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From Field Consensus to Fragmentation: How Means-ends Decoupling Hinders Progress on Grand Challenges

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Abstract

Grand challenges are complex problems with far reaching societal implications that lack a clear technical solution. To make progress on grand challenges, many different communities need to collaborate over an extended period of time in complex organizational fields. However, institutional scholars have primarily focused on how communities form consensus on a grand challenge's initial goals during the earliest stages of field emergence. There is little exposition of how various communities collaborate after initial field goals have been set and substantive solutions need to be pursued. With an in-depth study of the nanotechnology field, we show how disparate communities created alignment on field level goals during the early phase of field emergence. In a later phase, however, these same communities shifted to local action to the neglect of prior shared goals. This process decoupled the means and ends pursued by the participating communities producing field fragmentation. Our research shows how early consensus around a field's goals and the means to achieve these goals diverged over time. We contribute a more precise understanding of field dynamics and explain the mechanisms and conditions that can generate means-end decoupling. We conclude by discussing how field fragmentation and institutional complexity affects progress on grand challenges.

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ABSTRACT

Grand challenges are complex problems with far reaching societal implications that lack a clear technical solution. To make progress on grand challenges, many different communities need to collaborate over an extended period of time in complex organizational fields. However, institutional scholars have primarily focused on how communities form consensus on a grand challenge's initial goals during the earliest stages of field emergence. There is little exposition of how various communities collaborate after initial field goals have been set and substantive solutions need to be pursued. With an in-depth study of the nanotechnology field, we show how disparate communities created alignment on field level goals during the early phase of field emergence. In a later phase, however, these same communities shifted to local action to the neglect of prior shared goals. This process decoupled the means and ends pursued by the participating communities producing field fragmentation. Our research shows how early consensus around a field's goals and the means to achieve these goals diverged over time. We contribute a more precise understanding of field dynamics and explain the mechanisms and conditions that can generate means-end decoupling. We conclude by discussing how field fragmentation and institutional complexity affects progress on grand challenges.

INTRODUCTION

Many grand challenges like curing cancer, combating climate change and reducing poverty face the world today (Howard-Grenville, Buckle, Hoskins, & George, 2014; Kates & Dasgupta, 2007). Government, private and non-profit organizations pour billions of dollars per year into initiatives designed to address some of these grand challenges. Grand challenges share a number of key features: they lack a clear technical solution and encompass incomplete, contradictory, or changing requirements (Churchman, 1967; Rittel & Webber, 1973). It is often difficult to evaluate solutions due to the complex web of interdependencies involved in grand challenges. Determining how changes to one part of the system shape other parts of the system may be difficult to determine a priori. Thus, many diverse participants are needed to contribute to new technical or social innovations and address grand challenges at the field level. Yet, many of these initiatives fall short of achieving their initial goals. Why?

Research on field emergence can shed some light on this question. Organizational fields are a set of organizations “that partake of a common meaning system and whose participants interact more frequently and fatefully with one another than with actors outside the field” (Scott, 2000: 56). Many scholars have examined how disparate actors craft shared goals at the field level in the face of grand challenges (Lawrence & Phillips, 2004; Lounsbury, Ventresca & Hirsch, 2003; Maguire, Hardy & Lawrence, 2004; Mair & Hehenberger, 2014; Weber, Heinze & DeSoucey 2008; Wry, Lounsbury & Glynn, 2011). Lounsbury et al. (2003) show how activists assumed a different frame to transform recycling from a waste activity to a mainstream commercial activity – achieving great environmental benefit in the process. Maguire et al. (2004) detail the struggles that HIV/AIDS patients engaged in to create a common field around HIV/AIDS treatment in order to foster societal acceptance and stimulate increases in funding. Weber et al. (2008) explain how members of the grass-fed movement used rhetorical strategies to create an appreciation of and thus a market for grass-fed beef to advance ecological sustainability. However, this research tends to focus on how field participants use

framing and rhetorical strategies to generate consensus and mobilize participation and resources in the earliest stages of field formation. In doing so, they overlook the processes through which fields start to deviate or decouple from their founding goals.

There are many ways in which a field's goals evolve. This process can happen through explicit rhetoric as the contested process through which the use of DDT changed from acceptable to unacceptable (Maguire & Hardy, 2009). Or, alternatively, the goals of a field can drift over time in ways that are less noticed. Sometimes, managers and leaders seemingly adopt mandated rules or policies but fail to adopt them in practice ("symbolic adoption") (March, 1962; Meyer & Rowan, 1977; Tilcsik, 2010). Recently scholars have begun to study means-ends decoupling, which occurs when rules or policies are adopted and followed but are only loosely tied to an organization's ends or goals ("symbolic implementation"). This can happen, when an organization's focus on measurement and evaluation distracts them from activities that align with stated goals (Bromley & Powell, 2012). However, there has been little examination of how means-ends decoupling unfolds or the conditions that are more or less likely to trigger it.

