Means Shifting:
Creating Institutional Complexity during the Emergence of the Nanotechnology Field

STINE GRODAL
Boston University
School of Management
Boston, 02115, MA
Tel: (617) 353-5617
grodal@bu.edu

May 2013
DRAFT

Acknowledgements. I am grateful to Stephen R. Barley, Walter W. Powell, and Chip Heath. This work was supported by National Science Foundation Grant No. SES-0531146.
ABSTRACT

Organizational fields consist of multiple communities each with their own and often conflicting institutional logic. Recently scholars have addressed how field participants manage such institutional complexity, yet this literature leaves unexplored the paradox of how such complexity arise in the first place. I show that this emergence-complexity paradox can be attributed to the process of means shifting – that is the process whereby participants shift from coordinating around goals to coordinating around activities. In the early phase field coordination happens around goals and takes place collectively. However, in the later phase of the field participants shift to coordinating around activities, coordinating locally and neglecting the maintenance of the prior goals. Each of these mechanisms leads to an increase in complexity within the field as the means and the goals of the involved communities become decoupled. This research adds to our understanding of the emergence of organizational fields, theories of complexity and contributes to the emerging novel views of decoupling within organizational fields.
INTRODUCTION

Organizational fields consist of multiple communities each with their own institutional logic (DiMaggio and Powell 1983). Organizational fields therefore display a high degree of institutional complexity, that is “incompatible prescriptions from multiple institutional logics” (Greenwood, Raynard et al. 2011 p. 317). For example, Jones et al. (2012) show that the field of modern architecture evolved by communities with different institutional logics shaping the values and material practices that architects espouse. Institutional logic are “the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality” (Thornton and Ocasio 1999 p. 804). Institutional logics provide participants both with large organizing principles, which drive their goals, as well as means-ends designations, which guide the exact actions that they take in order to achieve those goals (Friedland and Alford, 1991). Institutional logics can be held at the level of the community, where community members share similar belief systems. Each community thus approach the field from different vantage points (Smets, Morris et al. 2012; Thornton, Ocacio et al. 2012).

The existence of multiple communities within organizational fields each of which adhere to a different institutional logics creates complexity within fields (Zilber 2012). Institutional logics may compete because the demands that they impose are not easily reconciled. In particular, the imposed demands might vary both with regards to the goals that different communities adhere to and the means that they employ in order to reach those goals (Pache and Santos 2010). In organizational fields the complexity that is created might therefore vary either by discrepancies between the goals of the involved communities or the means that they espouse to carry out the goals.

Managing complexity is difficult (Oliver 1991; Kraatz and Block 2008). Recently scholars have show how different groups struggle to change organizational fields (Zietsma and
Lawrence 2011), retain organizational functioning (Battilana and Dorado 2010) and maintain identities (Zilber 2012) in the face of complexity. Understanding the sources of complexity is important as a high degree of complexity can lead organizational fields to fragment and decay (Pache and Santos 2010).

While the recent literature has made great strides in understanding how complexity is managed they have taken the existence of complexity as a point of departure and have thus started their studies after institutional complexity had already arisen. For example, Pache and Santos (2010, p. 461) begin with a situation in which “conflict emerges and is not resolved at the field level”. Yet, these studies do not problematize how such conflicts arise in the first place. As complexity impedes communication it is puzzling how organizational fields arise and how complexity is created. In particular, as studies of field emergence have emphasized how the creation of shared understandings among members of emerging field is essential for the emergence process (Lawrence and Phillips 2004; Maguire, Hardy et al. 2004; Weber, Heinze et al. 2008). In their study of the satellite radio industry Navis and Glynn (2010) show the efforts that satellite radio producers engage in to create a common understanding of the emerging field among stakeholders. Likewise Lounsbury, Ventresca and Hirsch (2003) show that the creation of new understanding around waste facilitated the rise of the for-profit recycling field. Together these two literatures highlight the emergence-complexity paradox: How does complexity arise within organizational fields in the first place if it is detrimental to the emergence process? The goal of this study is to address this paradox by pushing back our examination of institutional complexity to understand its infancy.

Examining five communities within the nanotechnology field I identify that institutional complexity arose due to means shifting – that is communities began to coordinate around the means for creating the field instead of the goals that the field is mean to achieve. I show that there are two phases during field emergence: goals orienting and means shifting. The phase of goals orienting is characterized by a coordination around goals that tends to
involve all the participating communities. After the involved communities have created a goal for the field participants shift towards emphasizing the means to achieve the development of the field. There are three elements to this phase: coordinating around activities, coordinating locally and goals drift.

These findings make several theoretical contributions. First, this study explains how complexity within organizational fields arises through the process of means shifting. Second, this study contributes to our understanding of the emergence of organizational fields by examining the institutional work that participants engage in, which ends up creating institutional complexity. Whereas most prior studies of field emergence and institutional complexity have focused on one or two communities only this study provides a longitudinal analysis of five communities and their interrelationship.

**COMPLEXITY WITHIN ORGANIZATIONAL FIELDS**

An organizational field is defined as “a mutual awareness that [different participating communities] are engaged in a common debate” (Hoffman 1999). Examples of communities that comprise organizational fields are scientists, entrepreneurs and government officials. Communities are defined as groups that have distinct institutional logics (Thornton, Ocacio et al. 2012). Each of these communities has their own institutional logic, which drives their actions within the field. Scientists are for example driven by a professional logic of scientific purity (Gieryn 1983), entrepreneurs are driven by a market logics, which is focused on wealth creation (Thornton 2004), and government officials are embedded in the bureaucratic state (Friedland and Alford 1991). For fields to arise these diverse communities, thus, need to recognize that they are engaged in the same issue (Hoffman 1999; Fligstein and McAdam 2012). The institutional logic of each of the communities shape both their goals and the means that that they use to pursue those goals. Pache and Santos (2010 p. 459) state that conflicting logics “may influence organizations at the ideological level, prescribing which goals are
legitimate to pursue, or they might exert pressures at the functional level, requiring organizations to adopt appropriate means or courses of action”. Yet, understanding institutional complexity within fields calls for an examination of not only the goals and the means of all the involved communities, but also of the relationship between them. Indeed, Bromley and Powell (2012) emphasize that many contemporary fields are characterized by a decoupling between the goals that communities pursues and the means that they use to pursue them.

Field Emergence and the Creation of Complexity

As fields emerge they display an increasing degree of complexity. Current studies of field emergence have focused primarily on the struggles of institutional entrepreneurs in mobilizing support for the field, the role of rhetoric in legitimizing fields, or the impact of professionalization. McGuire, Hardy and Lawrence (2004) detail, for example, the activities of institutional entrepreneurs in Canada mobilizing support for HIV/AIDS. Philips and Lawrence (2006) show how rhetoric around whales from depicting them as creatures of destruction to friendly foes aided the emergence of the Canadian whale watching industry. Likewise focusing on rhetoric, but at a more detailed level Etzioni and Ferraro (2009) emphasize how the use of analogies to financial accounting facilitated the legitimation of sustainability accounting. In a similar vein Jones et al. (2011) show the meaning construction process that went into constructing the field of modern architecture.

The actions of community members in shaping the emergence of an organizational field are evident in DiMaggio’s (1991) study of the construction of the organizational field of art museums. Multiple communities like philanthropists, museums workers, and museum visitors played a key role in the contestation over the museum reform movement, which attempted to discredit existing museums. Communities had to justify their actions on the basis of widely accepted rational myths of justice and progress to enable them to draw on legitimacy from already established fields. The participants in the museum reform movement borrowed
models from other fields by comparing museums to libraries, departments stores, or symphony orchestras, but avid contestation among the participants arose about which model was most appropriate.

