enhanced medical imaging
- High efficiency, cost effective solar cells
- Improved fuel cells
- Efficient technology for water-to-hydrogen conversion
- Carbon sequestration

#### Long-term (20+ years)

- Drug delivery through cell walls
- Molecular electronics
- All-optical information processing
- Neural prosthetics for treating paralysis, blindness, and other conditions
- Conversion of energy from thermal and chemical sources in the environment

## **APPENDIX 3**

### **Interview Protocol**

Each interview began with a brief discussion where I presented by study with a few words. I kept this introduction in a general level such as saying that I am interested in the contribution of nanotechnology in [domain of activity], and that my overall thesis aims to map the processes that led to the emergence of nanotechnology as a field of activity from different viewpoints. In this discussion I informed the interviewees about my data collection methods in general, and asked for their permission to record the interview and use the data for the study. Once we had agreed on the above issues, and I had answered any questions the informants may have had, the interview began. I typically started by asking the informants to tell about their background so as to warm up, and then moved to more specific questions regarding nanotechnology in their domain of activity. I present below some of the types of questions that I would ask during the interview.

#### **Background information**

What is your background and speciality? How about in the domain of nanotechnology?

What do you personally see as most interesting areas of nanotechnology? What is new and interesting about it?

#### **The principal question**

What is new and significant in nanotechnology from your/your [domain of activity] point of view?

#### **Themes of sub questions**

How has nanotechnology come about in [domain of activity]?

What characterizes nanotechnology in [domain of activity]?

What is truly new about nanotechnology in [domain of activity]?

What stage of development nanotechnology is currently in [domain of activity]? How advanced is this compared to other domains of activity?

Who are the central actors in [domain of activity]? What are their main contributions to nanotechnology in [domain of activity]?

What are the similarities and differences of application areas of nanotechnology between [domain of activity] and other domains of activity?



What is the role of multidisciplinary in nanotechnology in [domain of activity] and in general?

What are your visions of the future developments of nanotechnology in [domain of activity] and in general?

What other issues on nanotechnology you find worth mentioning that have not been addressed so far?

### **Probes**

probes, such as the following, were prepared and used where appropriate to obtain rich detail:

- Can you give me an example?
- How do you feel about that?
- What do you think might have been the effect of that?

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