This is an important omission, particularly when considering emerging fields, because in many fields, the early establishment of consensus does not necessarily last. In the early stages of field formation, there is excitement and momentum around shared goals. However, the momentum that propels cooperation in a field's early stages may dissipate as the field matures. As fields evolve and a more diverse body of participants begin contributing to the field, and the field moves beyond rhetoric toward action, the scope of the field's goals broaden and consensus may be more difficult to achieve. For example, in the early days of satellite radio, competitors cooperated to increase the legitimacy of the field, but in later stages, they competed (Navis & Glynn, 2010). To make progress on a grand challenge, diverse field participants contributing vital knowledge and resources need to cooperate on common goals, but each may have their own logic, goals and means for achieving grand field level goals (DiMaggio & Powell, 1983; Greenwood, Diaz, Li, & Lorente, 2010).

Fields consist of communities and distinct communities may approach a grand challenge from different vantage points (O'Mahony & Lakhani, 2011; Smets, Morris & Greenwood, 2012; Thornton, Ocasio & Lounsbury, 2012; Van Maanen & Barley, 1984), which can either cohere or fragment these participants' ability to work toward collective goals. For example, the field of modern architecture evolved as multiple communities with different interests shaped the values and material practices that 'modern architects' espoused (Jones, Maoret, Massa & Svejnova, 2012). Community interests provide organizing principles, which drive community goals, as well as the means appropriate to achieve those ends (Friedland & Alford, 1991). Alignment among these interests cannot be taken for granted and disparate community interests may compete when the demands they impose are not easily reconciled. In other words, fields can vary with regards to the diversity of communities and the diversity of the goals and means these communities adhere to in order to reach those goals (Greenwood et al., 2010; Pache & Santos, 2010).

When a field has multiple communities with potentially competing interests, creating and maintaining the consensus and coordination necessary to advance a grand challenge can become a challenge. This is particularly problematic when field participants need to transition from rhetoric about goals to the concrete actions needed to achieve those goals. Yet, how collaboration among multiple communities on specific endeavors might generate means-end decoupling after initial consensus on field level goals has been established is under explored. Addressing this question is important if we want to explain why field level efforts to address grand challenges advance or fall short of their aims. To address this gap, we examined the nanotechnology field dedicated to the grand challenge of creating "the ability to manipulate matter at the atomic and molecular level... [generating advances such as] shrinking all of the information at the Library of Congress into a device the size of a sugar cube" (President Clinton, January 21, 2000). If the grand challenge for the field of nanotechnology sounds ambiguous, it

was in that the aim was to create a fundamental capability that could have relevance to many social and commercial applications.

We identify two phases to the evolution of the nanotechnology field. During the first phase, three communities (futurists, government officials and service providers) generated common ends and converged on the field's goal: to facilitate atom-by-atom control and manipulation at the nano-scale. However, after consensus was reached, these founding communities transitioned from rhetoric to action; and shifted their attention to advancing the means for achieving their common goal. In the second phase of the field's evolution, two additional communities (scientists and entrepreneurs) became involved in the field. With five communities in the field, reaching consensus on common field level goals became more challenging. As each community turned their attention to local actions, they became more focused on the means to achieve local goals rather than on field level goals - neglecting the field's collective goals. The field, thus, underwent the process of means-end decoupling, transitioning from consensus to fragmentation - where communities lacked agreement on common goals and the means to reach them.

Our research details the mechanisms that drive means-ends decoupling at the field level. In doing so, we move beyond rhetorical explanations of the emergence of field consensus to identify some of the challenges fields face as they mature and specify the conditions that lead to fragmentation. Because progress on grand challenges requires a long time horizon, the initial stages of field formation are unlikely to be adequate to make progress and a longer time horizon of field level cooperation may be necessary. Means-ends decoupling is one potential threat to advancing progress on grand challenges, because this process generates misalignment among a field participants' means and ends, thus fracturing the field. By examining how a field transitions from crafting common field goals to one means-end decoupling we identify the conditions under which fields are likely to experience either field consensus or fragmentation and explain how this affects the coordination needed to address grand challenges.

THE MEANS-ENDS DECOUPLING OF ORGANIZATIONAL FIELDS

Field Emergence: Making Progress Towards Grand Challenges

For a new organizational field to emerge, diverse communities need to recognize that they are engaged in the same issue (Hoffman, 1999; Fligstein & McAdam, 2012). This assertion is supported by studies that have shown that for fields to emerge, it is important for communities to use rhetorical strategies to convince others of the value of their shared vantage point. McGuire, Hardy and Lawrence (2004) detail, for example, the activities of institutional entrepreneurs in Canada in mobilizing support for HIV/AIDS, thereby creating the initial foundations of the field of HIV/AIDS. Phillips and Lawrence (2004) show how a change in rhetoric around whales from creatures of destruction to friendly foes aided the emergence of the Canadian whale watching industry. Focusing on rhetoric, but at a more detailed level, Etzion and Ferraro (2010) emphasize how the use of analogies in financial accounting facilitated the legitimation of the field of sustainability accounting by uniting diverse stakeholders around a common framework. In a similar vein, Jones et al. (2012) detail the slow process of meaning construction that went into shaping the field of modern architecture and Weber et al. (2008) identify how participants used opposing meaning pairs to change the connotations of “grass fed beef”. Overall, these studies help explain how disparate actors leverage rhetorical strategies to collaborate on the creation of a new field.