Both Navis and Glynn (2010) and Kennedy (2008) show in two different industries that an important part of establishing legitimacy for a new field is to initially reference your competitors so that stakeholders begin to view the emerging field as a coherent category. Only later during the evolution of the field ought firms to create markers of distinction between themselves and their competitors. In general these studies have provided us with important insights into the processes through which fields emerge. Despite these advances, this literature has not accounted for how complexity arises within organizational fields. Instead their focus has been on how homogeneity within fields is achieved.

In this paper I address this problem in the literature by showing that one possible way complexity can arises within organizational field is through a shift from coordinating around goals to coordinating around means. I specify that in the early part of the field participates coordinated globally and around shared goals, whereas later they shifted to coordinating primarily around local activities.

**METHODS**

**Setting: The Emerging Nanotechnology Field**

I chose to study the nanotechnology field because it displayed a high degree of institutional complexity. This choice was informed by Garfinkel’s (1967) advice to choose areas of investigation where the phenomenon of interest occurs in abundance. Pache and Santos (2010) argue that field complexity is most difficult to navigate when fields are moderately centralized, because they (unlike the ones that are very centralized) are not governed by a single entity that controls and guides the interaction and that they (unlike the ones that are weakly centralized) need to coordinate and interact with each other. The nanotechnology field is moderately
centralized, because on the one hand the communities within the field have to interact in order to coordinate joint activities and there are powerful communities that facilitate this process like for example the government. However, the government does not control the nanotechnology field in the way that it controls the military (see Pache and Santos 2010). On the other hand the field is sufficiently close knit in that communities within the field need to coordinate in order to create products, whether they been scientific paper, commercial products, conferences or trade reports.

As with most other fields the nanotechnology field does not have a specific date of birth. Depending on the criteria chosen scholars will be able to point to slightly different dates to marks its time of inception. The scientific foundations of nanotechnology were advances made in materials science, physics and chemistry about how nano-scale particles of a substance might behave differently than their bulk counterparts. Science at the nano-scale began already in the 1950s, but some of the major breakthroughs came in the 1980s with the invention of the atomic force microscope. In contrast the ontological foundations of nanotechnology were laid by a group around Eric Drexler, who started out as a PhD student at MIT and became a technological visionary who was primarily concerned with developing the field of nanotechnology. I term the group around Eric Drexler the “futurist” community. I examine the nanotechnology field since its beginning up to year 2005. While the first article in my data set is from 1953 the field very little activity occurs until 30 years later in the early 1980s. Starting in the 1980s where the futurists community were the only community involved in the field I investigate how four other communities (government officials, service providers, entrepreneurs and scientists), with vastly different institutional logics came to be part of the nanotechnology field. I describe these five distinct communities in more detail below.
Data Collection

I used theoretical sampling to guide my data collection process. In particular I began my data collection with a broad theoretical notion to study the emergence of complexity within organizational fields. As I collected data my understanding of the theoretical notion of interest became more focused and with it so did my data collection efforts. While I present these phases of data collection chronologically some of them overlapped.

**Phase 1: Ethnographic observation.** I started out doing ethnographic observations at conferences and networking events. Conferences and networking events are field configuring events in which participants come together to negotiate the meaning of the field (Garud 2008; Zilber 2012). The conferences and network events that I attended were focused on the commercialization of nanotechnology. These conferences tended to attract multiple communities within the field and they therefore displayed the highest degree of institutional complexity. During the ethnographic observations I recorded presentations and took notes on the activities and conversations of participants. I wrote up my field notes after each conference. While I was writing up my field notes I began to engage in the first process of data analysis. It was during the process that I identified the five communities involved in the nanotechnology field. See Table 1 for an overview of the communities and their associated logic.

------------

Insert Table 1 about here
------------

**Phase 2: Interviews.** The next phase in data collection was to conduct interviews with representatives from each of the communities. I initially contacted participants to interview that I met at the conferences and networking events. I then used snowball sampling to identify more informants. I also used archival resources in order to identify informants. In particular I made sure that I interviewed informants that had been involved in the nanotechnology field at all phases of its emergence even though they might not presently be involved in the field. In
total I conducted 77 interviews. Table 2 depicts an overview of how these interviews are distributed across the communities.

---------
Insert Table 2 about here
---------

Phase 3: Archival research. In order to track the development of the field over time I conducted extensive archival research. First, I collected a broad extensive archival dataset by identifying documents pertaining to the central events that occurred during the emergence of the nanotechnology field. This archival material would cover the first scientific articles written by Eric Drexler, which lays out a possible path for the development of nanotechnology, all the reports released by the Presidents Council of Science and Technology, important books written on the topic like Drexler’s *Engines of Creation*, etc. In addition to the broad archival material I also spent four days copying documents from the Foresight Institute archives in order to understand the early develop of the field. Up until the mid 1990s the Foresight Institute saw it as one of their primary missions to document the development within the field and had copies of all the documents even remotely related to nanotechnology. After the mid 1990s the field grew so large that they became more selective in the kinds of information that they collected.

Second, in addition to the general historical materials I collected a systematic dataset for each of the five communities. For each of the communities I identified a datasource in which they internally conversed about the field. For the futurists I identified their monthly newsletter, *The Foresight Update*. For government officials I collected congressional hearings. For the service providers I collected documents from the business press. For the business community I collected press releases and for the scientific community I collected articles from the journal *Science*. In order to identify relevant articles from each of these data sources I developed a list of search words related to nanoscience. I took as a point of departure a list of search words developed by the Fraunhofer institute. To this list of search words I added
additional terms that I based on my prior collected data found to be missing from the list. Furthermore, I consulted experts in the field in order to get their opinion about the field. The final list of search terms is located in Appendix 1. I used this list of search terms in order to identify a set of articles relating to each of the communities totaling 9,011 articles primarily covering the period 1984-2005. Furthermore, I also collected 3,762 articles from the top 50 US Newspapers in order to contextualize the general development of the field. See Table 2 for a detailed overview of the archival data.

**Data Analysis**

I coded the data using a grounded theory approach. My analysis started very broad during my initial data collection and proceeded to become more focused over time. Already during data collection I began to puzzle over the extent of institutional complexity within the nanotechnology field and how it had arisen. As my data analysis progressed I began to ask more specific questions regarding how this institutional complexity had been created. After I had collected all the data I uploaded the ethnographic observations and interviews in Atlas.TI and began open coding. I also arranged all the archival material chronologically in order to get an in depth understanding of the temporal development of the field. Based on this initial setup my analysis proceeded in three steps: 1) Identifying the two phases “goals orienting” and “means shifting”, 2) specifying the practices that contributed to goals orienting, and 3) specifying the practices that contributed to means shifting.

*Step 1: Identifying the two phases “goals orienting” and “means shifting”.* After I had engaged in open coding and had identified elements of institutional complexity I began to compare and contrast how this complexity had shifted during the development of the nanotechnology field. This led me to identify two phases during the development of the nanotechnology field “goals orienting” and “means shifting”. I identified “goals orienting”
when participants would make statements that indicated communities were focused on the overall goal of the field like “we and the government both wanted to see nanotechnology develop”. In contrast I labeled as “means shifting” statements, which were focused on how to manage the day-to-day activities associated with the field like when a government agent said “most of our time is spent making decisions about who to fund”.

**Step 2: Identifying the practices that contributed to goals orienting.** In my next step of analysis I examined the excerpts associated with goals orienting in order to identify the practices that contributed to this dynamics. I labeled practices as “coordinating around goals” if community members made statements like “we were trying to develop a roadmap for nanotechnology”. I coded statements like “we invited people within many different backgrounds -- scientists, people from government and business people” as instances of “coordinating globally”.

**Step 3: Identifying the practices that contributed to means shifting.** In the next step of data coding I examined statements related to means shifting in order to tease out the practices that contributed to this process. I labeled practices as “coordinating locally” in informants or descriptions within the archival data describe coordinating with one or two communities only.