By focusing on these rhetorical strategies, the literature on field emergence has emphasized how consensus can be reached across disparate actors to form a new field. DiMaggio (1991) shows, for example, how philanthropists, museums workers, and museum visitors engaged in vivid contestation over the museum reform movement by making comparisons to already established fields like libraries, department stores, or symphony orchestras before they settled on a new understanding of the museum. Likewise, both Navis and Glynn (2010) and Kennedy (2008) show, in two different industries, that entrants to a new field

established their legitimacy by initially referencing their competitors so that external stakeholders would view the emerging field as addressing a coherent set of issues.

However, what is missing from these studies is an understanding of what happens after consensus on the goals of the field is established. How are goals maintained as the field initiates the means necessary to achieve grand challenges? How does the growth of new participants entering the field affect the ability to make progress on common goals? A focus on only the establishment of consensus is problematic, because many fields evolve to become heterogeneous and fragmented and as a result become increasingly complex (Greenwood et al., 2010). This can no doubt affect a field's ability to coordinate on grand challenges. While field complexity is in vogue, the existing literature cannot explain how alignment among field actors becomes preserved or fractured.

The lack of attention to what happens after initial consensus on field goals has been achieved is particularly problematic if our goal is to understand how to achieve grand challenges, because many efforts to achieve grand challenges fail. For example, while 154 of the world's countries reached consensus on climate change in 1992 through the United Nations Framework Convention on Climate (UNFCCC), over 20 years later little progress has been made towards this goal. Several countries are becoming dissatisfied with the lack of progress and some countries (like Canada) have decided to withdraw from the Kyoto protocol, which in 1997, established binding emissions targets. However, current theories of field emergence can not account for what happened after the field initially achieved consensus (Howard-Grenville et al. 2014). How did this field move from consensus to fragmentation?

To answer questions like these, we need to examine all of the different types of participants engaged in a field. Fields consist of multiple communities—"voluntary collection[s] of actors whose interests overlap and whose actions are partially influenced by this perception" (O'Mahony & Lakhani, 2011: 7; see also DiMaggio & Powell, 1983). That is, fields consist of multiple communities each with disparate interests for participating in a common field (Glynn,

2008; Wenger, 1998). The interests of each community shape both their goals and the means they use to pursue those goals. Pache and Santos (2010: 459) state that conflicting interests may influence communities “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.” For example, many fields involve entrepreneurs driven by wealth creation (Thornton, 2004); scientists driven by making scientific progress (Gieryn, 1983) and government officials interested in the functioning and wealth of the state (Friedland & Alford, 1991). These three communities may share some common interests, but also maintain divergent goals. To understand how fields develop beyond the initial consensus that drives field emergence, we need to examine how the goals and means of disparate communities become aligned or misaligned.

Although diverse communities might have achieved consensus on a general goal for the field, their views on the appropriate means to advance the field might differ. For example, in Hoffman’s (1999) study of environmentalism within the chemical industry, the interests of the non-governmental organizations (NGOs) and the chemical industry differed dramatically in that NGOs emphasized that “the continued use of [DDT] and other synthetic chemicals would disrupt the “web of life,” posing a hazard to all living organisms, including humans”, whereas the chemical industry adhered to the “accepted belief... that engineering advances improved the quality of life for all humankind” (Hoffman, 1999: 360). Communities within a common field can navigate their diverging interests, by cooperating on limited shared goals, while preserving distinct local goals. For example, O’Mahony and Bechky (2008) showed how hackers in open source communities cooperated with titans of the software industry on commercializing open source software even though their views on intellectual property fundamentally differed. The shared interest in commercializing open source software was strong enough to support a defined space for collaboration that allowed both parties to maintain divergent interests.

The existence of multiple communities with different interests can make coordination on field level goals more challenging by creating plurality as to the appropriate means and ends for a field. For example, Dunn and Jones (2010) showed how medical education, while aligned on the field goal of enhancing medical understanding, encompassed an inherent tension between a focus on care and a focus on science. Powell and Sandholtz (2012) showed how the early biotechnology field was focused on generating human therapeutics based on genetic engineering, while incorporating communities focused on progressing science and communities interested in wealth creation. Jay (2013) details how both for-profit and non-profit organizations collaborated on environmental initiatives despite maintaining differing interests. The challenge for any field hoping to make progress on a grand challenge is to figure out how to maintain convergence on a common goal.

Means-end Decoupling and Field Evolution

Even when disparate contributors to a field are enthusiastic about a new idea, over time, a disconnect between the rhetoric field participants display and their adherence to the new practice might arise. For example, although many managers claimed that they had implemented Total Quality Management (TQM), they were often quite selective as to which practices they implemented (Zbaracki, 1998). The result was a disconnect between the official policies of TQM and the practices individual organizations engaged in. This pattern is characteristic of policy-practice decoupling where the policies and rules that an organization claims to adhere to and the actual practices of the organization become disconnected or decoupled (Bromley & Powell, 2012). Weick (1976) contends that one of the reasons policy-practice decoupling happens is to facilitate coordination. Often abstract policies are difficult to implement in a complex organization and a loose coupling of policies and practices facilitates localized coordination. This is particularly the case in uncertain or complex environments where it is difficult for managers to foresee the consequences of a particular policy implementation.

In contrast to policy-practice decoupling which entails symbolic adoption of practices, means-end decoupling is the symbolic implementation of practices. Means-ends decoupling unfolds over time as organizations shift their focus from goals to engage on the implementation processes needed to reach those goals. “A focus on information and procedure rather than directly on ultimate goals is at the core of means-ends decoupling” (Bromley & Powell, 2012: 26). When means-ends decoupling happens, the degree to which means are coupled to goals is unexamined and the means become ends in themselves leading to goal drift or goal displacement. Means-end decoupling has often been observed within organizations that have a social goal (Bromley & Powell, 2012). While these organizations set out to achieve a societal goal, the means they employ can divert attention from those goals. For example, the introduction of rationalistic procedures can foster goal displacement as leaders pursuit of power and influence supersedes their societal interests (Michels, 1966; Osterman, 2006; Piven & Cloward, 1977; Voss & Sherman, 2000).

Means-end decoupling need not be deliberate. Even when leaders are not power-seeking, attention toward organizational maintenance can sway the organization away from their initial goals, creating goal displacement. For example, Selznick (1949) showed how the Tennessee Valley Authority (TVA)’s efforts to gain legitimacy and attain resources led it to adopt policies that subverted its founding goals. Instead of being responsive to community interests, the agency became beholden to a small, powerful group of agrarian landholders. Nor is this a unique problem. Over attention to procedure can threaten the values that cultural agencies (Glynn & Lounsbury, 2005; Townley, 2002), universities (Kraatz, Ventresca & Deng, 2010), and other nonprofit organizations (Hwang & Powell, 2009) like museums are founded upon. While a museum might be founded with the goal of enhancing the cultural awareness of local communities, their goals over time may drift toward their own survival. The goal of cultural awareness through exhibitions is displaced by the goal of running cafes and giftshops.

Suffice it to say, the goals that organizations initially establish and the means they engage in to achieve those goals are not static over time. This can make coordination among disparate participants on common goals at the field level challenging. If multiple organizations from disparate communities are all contributing toward a common field goal, maintaining convergence on a common goal may require some vigilance. Drawing on an in-depth study of the nanotechnology field over a twenty-year period, we show that during the earliest period of field emergence, field participants generated common ends for the field, whereas later, as the field diversified, participants shifted to local forms of action to the neglect of shared goals. We identify the specific mechanisms underlying means-ends decoupling and show how this phenomena increased fragmentation of the field, inhibiting progress on a grand challenge.

METHODS

Setting: The Emerging Nanotechnology Field

We chose to study the nanotechnology field because it is an example of a grand challenge with ubiquitous applications for science, health and society that attracted diverse field participants. However, the nanotechnology field has not achieved many of the original goals established by its founding participants. The choice of the nanotechnology field 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 fields are most likely to fragment when they are moderately centralized, because they (unlike ones that are very centralized) are not governed by a single entity that guides interactions but they (unlike ones that are weakly centralized) still need to coordinate and interact with each other. We identified nanotechnology as a moderately centralized field in which participating communities had to interact in order to collaborate on joint activities. The field was, however, not fully centralized because no community – not even the powerful government – excerpted full control over the field (unlike for example the military (see Pache & Santos, 2010)).

As with most other fields, nanotechnology did not have a specific date of birth. Depending on the criteria chosen, scholars can point to slightly different dates to mark its inception. Science at the nano-scale began 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 Eric Drexler, a MIT PhD student who became a technological visionary primarily concerned with developing the field of nanotechnology (Granqvist, Grodal & Woolley, 2013; Granqvist & Laurila, 2011; Kaplan & Radin, 2011; Kennedy, Lo & Lounsbury, 2010). We call the group that grew around Eric Drexler the “futurist” community. We examine the nanotechnology field since its beginning up to the year 2005. While the first article in our data set is from 1953, very little activity occurred until 30 years later. Starting in the 1980s, when the futurist community was the only community involved in the field, we investigate how four other communities (government officials, service providers, entrepreneurs and scientists), with vastly different goals, means and interests came to be a part of the nanotechnology field. We describe these five distinct communities in more detail below.