In the rest of the paper I elaborate on my findings and provide supportive examples from my data. Table 3 offers additional examples of the practices underlying the means shifting process.

----------------------------------
Insert Table 3 about here
----------------------------------

**CREATING INSTITUTIONAL COMPLEXITY IN NANOTECHNOLOGY**

I found that by 2005 institutional complexity was rampant within the nanotechnology field. Five different communities were involved in the field and many of them were divergent with regards to either their goals for the field or the means that they engaged in to reach the goals.
Table 4a provides an overview of the institutional complexity within the nanotechnology field with regards to the goals of the field and Table 4b shows the institutional complexity with regards to the means.

By 2005 of the ten dyadic relationships between the communities with regards to their goals for the field, I found that five were divergent, two were both aligned and divergent and the remaining three were aligned (see Table 4a for an overview of which of the relationships between the communities fall into each of these categories with regards to their goals). When examining the dyadic relationships with regards to the means the communities engaged in during their involvement with the field I found that four pairs were divergent, two were both divergent and aligned and four were aligned (see Table 4b for an overview of which of the relationships between the communities fall into each of these categories with regards to their means).

At this point in time the nanotechnology field, thus, displayed a great degree of complexity. In the remainder of the paper I will explain how this complexity arose. In particular I found that the earliest phase of the emergence of the nanotechnology field was characterized by efforts to align the goals for involvement in the field for the involved communities – I term this phase goals orienting. During the latter part of the field when goals had been established communities changed to focused on the means through which the goals for the field could be achieved. I term this phase – means shifting. In the reminder of the paper I elaborate on these two phases to explain how they contributed to the creation of the complexity depicted in tables 4a and 4b.
GOALS ORIENTING

The first phase in the creation of the nanotechnology field was that several communities became involved in nanotechnology. During this phase the communities involved in the field engaged in two practices coordinating around goals and coordinate collectively. I detail these practices below.

Coordinating around Goals

The emergence of the nanotechnology field was characterized by the gradual involvement of new communities. While the futurists were the first community to become involved, other communities like the government and service providers quickly became part of the nanotechnology field. During this early part of the field the involved communities coordinated around goals that is they engaged in work in order to align the goals of each of their communities so that they could rally around a common goal for the field.

The futurists. The idea to create a new organizational field around nanotechnology emerged in the 1980s and was the brainchild of Eric Drexler. He popularized his vision of nanotechnology in his 1986 book The Engines of Creation. In the book he describes his vision that the future of technology would be to develop bottom-up molecular manufacturing, where goods like calculators and computers would be produced through assembling individual atoms. In particular he envisioned the creation of desktop manufacturing systems that would build all things on demand atom-by-atom and nano-robots that would flow around the bloodstream and remove plague. The futurists believed that it was important to guide the process through which nanotechnology was going to develop in order to ensure that it was done in a timely and responsible manner. In the first issue of the Foresight Update the futurists write the following about the goal of the Foresight Institute:

The ideas behind the Foresight Institute grew up alongside the ideas in Engines of Creation. The need for an organization was obvious: If we face great challenges as a civilization, shouldn't we organize in some way to meet them? In
the coming months and years, the approach of nanotechnology and artificial intelligence will raise a host of issues, with technical, economic, political, and ethical dimensions. We will need networks of informed individuals and forums for discussion. We will need organizations able to influence public policy, including international policy. How to proceed was less obvious. Organizations can take many forms, and our experience in other broad, technology-oriented organizations suggested many pitfalls. *(Foresight Update, 15 June 2012, p. 1)*

In this statement the futurists are clear in the goal that they want to achieve in influencing public policy and they set out to make sure that other communities shared their vision. However, they also acknowledge that the means to achieve a nanotechnology field were “less obvious.”

In order to help develop the field the futurists needed the involvement of other communities. One of the main activities that the futurists engaged in was trying to involve new communities within the field. In particular they tried to organize other communities around the goal of creating a technological field focused on nano-robots and desktop manufacturing systems. This vision resonated with both government officials and service providers.

**Government officials.** In the early 1990s bureaucrats within the U.S. government were looking for a way to increase funding for science and engineering. When they heard of the futurists’ visions of a nanotechnology field they saw this as an opportunity to generate support in congress for an increase in science funding. The futurist goal of a new revolutionary “nano”-technology built around grand visions like “storing the library of congress in a device the size of a sugar-cube” (Clinton, 2000, p. 1) was compatible with politicians’ wishes to appear as the leaders and builders of the next scientific revolution. A congressional aid, Eric Warming, for example, explained how the congressman he was working for, Brad Balling, came to be one of the spearheads of nanotechnology within the government:

> I mean part of my responsibility was to come up with areas where Brad could try to take the lead - things that he could do. So that’s where I identified nanotechnology as something for him to do – a place for him to go.
In an interview in *Small Time Magazine*, on March 4th, 2005 Tom Kalil, who was on the Presidents Council for Science and Technology (PCAST) during the Clinton administration, elaborated on his reason to push nanotechnology as part of the government’s agenda:

I was very interested in increasing support for the physical sciences and engineering and ensuring U.S. leadership in an emerging technology in which global leadership was up for grabs......... I thought the initiative model had been one way in which I’d been successful in getting high-level support, interest and visibility for a particular area of research. I was confident enough that nanoscale science was such a broad area that it was appropriate for the government to emphasize that in its investment strategy.

Tom would like to increase funding for science and engineering and he believed that the “initiative model” that is creating a government initiative around a particular scientific area and using such an initiative to mobilize support had been successful in the past. He saw nanotechnology as an opportunity to create a new government initiative that could be used to generate more funding for science and technology. There was, thus, an alignment among the goals of the futurists and the government officials.

**Service providers.** Service providers (e.g. lawyers, venture capitalists, and journalists) also saw the futurists’ goal of creating an organizational field around nanotechnology as a welcomed opportunity. Service providers were always looking to become involved in new fields that would drive demand for their services, which they would do by creating a real or perceived information asymmetry between themselves and their clients. It is easier to create a perceived information asymmetry in novel fields, where potential clients often are at loss with even the most basic aspects of the characteristics of the field. Service providers, therefore, became involved in the nanotechnology field early and began to promote both the field and their own services. For example there were service providers who saw opportunities in starting conference organizations and trade magazines to both capitalize on this emerging market and to be part of building a community. Louise Hansen, the CEO, of the trade magazine *NanoNews,*
describe the role that she saw *NanoNews* having when the nanotechnology field was in its infancy:

We were established to provide a community voice to an industry segment that had no community at the time, or business community. And so the idea was to really give some coherence to the discussion, and develop a dialogue or a place where people could really see how these emerging technologies are making an impact and so our role wasn't just to be an observer of it, but to really develop a community that recognized the commercial importance of the technologies. And I think when we first started out, a lot of our role was to even make people aware that the technologies had commercial potentials.

The goal of *NanoNews* at this point in time was aligned with both the goals of the futurists and government officials as they were all aiming to build a new field around nanotechnology.

Venture capitalists were also excited about the idea of developing a nanotechnology field and they spent time and efforts lobbying the government in hopes to increase their involvement in the field. Venture capitalists thought that a government initiative could help them fund the commercialization process from discovery to product creation and maybe even help ignite a new commercial space. Chick Vennum, a higher ranking official from UniTech (a top research university) and prior member of PCAST, described the role of the venture capitalists this way:

Now here, if we look at UniTech, I can think of a few venture capitalists who were very excited very early on about this area and even talked it up and were around here probing for ideas. I particularly had in my mind, Carl Henning, from New York, who now is totally specialized in this area.

Patent lawyers as well were excited about the prospect of a new field, which might lead to the creation of a whole new area of patent-litigation.