Data Collection

The first author used theoretical sampling rather than representational sampling to guide data collection. Data collection began with a broad theoretical notion to study the emergence of complexity within organizational fields. As the first author collected data, the theoretical notion of interest became more focused and so did data collection efforts. While we present these phases of data collection chronologically, some events overlapped.

Phase 1: Ethnographic observations. The first author began data collection by conducting ethnographic observations at conferences and networking events. Conferences and networking events are field-configuring events where participants come together to negotiate the meaning of a field (Garud, 2008; Zilber, 2012). The conferences and networking events that

the first author attended were focused on the commercialization of nanotechnology and tended to attract multiple communities. During ethnographic observations, the first author recorded presentations and took notes on the activities and conversations of participants and elaborated on these field notes after each conference. During this process, we identified five different communities involved in the nanotechnology field, although they did not all enter the field at the same time. See Table 1 for an overview of the five communities and their general goals and means.

Insert Table 1 about here

Phase 2: Interviews. The next phase in data collection was to conduct interviews with representatives from each community. Initially, the first author contacted participants to interview by selecting representatives from each community identified at field-configuring conferences and networking events. The first author then used snowball sampling to identify additional informants. Archival resources also helped identify informants. Efforts were made to ensure that informants interviewed 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, the first author conducted 77 interviews (13 with futurists, 11 with government officials, 18 with service providers, 24 with entrepreneurs and 11 with scientists). Table 2 depicts an overview of how these interviews are distributed across the communities.

Insert Table 2 about here

Phase 3: Archival research. To track the development of the field over time, the first author conducted extensive archival research. First, the first author collected an extensive archival dataset by identifying documents pertaining to the central events that occurred during the emergence of the nanotechnology field. This archival material covers the first scientific articles written by Eric Drexler, which established a possible path for the development of

nanotechnology; all the reports released by the Presidents Council of Science and Technology; and important books written on the topic like Eric Drexler’s popular (1986) book *The Engines of Creation: The Coming Era of Nanotechnology*.

Second, in addition to historical materials, we collected a systematic dataset for each of the five communities by identifying a data-source in which community members conversed about the emerging field of nanotechnology. Across the five communities we identified 9,011 articles over the period 1984-2005. We also collected 3,762 articles from the top 50 US Newspapers to contextualize the evolution of the field. See Table 2 for a detailed overview of the archival data.

Data Analysis

We coded the data using a grounded theory approach (Lofland & Lofland, 1995). We arranged all the archival material chronologically to obtain an in depth understanding of the temporal development of the field. Based on this temporal ordering, our analysis proceeded in five steps. Figure 1 provides an overview of our coding process.

Insert Figure 1 about here

Step 1: Identifying the shift from consensus to fragmentation. The first step in our data analysis was open coding. During this coding process, we realized that in the beginning of the field the founding communities crafted shared goals, however, these goals were never met, and the field had become fragmented with regards to the goals that the different communities strove towards.

Step 2: Identifying two processes “generating common ends” and “means-end decoupling”. We compared and contrasted across the five communities to understand how field

fragmentation developed. This led us to identify two processes: “generating common ends” and “means-end decoupling”.

Step 3: Identifying the mechanisms that contributed to generating common ends. In the next step of analysis, we examined the coded text associated with generating common ends. We identified two mechanisms: “crafting field goals” and “coordinating collectively” which contributed to generating common ends.

Step 4: Identifying the mechanisms that contributed to means-end decoupling. In the next step of data coding, we examined statements related to means-end decoupling to tease out the mechanisms that contributed to this process. We identified three mechanisms that constituted means-ends decoupling: “translating goals into action”, “coordinating locally” and “neglecting field goals”.

Step 5: Identifying the conditions that triggered the process from field consensus to fragmentation. In the final step of data analysis, we revisited the data to identify the underlying conditions that set the means-ends decoupling process in motion, triggering the transition from consensus to fragmentation. In comparing and contrasting the two field processes we identified three conditions that fostered means-end decoupling: 1) Introduction of new resources; 2) the need to integrate with existing institutionalized practices; and 3) increased diversity of field participants.

FROM FIELD CONSENSUS TO FRAGMENTATION: MEANS-END DECOUPLING WITHIN THE NANOTECHNOLOGY FIELD (1986-2005)

We explain how the nanotechnology field transitioned from consensus on field goals, to a fragmented field where a growing number of communities shifted to focus on local action. A field becomes fragmented when there are many constituents who lack agreement on common goals and the means to reach them. During an initial period of field consensus, from around 1986 until the announcement of the National Nanotechnology Initiative (NNI) in 2000, three

different communities became involved with the nanotechnology field and oriented around the common goal of making progress on creating new techniques to control matter at the atomic and molecular level. After the initiation of the National Nanotechnology Initiative, in 2001, until 2005, two more communities entered the field. With five communities participating in the development of the field, communities began to diverge with regards to both their goals for the field as well as the means to reach those goals.

We argue that the transition from field level consensus to fragmentation can be explained through the process of means-end decoupling. Although this construct is discussed in the literature (Bromley & Powell, 2012), the drivers that underlie means-end decoupling are not well understood. Our research identifies the specific mechanisms and processes by which means-end decoupling takes place at the field level.

GENERATING COMMON ENDS (1986-2000)

During the 1980s and 1990s, three different communities became involved in nanotechnology – each with their own set of interests: Futurists, government officials and service providers, but they all coordinated on common field goals. Figure 2 shows how communities’ interest in the field evolved between 1986 and 2000 by indicating the degree to which articles on nanotechnology appeared within each community.

Insert Figure 2 about here

The futurist community was the first and only community crafting goals for the nanotechnology field in the 1980s. During the late 1990s, government officials and service providers became interested in nanotechnology as well and all three communities began to orient around a grand challenge for the field of nanotechnology: Advancing atom-by-atom controlled manipulation at the nano-scale. This was a broad but ambitious goal that could transform production of all

material things. We identified two mechanisms that fostered the generation of common ends at this time: 1) *crafting field goals* and 2) *coordinating collectively*.

Crafting Field Goals

The first mechanism that fostered field consensus on the grand challenge for nanotechnology was the creation of common goals for the field despite different communities' divergent interests. We explain how each community converged on goals for the field in the order in which they engaged with the field.

The futurists. The idea of creating a new organizational field around nanotechnology emerged in the 1980s and was the brainchild of futurist Eric Drexler. He popularized his vision of nanotechnology in his 1986 book *The Engines of Creation: The Coming Era of Nanotechnology*, which we take as the beginning of field formation. This book speculated that the future of technology would be bottom-up molecular manufacturing, where goods like calculators and computers would be produced by precisely assembling individual atoms into desired structures. Drexler envisioned the creation of desktop manufacturing systems using only a raw material like crude oil that would build things on demand atom-by-atom, and nano-robots that would flow around the bloodstream and remove plaque. The futurist community wanted to develop a field that would aid humanity and prevent any negative consequences that could arise from nanotechnology. In the first issue of the *Foresight Update*, the futurists discussed their goals for the emerging nanotechnology field:

If we face great challenges as a civilization, shouldn't we organize in some way to meet them?... We will need networks of informed individuals and forums for discussion. We will need organizations able to influence public policy, including international policy. (*Foresight Update*, 15 June 2012: 1)

The community of futurists was clear in their desire to influence public policy and set out to ensure that other communities in the field shared this vision. However, they were less certain about the means to achieve those goals. One of the main activities futurists engaged in was

mobilizing other communities around the goal of developing 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, government officials with the U.S. President's Council of Advisors on Science and Technology (PCAST) were looking to convince Congress to increase funding for science and engineering to enhance US competitiveness in science based industries. When they heard the futurists' vision of a nanotechnology field, they saw an opportunity to generate support in Congress for increases in science funding. The futurists' ideas about nanotechnology were compatible with politicians' desire to appear as leaders and builders of the next scientific revolution. A government white paper on nanotechnology highlights some of the questions under consideration at this time:

What if we could build things the way nature does – atom by atom and molecule by molecule?... How about bricks and other building materials that can sense weather conditions and then respond by altering their inner structures to be more or less permeable to air and humidity?... (IWEG, 1999: 2).

The goals of government officials aligned well with the futurists' goals of securing funding to advance general scientific and technological progress and further the nation's intellectual leadership. A member of PCAST, Tom Kalil, 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. (*Small Time Magazine*, March 4th, 2005)

From Tom's perspective, one of the government's major roles was to ensure the nation's long-term competitiveness and he, among others, thought could happen by increasing funding for science and engineering.

Service providers. Service providers are professionals (e.g. lawyers, venture capitalists, and journalists) aiming to provide services and increase information about the field of nanotechnology. Service providers saw opportunities to join and stimulate the growth of the nanotechnology field to capitalize on this emerging market by starting conference organizations and trade magazines. Louise Hansen, the CEO, of the trade magazine *NanoNews*, described the role she envisioned for *NanoNews* when the 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.

At this time, the goal of *NanoNews* was aligned with the goals of both the futurist and the community of government officials as they all aimed to build a common field to advance the capability to “shape the world atom by atom”. At this time, these field goals could be pursued in tandem without conflicting with the goals each community had for their members.

Service providers, like venture capitalists, were excited about developing a nanotechnology field and lobbied the government in the hope of increasing the government’s involvement in the field. Venture capitalists thought a government initiative could help them fund the commercialization process from discovery to product creation and ignite a new commercial space. Chick Vennum, a high-ranking official from UniTech (a top research university) and prior member of PCAST, described the role of the venture capitalist community at this time:

...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.