[Nanotechnology] is now and will continue to be a very lucrative area for patent lawyers. Right now we’re doing some of the basic technology transfer from universities and the startups and writing some of the early patent applications but it won’t be long before there’s a lot of litigation in nanotechnology, which is
an area where I'm very interested in trying to litigate some of these patents. 
......[......]......I'm looking at the long term - if I get in early, I understand the 
field and I get my name known and the firm’s name known then when 
somebody’s looking for a patent firm to handle their litigation we’ll have been 
around for a long time and be sort of the household name in nanotechnology. 
One of many, obviously, we're not the only firm getting involved. We're one of 
the few firms in Los Angeles and even in California that’s spearheading 
nanotechnology at this point. So getting in early is good.

In order to facilitate the development of the field and become knowledgeable about the 
field early on many patent lawyers attended early nanotechnology conferences and meetings 
where they took part in discussing the future goals of the field.

**Scientists and entrepreneurs.** The futurists had early made an attempt to involve 
scientists within the nanotechnology field. In fact the futurists thought the scientists ought to be 
the community that were the most interested in seeing the nanotechnology field develop.

Indeed, Eric Drexler, saw himself primarily as a scientists, and thus wished to involve fellow 
scientists in his vision around nanotechnology. However, the futurists were largely 
unsuccessful in this endeavor, as the institutional logics espoused by most scientists were not 
aligned with the goals of the nanotechnology field as articulated by the futurists. In particular, 
the goals that the futurists had set forward around creating microscopic molecular machines and 
molecular desktop manufacturing were too far removed from the scientific reality at the time 
for scientists to view nanotechnology as a serious scientific endeavor. To most scientists at the 
time it sounded like science fiction and thus far removed from a project of scientific purity.

One scientist, Matt Klinger, explained this position.

Most people think [Drexler] is kind of crazy….I think scientists generally have a 
negative view… [Scientists] have a very rigid view of the way things should be 
done, and [Drexler] doesn't do it that way. Scientists are very, very critical 
people. Criticizing people is kind of what scientist do. He is an easy target. He 
gets a lot of criticisms geared toward him. I have to say, I have heard ranting and 
raving over how it's basically criminal for us not to freeze people just before they 
die, because surely, with nanotechnology, we would be able to thaw out a frozen 
body and repair whatever it was thought to have died from, and it's basically 
murder not to freeze someone who is about to die. To hear something that 
extreme, it does make you think, “Wow, this guy really is off the deep end”.

17
Many entrepreneurs also thought that the futurist’s ideas were not legitimate as a contribution to technological development. Below is a quote from Carl Wanger, who expresses a view of the futurists commonly held in the business community:

[The futurists] are probably good at writing novels. Maybe they should just worry about their science fiction novels. I don't get those guys. ….. They have such a bizarre thinking.

Due to their rejection of many of the goals of nanotechnology espoused by the futurists, government officials and service providers few scientists and entrepreneurs participated during the early period of the field’s development and thus were only peripherally engaged in creating the goals associated with nanotechnology.

**Coordinating Collectively**

The first phase of the nanotechnology field was not only characterized by communities coordinating around goals – it was also characterized by all of these communities interacting with each other in the coordination effort – a process that I term *coordinating collectively*.

Collective coordination during the early part of the nanotechnology field was among other achieved through general conferences that had the participation of multiple communities. One of the major efforts of the futurist community in the early years was to organize an annual conference called the Foresight Conferences on Molecular Nanotechnology\(^1\) where they invited representatives from all the different communities to participate. The first Foresight conference was held in 1989 and acted like a field configuring event (see Garud 2008) in which community members that prior had been separate were brought together in order to negotiate the goals of the field. In particular the conference held in 1993 brought together futurists, entrepreneurs, service providers, government officials and scientists in order to debate the future of the field. One of the important aspects of the Foresight conference was that it was the one gathering place for

---

\(^1\) Note that the name varied slightly from year to year. The first conference held in 1989 was called “First Foresight Conference on Nanotechnology”, whereas starting in 1993 the conference incorporated the word “molecular” in front of nanotechnology.
everyone interested in nanotechnology, as there were no other places for people interested in nanotechnology to congregate. As one of the early futurists, Catherine Patti explains:

People were talking about it [nanotechnology] mainly starting in our conferences starting in 1989. That was the place that you came to talk about these things. There were not really anywhere else to go. There were not any other nanotechnology conference until after the year 2000. I think that the other conference series started in the year 2001 and 2002. But prior to that there were not anywhere else to go other than our conferences to talk about nanotechnology. There were nowhere else.

From the beginning of the field in the late 1980s until year 2000 the Foresight conference was the place people met up to discuss the goals of the nanotechnology field. Collective coordination also happened through the futurist’s newsletter, The Foresight Update, which was the primary location in which the involved communities debated the state of the field.

After government officials became involved in the field in the 1990s, however, they also began to organize meetings to get all the communities in the same room together for example by arranging for representatives from each of the communities to present in congressional hearings.

In conclusion the early part of the field was characterized by the involved communities coordinated around goals collectively as representative from each of the communities were often together in the same room discussing the future of nanotechnology.

**MEANS SHIFTING**

During the second phase of the nanotechnology field the emphasis shifted from primarily coordinating around goals to coordinating around activities. At the same time coordination began to happen locally and decoupled from prior espoused goals.
Coordinating around Activities

After the nanotechnology field had grown to include futurists, government officials and service providers, who all agreed on the general vision about the future of nanotechnology, the conversation began to shift towards the means and activities necessary in order to create a nanotechnology field. For example, after congress passed the National Nanotechnology Initiative government officials in each of the individual agencies had to figure out which exact proposals to fund. However, as few scientific projects or businesses were even remotely close to building desktop manufacturing systems and most of the prominent scientists were not working in these areas, government agencies allocated funds to research projects that were at the nanoscale albeit with goals that were more readily accomplishable and that were appreciated by mainstream science. The same happened to venture capitalist, who were excited about the goals for nanotechnology laid out by the futurists, but when it came time to allocate funding they sought after companies that would yield a return on investment within a short time span. For example, William Peterson, a prominent venture capitalist described how he had initially been taken with the vision of nanotechnology presented by the futurists:

This was back in 1997 or 1998 - this was before nanotechnology was this big thing. All of these people were taking about Drexler’s idea of building things atom-by-atom so …[sic]…we started discussing it here [at the VC firm], and one of the things that was apparent is that once you move matter from the analog domain to the digital domain then you can actually start manipulating it in a fashion that we are used to.

However, even if it was Drexler’s vision of creating robotic systems atom-by-atom that initially captivated venture capitalists and led them to participate in the nanotechnology field they subsequently focused on funding applications far removed from this original vision. William Peterson continued explaining how they ended up investing during the first couple of years of the new millennium:

So, we should start looking at it [nanotechnology]. And then it begs the question what do we invest in? Because we are not going to invest in Eric Drexler's little machines and little subversibles. We are going to invest in something that fits
our investment framework. So, what we set out to do is look for businesses that would get to revenue within one to two-years and then get to profitability within three to four-years and then have some kind of exit that we could get to maybe within four to six-years and that fits within our criteria. The place that we saw opportunity was in tools for nanotechnology, so the picks and the shovels that will build the groundwork for all of this, and also very rudimentary components, very very simple things. And if the right thing came along we would invest in something that was a little further off. If it was really radical - really game changing. But for the most part the stuff that we've looked at investing in are some [nano] materials, some firms that use carbon nano-tubes or [nano] powders or whatever. Both process tools for making nanotech stuff and metrology tools for measuring were key.