Service providers like patent lawyers were also excited about the prospect of a new field, which could help create a new lucrative area of patent-litigation.

[Nanotechnology] is now and will continue to be a very lucrative area for patent lawyers.....[.....]......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.

To facilitate the development of the field and increase their knowledge of nanotechnology, many patent lawyers attended early nanotechnology conferences and meetings where they took part in discussing the goals of the field with both the communities of futurists and government officials. The community of service providers were interested in creating a market for nanotechnology expertise and thus their goals were aligned with the other two communities to create a common field that could attract both government and venture capital funding and further scientific as well as commercial growth of nanotechnology applications.

Scientists. The futurists had made early attempts to involve scientists within the nanotechnology field as they thought the scientific community ought to be the most interested in seeing the nanotechnology field develop. They recognized that scientific expertise was needed to actually make progress on their grand vision. Indeed, Eric Drexler, saw himself primarily as a scientist, and thus knew that the involvement of other scientists was necessary for the field of nanotechnology to mature. However, the futurists were largely unsuccessful in this endeavor, as the logic of science espoused by most scientists was not well aligned with the goals of the nanotechnology field at this time (see also Kaplan & Radin, 2011). To most scientists, the goals of the nanotechnology field sounded like science fiction and were far removed from serious scientific endeavors. One scientist, Matt Klinger, explained this position.

Most people think [Drexler] is kind of crazy....I think scientists generally have a negative view [of the futurists]... [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 [Drexler] is an easy target.

Entrepreneurs. Entrepreneurs, were more interested in the nano grand challenge than the scientific community, but were still skeptical about the short-term commercial application of these ideas. The entrepreneurial community was focused on near-term economic gain and the visions promoted by the other three communities at this time seemed a long time into the future. In particular, entrepreneurs thought that the futurist's ideas were at odds with a quick technological development. Below is a quote from Carl Wanger, who expresses a view of the futurists commonly held in the entrepreneurial 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.

Thus, few scientists or entrepreneurs participated in crafting field goals during the 1980s and 1990s. While the futurists tried to involve these two communities, most scientists and entrepreneurs considered the grand challenge of achieving atom-by-atom control over matter too far into the future to warrant their involvement. However, both the government and service providers were on board with the futurists. An interagency governmental working group reported that:

The emerging fields of nanoscience and nanoengineering are leading to unprecedented understanding and control over the fundamental building blocks of all physical things. This is likely to change the way almost everything –from vaccines to computers to automobiles tires to objects not yet imagined is designed and made. (*IWGN, 1999: 1*)

For the scientists, bold language such as this conflicted with values of scientific purity and peer review (Gieryn, 1983), where statements needed to be justified by drawing on existing scientific knowledge. There was no clear scientific path to explain how these grand challenges could be achieved. Scientists and entrepreneurs therefore explicitly rejected the goals espoused by futurists, government officials and service providers and were only peripherally engaged in creating the goals associated with nanotechnology during the field's early stages.

Coordinating Collectively

An additional mechanism that fostered field level consensus on the grand challenge for nanotechnology was the communities' willingness to coordinate collectively on common field goals. During the 1980s and 1990s, the futurists, government officials and service provider communities all *coordinated collectively* with each other by interacting directly with each other to craft field level goals. Collective coordination was achieved through nanotechnology specific conferences that included all three communities. The futurist community organized an annual conference where representatives from all three communities were invited to participate.

From the late 1980s until year 2000, the Foresight conference was the convening place where people met to discuss the goals of the nanotechnology field. The first Foresight conference, held in 1989, was a field-configuring event (see Garud, 2008), where community members collectively negotiated the goals of the field. At this conference, field participants collectively defined nanotechnology as the “thorough control of the structure of matter” and set the goal for the field as “understanding and building structures, devices, and systems on the scale of molecules” (*Foresight Update 7*, 1989: 1). The Foresight conference was the one gathering place for everyone interested in nanotechnology, as there was no other place 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.

Only a few entrepreneurs and scientists were present at the 1989 conference (or earlier) as these two communities were focused on their current goals of advancing the products and the science relevant in the here and now: they both viewed the nanotechnology field as too future oriented and thus less relevant to them.

After the government community became involved in the field, they became conveners, organizing meetings that invited all of the communities. However, these hearings were dominated by the futurists, government officials, and service providers. From the early 1980s to the year 2000, three communities: futurists, government officials and service providers generated common ends on the lofty but ambiguous grand challenge of “shaping the world atom by atom”. Although each community had very different interests, they still managed to organize around common field goals and coordinate collectively in the same forums.