While venture capitalists, thus, were fascinated by the original vision the means that they employed to achieve the vision had to be aligned with their market driven institutional logic, where returns on investment had to come within a limited time frame. The futurists disagreed with both the venture capitalists and government officials about the means for achieving the nanotechnology vision. Instead of funneling monies into existing research the futurists wanted the government to spend money on the “proof of concept” that the idea of molecular manufacturing – that is creating tools and technologies atom-by-atom was possibly. Originally the National Nanotechnology Initiative included some funds that were earmarked for this specific purpose, however, during the legislative process these provisions were removed from the legislation - an action that infuriated the futurists. One of the prominent futurists marveled at how this was possible:

In this latest bill on nanotechnology that was passed in December of `03 we had gotten a National Academy of Sciences study of molecular manufacturing, and we were very pleased about that. It was all fine it was in there. But the problem is that at the very last second, very very soon before the vote - in the last minute it was changed and nearly nobody in the whole process knew about it. It changed from molecular manufacturing to molecular self-assembly ….which is a meaningless term, because it is already done all the time.

Simultaneously, as government officials were making funding decisions service providers began creating investment funds and organizing nanotechnology conferences. Many of these activities drew scientists and entrepreneurs into the nanotechnology field by asking them not to buy into the overall vision of the nanotechnology field, but instead offering them
the opportunity to present their current research at conference and networking events. While both scientists and entrepreneurs were still wary of the overall goal of nanotechnology they did find participating in these conferences useful as it provided visibility and contact to stakeholders that they would otherwise not have access too.

Furthermore, the funding provided by the National Nanotechnology Initiative was a strong motivator for scientists and entrepreneurs to become involved with the nanotechnology field. As one scientist, Sam Weiwei, explained:

It's kind of like rock music. You know, some artists came out, it was an album, and it's just kind of spread like wildfire. I think that initiative had that effect. Some people reluctantly others more willingly. John [my senior colleague] jumped into bandwagon. In my case it's completely neutral. I don't care as long as the work is interesting it doesn't matter [what field you are in].

The scientists and entrepreneurs, thus, became involved in the field because they were aligned with the government and service providers regarding the activities for creating the field not because they shared the overall goal of where the field was heading. The involvement of scientists and entrepreneurs within the nanotechnology field meant that the institutional complexity of the field increased as these communities were not aligned with the other communities with regards to their view of the goals of the nanotechnology field.

**Coordinating Locally**

Another important mechanisms in increasing the complexity during the second phase of field emergence was that not all communities were engage in a collective coordination process. Instead, coordination happened locally and in dyads instead of involving all of the communities collectively. Complexity, thus, arose not only because field participants began to coordinate around activities, but also because coordination processes did not involve all communities at the same time. For example, venture capitalists would find companies to invest in that suited their vision without adhering to the overall goals of the field. However, they would still claim
that the funds they were investing in were “nanotechnology”. Likewise, individual funding agencies within the government like the National Institute of Health (NIH), the National Science Foundation (NSF), the Environmental Protection Agency (EPA) and the Defense Advance Research Project Agency (DARPA) all allocated funds under the goal of promoting nanotechnology. However, the funders within the agencies were primarily focused on funding the best science whether or not those proposals had the best alignment with nanotechnology goals or not. One government official employed in the EPA, Dr. Balunski, explained the process through which her department would choose which proposals to fund:

We choose the best science - that's really what's happening. We choose the quality research projects and, of course, we can't fund them all. We are sitting on 157 right now that maybe about 30% passes peer-review so that means we will probably get about 50 out of there, and we can probably fund about half of those. Remember what we are looking at are the implications, so we are not really looking at nanotechnology. We're really looking at the implications of nano materials - specifically manufacturing nano materials—not something that's just done in the research lab; it's something that people or the environment could come in contact with.

What Dr. Balunski explains above is that her strategy to allocating funds was not to follow the exact guidelines of what was defined as nanotechnology or not. Her main concern was to fund the best science as defined by the peer review process. That is who got funded was negotiated locally between government officials and the scientists participating in the peer review process. Of the proposals that got funded some might support the prior agreed upon goals of nanotechnology and others might not. Furthermore, employees at the EPA were shaped by the main goal of their institutional logic, which was ensuring the safety of people and the environment, then attention to whether the proposals that they funded were aligned with the vision of nanotechnology outlined by the futurists and passed through congress or not, was not their main concern. This meant that most of the proposals that were funded with monies from the National Nanotechnology Initiative were not allocated to research projects that would lead to the development of Drexler’s vision of desktop manufacturing systems or nanobots, but
instead to research projects investigating more mundane near-term science applications like how nano-materials might interact with water.

The local coordination of activities led to a decoupling between the goals that were originally espoused for the field and the actual activities that participants later carried out. This disconnect was possible both because even though communities were aligned in the goals that they espoused they might not be aligned with regards to the means to carry them out. Furthermore, it was not always the same people within a community, who agreed to particular goals and who were in charge of carrying out the exact activities. This decoupling happened at two levels both within individual communities and between communities. First decoupling happened between the means communities engaged in and their espoused goals for the field. Second, decoupling happened between the various goals that communities’ pursued within the field leading to an increase in complexity.

**Goals Neglect**

Research in institutional work has cast novel focus on the fact that institutions do not endure without effort, that is maintaining institutions take work (Lawrence and Suddaby 2006).

Identifying patterns of actions that do not take place can be harder than identifying actions that take place. However, within the nanotechnology field I found evidence that the lack of goal maintenance contributed to the emergence of complexity within the nanotechnology field. While early in the field communities spent considerable effort coordinating around goals this activity received less attention after means shifting had occurred. The lack of attention to the goal of the field meant that the goals the different communities associated with nanotechnology shifted. While the futurists still saw the goal of the nanotechnology field as the creation of microscopic assembler robots this was no longer true for many of the other participants. For example, most government officials were content as long as monies were flowing into the nanotechnology field. One futurist, Sam Mallort, complained about how many of the other
communities no longer wanted to engage in a discussion about the overall goal of nanotechnology:

“[We don’t have the same goals now]. A very simple example. If you're a group that openly talks about the potential downsides of nanotechnology and how we need to really address them – like, for instance, we bring out the Foresight Guidelines, which are in their fourth revision. Some people say, "Oh, well, we don't want to scare these poor little legislators so let's not [show then this]. We don't want them to think about this. We want them only to think about allocating money that I can go get a grant for. Let's have them think about that so let's just not discuss any of this scary stuff, let's discuss how many billions are going to be allocated so my buddies can get grants that say 'nano' on them."

What Sam explains is that whereas early in the field the other communities had been willing to discuss the overall goal of the nanotechnology field they were no longer willing to do so as the other communities were afraid that any discussion of the overall goals of nanotechnology might disrupt the current equilibrium where the focus on coordinating around activities meant that all communities (except the futurists) were content.

**DISCUSSION**

While scholars have addressed how communities manage institutional complexity (Battilana and Dorado 2010) we know less about what gives rise to complexity within organizational fields in the first place. This question is particularly important, because the creation of complexity seems paradoxical. If collaboration in the face of complexity is so hard how come it arises in the first place? This paper begins to address this emergence-complexity paradox by showing that complexity develops through the differentiated temporal involvement of multiple communities within a field. In order to understand how complexity comes to exist we thus need to consider a field’s historical contingencies. I show that the processes of *means shifting* changes the focus of involved communities from the goals associated with the field to the means needed to achieve that goal.
The Creation of Complexity

The first contribution of this paper is to our understanding of how complexity arises within emerging organizational fields. This focus extends existing research that has focused primarily on fields after complexity has already arisen (Morrill, 2006; Purdy and Gray, 2009; Battilana and Dorado, 2010; Smets, Morris, and Greenwood, 2012; Kraatz and Block, 2008). This research extends the theoretical work by Pache and Santos (2010), because it shows that complexity regarding goals and complexity regarding means might be important at different points in time during the emergence of an institutional field. It might therefore be that the strategies Pache and Santos (2010) point to are more prevalent at different points in time during the emergence of an organizational field. Furthermore, Pache and Santos (2010) emphasize that the degree of centralization within a field might be related to the extent to which organizations experience conflicting institutional demands. This study suggests that the degree of complexity within a field is also related to the degree of institutional work that organizations within the field have engaged in during the emergence of the field. It is, thus, possible that in different fields the degree of centralization or social-cohesion is not an exogenous concept, but is the outcome of the amount of institutional work that participants within the organizational field have engaged in. While the communities involved in nanotechnology did some institutional work in order to maintain the field they could have done more in order to collectively coordinate also the activities that participants engaged in. This distinction becomes clearer when the emergence of the nanotechnology field is contrasted to the emergence of the biotechnology field in which scientists early on were engaged in coordinating the exact activities that could be carried out within the field (Markel and Robin 1985). In particular early participants within the biotechnology field were concerned that fear within the population of human cloning might lead to the demise of the field. They thus put self-imposed restrictions on which activities would be permissible, which led to less of a decoupling after the field shifted to coordinated around activities.
Furthermore, while most studies of field emergence have emphasized the actions of institutional entrepreneurs (Maguire, Hardy et al. 2004; Etzion and Ferraro 2010) I find that not all institutional work was intentional in the sense that the participants were actively trying to create a new field. While the communities that became involved in the field during the early period consciously engaged in field creation activities this was less true for the communities that entered later. Participants in these communities were not vested in the development of the field, but were just acting on opportunities to forward their work. Ironically, many of these later entrants were instrumental in solidifying the field and enabling it to survive. In order to understand how participants create organizational fields we, thus, need to consider both institutional work that is done with the purpose of creating a field, and the institutional work that participants engage in just in order to get their daily work done.

While institutional scholars have been interested in organizational fields for several decades most studies of fields have examined the role of one or two communities only in the creation of an organizational field (Lawrence and Phillips 2004; Maguire, Hardy et al. 2004; Weber, Heinze et al. 2008). Due to the focus on two communities these studies have not investigated a differentiated involved of communities at different points in time. In contrast this study traces the evolution of five communities since the inception of a field. By studying multiple communities this study brings attention to the different institutional logics that communities bring with them when they begin to participate in a field. Indeed, due to both the shift in the communities that are involved in the field and thus the kinds of institutional logics that are represented, and the shift in focus on coordinating around goals to coordinating around means the complexity of the field increased.

**Means-End Decoupling**

Institutional complexity is closely related to decoupling (March 1962; Bromley and Powell 2012). While the classic theories of decoupling have viewed decoupling has happening
primarily between the formal and the informal aspects of the organization (March 1962), decoupling can also happen with regards to the mean-end relationship (Bromley and Powell 2012). Bromley and Powell (2012, p. 14) argue that “decoupling between means and ends occurs in settings where formal structures have real organizational consequences, work activities are altered, and policies are implemented and evaluated, but where scant evidence exists to show that these activities are linked to organizational effectiveness or outcomes”. Indeed, many scholars have studied decoupling between the existence of formal rules and the lack of implementation of these rules (March 1962), Bromley and Powell (2012) call for studies of means-end decoupling, which they believe might be more prevalent in contemporary fields. Bromley and Powell (2012, p. 17) elaborate: “Whereas policy–practice decoupling can be thought of as symbolic adoption, means–ends decoupling is better characterized as symbolic implementation. Means–ends decoupling helps to explain why organizations implement a range of practices (and associated ways of evaluating practices) that have an opaque relationship to outcomes”. This paper addresses this call by unpacking how the practices that participants engage in within fields can lead to means-end decoupling.

Furthermore, a debate within the decoupling literature has focused on the extent to which practices that were once decoupled can become “recoupled” (Espeland 1998; Hallett, 2010). In this paper I propose that recoupling can come about through the practice of goals neglect. As negotiations about the goals of the nanotechnology field ceased, the goals began to drift. However, part of this drift resulted in a recoupling where some communities slowly changed their goals so they were aligned with the outcomes of the implemented practices.

Another important debate in the literature on decoupling is the extent to which institutional pressures to decouple come from within the organizational system or are imposed from outside. Mayer and Rowan (1977) proposed that decoupling happens as organizations conform to rationalization pressures in the environment. This paper suggest that we might also
consider how communities’ institutional logics and the institutional work they engage in to navigate conflicting institutional demands might lead to a means-end decoupling.

**Future Research**

There are several limitations to this study that might be remedied in future research. In particular this paper focuses on the emergence of one field only. While many of the mechanisms identified in this study might be generalizable to the emergence of other fields identifying the boundary conditions of the study might yield additional insights. There might be several factors that impact the strength of the mechanisms and thus the degree of complexity experienced within a field.

Fields might, for example, vary with regards to the variance in the institutional logics of the involved communities. Within the nanotechnology field the communities that became involved in the field had conflicting institutional logics. This is likely to be the case in most technological fields as technological fields tend to bring together scientists, entrepreneurs, government officials and service providers, and in many cases also futurists or some other social movement, which adhere to conflicting logics. However, in other fields the participating communities might be more similar at the onset and thus create less complexity. For example, the field of finance bring together multiple communities (companies, investors, and regulators), but many of these communities are infused with a similar institutional logics that of finance, as most of the people who work in finance, whether they are working for regulators or investors are trained and educated in the same institutions (Ferraro, Pfeffer et al. 2005).
<table>
<thead>
<tr>
<th>Institutional Logic</th>
<th>Futurists</th>
<th>Government</th>
<th>Service providers</th>
<th>Entrepreneurs</th>
<th>Scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Goal of Institutional Logics</strong></td>
<td>Stimulate the creation of a new technological field around nanotechnology by educating the public about both the benefits and the dangers of nanotechnology</td>
<td>The government had the dual goal of increasing funding for science and engineering and stimulate the creation of a new technological field</td>
<td>Generate a market for their services.</td>
<td>Create breakthrough technologies with commercial potential.</td>
<td>Create new scientific breakthroughs. Obtain funding for their research and students.</td>
</tr>
<tr>
<td><strong>Means for achieving goal</strong></td>
<td>Organize conferences and newsletters. Stimulate conversations about the future technology.</td>
<td>Identify scientific and commercial work to fund.</td>
<td>Organize conferences, networking events, and write magazine articles.</td>
<td>Identify current market opportunities. Work on the product that is closest to commercialization.</td>
<td>Work on the scientific projects that they believe has the most value to science.</td>
</tr>
<tr>
<td><strong>Example</strong></td>
<td>“[Nanotechnology] is really going to happen at some point, and people deserve to know. … And what we can we do today that is relevant. And also look at longer term issues, like control issues and things like that…The ideas really got out there to the general public…”</td>
<td>“A science and technology initiative…is a targeted increase in funding for a particular area of science and technology. …The [National Nanotechnology Initiative] is a mechanism for the United States government to set priorities…… I’m not proposing initiatives as the sole driver for increases in funding. But my experience was if I had some of these they would also engender support more broadly for increases in sciences and technology”</td>
<td>“[Nanotech] is going to be…a very lucrative area for patent lawyers…I know there are some companies that are poised to be suing – like right now….there just isn't a lot of products on the market to be suing for. … But what I'm looking at in the long term is if I get in early…then when somebody's looking for a patent firm to handle their litigation we'll have been around for a long time and be sort of the household name in nanotechnology….“</td>
<td>“I believe that we are using nano-engineered principles to get unique properties and performance and features that will allow us to do commercially valuable things with products in the energy sector…[.] I see us as a company with a strong intellectual property position focused on a specific vertical market that is energy using nano-engineered materials to accomplish certain performance characteristics”</td>
<td>“I think [funding] has changed what people call it. I think we saw a lot of people change the name of what they are working on. Now they say that they work on nanotechnology and all that really happened is the scale that we pattern accurately decreased and people changed names around to get funding. … Instead of people getting a normal NSF grant they got an NSF grant that had nanotechnology in the title”</td>
</tr>
</tbody>
</table>

**TABLE 1 Overview of Institutional Logics with the Nanotechnology Field**
<table>
<thead>
<tr>
<th>Table 2  Overview of the Data</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Interviews</strong> (77)</td>
</tr>
</tbody>
</table>

| **Archival data source** | **Foresight Update** | **Congressional hearings** | **Fortune, Forbes, The Wall Street Journal, Business Week** | **Press releases** | **The journal Science** |


| **Articles analyzed quantitatively (9011)** | 926 | 925 | 494 | 4,157 | 2,509 |

| **Articles analyzed qualitatively (938)** | 204 | 142 | 189 | 170 | 233 |

**Additional material**

- Historical documents covering the major events that took place during the development of the nanotechnology field.
- Newspaper articles from the top 50 U.S. Newspapers (total 3,762)

Note: Totals listed in parenthesis.

- Real names of participants are listed in this table. All other names used in the paper are pseudonyms.
- The archival data listed above was supplemented with additional important documents that were pivotal in the development of nanotechnology.
- Many of the articles were only one or two paragraphs.
<table>
<thead>
<tr>
<th>Phase</th>
<th>Practice</th>
<th>Definition</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Goals</td>
<td>Orienting</td>
<td>Coordinating around goals is the process where multiple communities who aspire to become part of the field coordinate around what they believe are the goals of the field</td>
<td>In the earliest part of the field community members met at the Foresight Conferences, which acted as a field configuring event. During the 1990s government officials would hold workshops that included all the communities. For example, on June 22, 1999 the Committee on Science House of Representative held a panel to discuss the future of nanotechnology, which included representatives from scientists, futurists: “It is also appropriate for the Subcommittee to take a good look at the Federal Government's role in funding nanotechnology research, to discuss what can be done to help move this research from the lab to the marketplace, and to discuss where nanotechnology might be in 10, 20, 30 years from now….. The word &quot;revolutionary&quot; is too overworked to have much impact anymore, but nanotechnology, which is the subject of today's hearing, truly is revolutionary. As expressed in a recent report from the National Research Council, the ability to control and manipulate atoms, to observe and simulate collective phenomenon, to treat complex material systems, and to span length scales from atoms to our everyday experience provides opportunities that were not even imagined a decade ago. Nanotechnology will have enormous consequences for the information industry, the manufacturing of all kinds of medicines and health. Indeed, one of our witnesses has written that it will leave virtually no product untouched”. Later in the same hearing Ralph Merkle expanded: “I want to just say that this is an area where there are some differences in opinion about the particular routes to follow, but, nonetheless, agreement about the overall goals and objectives that we should be able to build, essentially, most of the structures that are consistent with physical law.”</td>
</tr>
<tr>
<td></td>
<td>Coordinating collectively</td>
<td>Coordinating collectively is the process through which all the communities that are involved in a field participate in the coordination process</td>
<td>During the early part of the field the participating communities coordinated collectively in that they were all present at the same conferences and meetings. As the field grew larger this was not longer the case. One futurist explained how the Foresight Institute contributed to a collective coordination early in the nanotechnology field: “One of the big contributions of Foresight has been along technical conferences. It was the first conference on nanotechnology. So it had scientists from all sorts of institutions, all sorts of places. Another thing that they did on an ongoing basis is they did publications – newsletters and little electronic newsletters, so hard copy and electronic variety of newsletters that just basically kept people up to speed on what was going on on the cutting edge of nanotech”</td>
</tr>
<tr>
<td>Means</td>
<td>Shifting</td>
<td>Coordinating around activities is the process through which participants begin to coordinate through a focus on means instead</td>
<td>Government officials and venture capitalists funded companies/scientists that did not comply with the original vision of nanotechnology. A venture capitalist said: “But the key thing was to put this in the context of an investment framework, an investment framework that works for us. Because we can't just invest in science projects and there are a lot of science projects out there”. Government agencies funded what they believed was the best science, even though it might not</td>
</tr>
</tbody>
</table>
of coordinating the overall goal of the field comply with what the legislators thought they had funded. One informant explained: “With the government, what happened there was that some of the people at a policy level were educated via a pretty much Drexler direct channel. So they were looking at the downstream possibilities. But the job of government is not to administrator - lawmakers don't administrator things. They pass legislation to set up a program, they pass legislation to fund a program and then it's carried out by other people. Now I haven't talked with these guys but I would be willing to bet you that there are some people who would be pretty surprised!”.

Scientists would claim to be doing nanotechnology in order to get access to part of the funding that was ear-marked for nanotechnology. “Well, if you understand the scientific peer review process, it's a very conservative process. Period. And I think the old open secret in the scientific community is that what you put your [grant] proposal in on is the stuff we've already done and when you get the grant, you bootstrap the money on doing your next thing so you can develop data and go onto the next proposal about stuff you've already done, right? It's the open secret about how things work.

<table>
<thead>
<tr>
<th>Coordinating locally</th>
<th>Venture capitalists coordinated with investors and companies around which firms to invest in. Government officials coordinated with scientists around which research proposals to fund.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coordinating locally is the process through which communities coordinate in dyads instead of coordinating among all the communities involved in the field.</td>
<td>One government official explained how the government agencies end up coordinating locally. Even though the decision that was taken to fund nanotechnology happened collectively among all the communities then it was the individual government agencies that took the final decision on what was being funded : “Essentially that is sort of an accounting and the memo goes out [from congress] and says, &quot;Here's a priority, but it doesn't say, &quot;We're going to take $10 million from the Department of Defense and give it to EPA because we think EPA needs more money in nanotechnology.&quot; Really what it's saying to EPA and the Department of Defense is &quot;Within your budget we want you to make these [for example nanotechnology] priority areas.&quot; So at the end of that process where the discussion goes back and forth between the agencies and the OMB [Office of Management and Budget]– at the end of all that what they finally have agreed then they say to the agency, &quot;Okay, now go back and tell us how much of the existing programs is nanotechnology,&quot; because almost none of them has a program that's called nanotechnology research. It's part of their program for clean water or their program for advanced sensors. So after all of the sort of functional programs have been agreed to and the levels of those then they do an accounting essentially. So it's not like we say in advance, &quot;This is how much we want to spend this year on nanotechnology.&quot; I think the sort of subtle distinction. People think that Clayton Teague [director of the National Nanotechnology Initiative] and the Coordination Office has a checkbook with a billion dollars or something. It is not like that. It is very much a sort of federation of programs. Now there is coordination that takes place through this inter-agency process so there's very much a sharing of &quot;Here's the direction was want to go,&quot; or &quot;Here's something --&quot; often the agencies will reach out to each to hand say, &quot;Let's work together on this,&quot; and they together put out requests for proposals for a particular area of research and so on. So I would say there still is an inter-agency coordination aspect even though the details of the budget are done within the agencies.</td>
</tr>
</tbody>
</table>
Goals neglect is the process through which the goals that were set initially are not maintained. Goals neglect lead the goals of participants within the field to drift apart.

There was no effort to get all communities together and create a central vision for nanotechnology. One futurist complained about how many of the other communities no longer wanted to engage in a discussion about the overall goal of nanotechnology.

As one futurist explained: “It started to broaden and by the time we get to year 2000 then even though in the popular mind we are still talking about nano robotics then by the time the NNI started….by the way this is like a founding coalition and what it was is that a very very very wide variety of folks got together and said this is a sexy word, and it is sexy mainly because of all this stuff that went on…..[sic]…. But the problem is that the term was broadened so much that it is not longer a coherent program. In the phrase National Nanotechnology Initiative there is the word national technology initiative, which to most people would mean that it sounds like we are developing a technology and that is really not what this is all about. This is an extremely broad array of basic science which we all love, but it is so broad that there is no coherence, and it is so broad that they are not developing a specific technology. If you would ask the general public based on these 14 years, if you would pole them, if you would ask them directly they would say that we are developing the little machines. We were promised the little machines, and as far as they know they are getting them. Unfortunately it is not happening. They are not getting them. First and foremost because this guy at the top. This guy who showed up here, he is not enthusiastic about it. It let to a whole paradigm shift.”

Another futurist, Catherine Zimmerman explained: “The problem is that the money is not really going towards what congress thought that it was going towards. It is being funneled into things that are much more near term”

Christine Peterson (2004) p. 11-12 describes how the government originally supported a grand vision of nanotechnology to enable the creation of molecular machines, but that overtime funding was only allocated to near term applications. “It seems unlikely that MNT [molecular nanotechnology] advocate Merkle would have been given such a central role (as one of four invited to testify [in front of congress]) if the new program’s proponents had not intended to send Congress the message that MNT research would be included in the expanded initiative. A 1999 NNI [National Nanotechnology Initiative] promotional brochure likewise described and seemingly endorsed “Feynman’s vision of total nanoscale control,” terming it “the original nanotechnology vision”. Another NNI document explained, “the essence of nanotechnology is the ability to work at the molecular level, atom by atom, to create large structures with fundamentally new molecular organization”. However, after the funding had been allocated “NNI director Mihail Roco attempted to shut down inquiry by decreeing that “None of this exists... this is only science fiction...these aspects stay outside the development of nanotechnology as we intend it”
<table>
<thead>
<tr>
<th>Goals</th>
<th>Government</th>
<th>Service providers</th>
<th>Entrepreneurs</th>
<th>Scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divergent</td>
<td>The government’s state logic conflicted with the futurists' community based logic. The goal of the futurists was to create microscopic assembler robots, whereas the government wanted to fund general science at the nano-scale.</td>
<td>The goal of the service providers’ professional logic was to create a new field. This temporal orientation towards the future was aligned with the futurists’ community based logic of securing a safe and responsible development of nanotechnology.</td>
<td>The goals of the entrepreneurs’ market logic conflicted with the goals of the futurists' community logic. The entrepreneurs’ market logic was focused on profit generation whereas the futurists’ community based logic emphasized responsible technological development. Furthermore, entrepreneurs had a short time horizon for the realization of nanotechnology, whereas the futurists took a much longer perspective.</td>
<td>The scientists’ science based professional logic diverged in their goals from the futurists’ community based logic as the goals of scientists were to invent and publish rigorous scientific knowledge. The goal of the futurists were to develop an agenda for the long term development of nanotechnology.</td>
</tr>
<tr>
<td>Aligned</td>
<td>The goal of the service providers’ professional logic was aligned with the government’s state logic of creating a new nanotechnology field.</td>
<td>Entrepreneurs and government officials were aligned in their focus on creating a new field, which might create new commercial opportunities. However, they were divergent because the entrepreneurs saw the creation of new commercial opportunities as the only goal of the field, whereas the agenda of the government was broader in also increasing educational offerings, minimizing pollution, and directing monies towards underfunded scientific and geographical areas.</td>
<td>*</td>
<td></td>
</tr>
</tbody>
</table>

Grey boxes represent divergence in the goals of the communities’ institutional logics. White boxes represent that the goals of the communities’ institutional logics are aligned. Light grey boxes represents that part of the goals of the communities’ institutional logics are aligned whereas others are divergent.
TABLE 4b  Means Complexity within the Nanotechnology Field anno 2005

<table>
<thead>
<tr>
<th>Government</th>
<th>Service providers</th>
<th>Entrepreneurs</th>
<th>Scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Divergent</td>
<td>Divergent</td>
<td>Divergent</td>
<td>Divergent</td>
</tr>
<tr>
<td>The futurists wanted to invest resources in testing the feasibility of the grand nanotechnology vision. Government officials wanted to invest money in funding the best science.</td>
<td>Service providers wanted to fund and write about companies that were already in existence. Futurists wanted to invest time and energy into testing the feasibility of their larger nanotechnology vision and write about inventions and companies that might arise in the future.</td>
<td>Entrepreneurs want to invest in problems that might yield commercial products in the near future. Futurists wanted to invest in problems that would test the feasibility of their grand nanotechnology goal.</td>
<td>The scientists wanted to make incremental rigorously tested steps forward. Futurists wanted to test big ideas and visions.</td>
</tr>
<tr>
<td>Aligned</td>
<td>Aligned/Divergent</td>
<td>Aligned</td>
<td>Aligned/Divergent</td>
</tr>
<tr>
<td>The means of the government’s state based institutional logic was aligned the service provider’s professional logic were aligned in that both emphasized the creation of interdisciplinary conferences and funding for a wide array of scientific and commercial enterprises.</td>
<td>The government and the entrepreneurs were aligned in their means regarding the nanotechnology field as both wanted to fund commercial enterprises that might participate in the creation of a field. They were divergent because the government also wanted to fund scientific areas that might not have a near-term commercial potential.</td>
<td>Scientists and government officials within various agencies agreed that monies ought to be allocated to the best science, although this was sometimes at odds with the government’s stated goals.</td>
<td>The means of the scientists and the service providers were aligned in that scientists benefited from being featured in the conferences and articles that service providers generated about the nanotechnology field. However, they were divergent in that service providers would talk about the scientists work in ways that conflicted with the scientists logic of scientific purity.</td>
</tr>
<tr>
<td>Aligned</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>The means that the service providers used to promote the nanotechnology field was to host conferences and write about companies that had the potential to become profitable within a short period of time. Entrepreneurs saw these conferences and articles as outlets, which could help them attract attention to their products.</td>
<td>The means of the scientists and the entrepreneurs were aligned in so far as they both were focused on creating near term scientific breakthroughs, which could either be commercialized or published in prestigious academic articles.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Grey boxes represent divergence in the means of the communities’ institutional logics. White boxes represent that the means of the communities’ institutional logics are aligned. Light grey boxes represent that the means of the communities’ institutional logics were both aligned and divergent.
### TABLE 5 Goals Orienting

<table>
<thead>
<tr>
<th>Futurists</th>
<th>Government</th>
<th>Service providers</th>
<th>Companies</th>
<th>Scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organizing around goals</td>
<td>Organizing around goals</td>
<td>Organizing around goals</td>
<td>Lack of involvement</td>
<td>Lack of involvement</td>
</tr>
<tr>
<td>Created the initial goals</td>
<td>Logics compatible with regards to their goals – create a vision of a new technology future</td>
<td>Logics compatible with regards to their goals – create a vision of a new technology future</td>
<td>Futurists vision is too far removed from the goals of most entrepreneurs, which was selling products in the immediate future</td>
<td>The futurists’ description of scientific future clash with goals of scientific purity.</td>
</tr>
</tbody>
</table>
The means that the futurists had envisioned was to do “feasibility studies” of their nanotechnology goal. These studies did not materialize.

<table>
<thead>
<tr>
<th>Futurists</th>
<th>Government</th>
<th>Service Providers</th>
<th>Companies</th>
<th>Scientists</th>
</tr>
</thead>
<tbody>
<tr>
<td>Decoupled engagement</td>
<td>Organizing around means</td>
<td>Organizing around means</td>
<td>Organizing around means</td>
<td>Organizing around means</td>
</tr>
<tr>
<td></td>
<td>Locating the most promising science projects to fund</td>
<td>Identifying the most successful companies or scientists to write about or fund</td>
<td>Engaging in research and development that would lead to the most near term benefits for the company.</td>
<td>Securing funding for their labs and their graduate students. Engaging in the research that furthers their current research streams.</td>
</tr>
</tbody>
</table>
REFERENCES


Bromley, P. and W. W. Powell (2012). "From Smoke and Mirrors to Walking the Talk: Decoupling in the Contemporary World." Academy of Management Annals.