MEANS-END DECOUPLING (2001-2005)

We identified three distinct triggers that set the means-ends decoupling process in motion. First, there was the introduction of new resources through the allocation of funds to the National Nanotechnology Initiative - a government initiative tasked with funneling hundreds of millions of dollars into nanotechnology research. Second, to make progress on the means to achieve the grand challenge, field founders needed to figure out how to integrate the field’s goal with existing practices in highly institutionalized environments like academic science. For example, government officials realized that to attract scientists and entrepreneurs to the field, they needed to craft funding proposals in ways that were consistent with scientists existing language and work practices. Third, the allocation of new resources to the field attracted more diverse participants who had not been part of collective coordination on field goals.

When the three founding communities shifted from crafting the grand challenge to the actual means of achieving this goal, they needed the engagement of scientists doing real science in this area and of entrepreneurs taking on the actual risk of commercial development. However, the goals of these two communities were not the ones espoused by the three founding communities. This chasm between means and goals widened through a process of means-ends decoupling which helped fragment the field and distance most communities from the field’s

founding goals. We found that the process of means-end decoupling depended on three mechanisms: 1) *translating goals into action*, 2) *coordinating locally*, and 3) *neglecting field level goals*.

Translating Goals into Action

The first mechanism, which contributed to means-end decoupling, was the shift among all communities from crafting common field goals to coordinating around the means or activities necessary to actually make scientific and technological progress in nanotechnology. After Congress passed the NNI, government officials in each federal agency had to figure out which proposals to fund. At this time, few scientific projects were close to building desktop manufacturing systems or robots made with atom-by-atom precision. Thus, government agencies allocated funds to research projects at the nano-scale with immediate goals that were more readily accomplishable and more likely to be appreciated by mainstream scientists than the goals articulated by the three founding communities.

Venture capitalists were excited about the grand goals for nanotechnology as laid out by the futurists, but when it came to allocating their investments, they sought growth companies that would yield a reasonable return within a short time span. Thus, they adopted their funding patterns to more immediate goals, much like government officials. For example, William Peterson, a prominent venture capitalist described how it was the grand challenge of creating robotic systems atom-by-atom that initially captivated venture capitalists and led them to participate in the nanotechnology field, but they focused on funding applications far removed from this original vision. William Peterson continued explaining how his venture capital firm 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..... 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.

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 “proof of concept” of molecular manufacturing – that is documenting that creating technologies atom-by-atom was possible. Originally, the NNI included funds earmarked for this specific purpose. However, during the legislative process, these provisions were removed from the legislation - an action that infuriated the futurists. One prominent futurist 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-assemblywhich is a meaningless term, because it is already done all the time.

As government officials began making funding decisions, service providers began creating investment funds and organizing their own nanotechnology conferences independent of the futurists. These convening events started to draw scientists and entrepreneurs into the nanotechnology field, but they were not asked to agree with the founders' overall vision of the nanotechnology field. Rather, both the scientific and entrepreneurial communities began presenting their current research at nanotechnology conferences and networking events that were not hosted by the futurists. While both scientists and entrepreneurs remained wary of the overall goal of the nanotechnology field, participating in these new conferences provided

visibility and connections to stakeholders as well as resources that they would otherwise not have access too.

Coordinating Locally

The second mechanism, which facilitated means-ends decoupling, was a shift from the founding communities collectively coordinating in common forums to select communities engaging in local coordination. Rather than all three communities working together directly with each other to determine common goals, actions to pursue field goals became negotiated and integrated within just one or two communities at a time. One EPA official, Dr. Balunski, for example, explained how her department chose 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'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.

Dr. Balunski's strategy for allocating funds to the scientific community was not to follow the exact guidelines of what was defined as "nanotechnology". Her main concern was to fund the best science as defined by the existing peer review process grounded in the current standards of what constituted quality science. That is, who got funded was negotiated locally between government officials and the scientists participating in the peer review process. Of the proposals funded, some might support the goals for nanotechnology agreed upon previously and others might not. This meant that most of the proposals funded with monies from the National Nanotechnology Initiative were not allocated to research projects aligned with the field's prior vision to produce desktop manufacturing systems or nanobots, but rather to research projects investigating more mundane and near-term scientific questions like how nano-materials interact with water.

The shift to local action between select communities fostered decoupling between the goals originally espoused for the field and the actual activities participants later carried out. This disconnect was possible because even though the three founding communities were initially aligned on their goals for the field, they were not necessarily aligned with regards to the means to carry them out. The process of means-ends decoupling initiated as each community began to diverge on the best course of action to accomplish espoused field goals.

Neglecting Field Goals

The third mechanism contributing to means-ends decoupling was goals neglect – where communities stopped attending to the field goals once agreed upon to the neglect of the field’s grand founding goals. Empirically, identifying patterns of actions that do not take place is more difficult than identifying actions that take place. However, we found evidence that the lack of goal maintenance contributed to goal neglect. Using a sports metaphor government official, Phil Bond, for example suggested that actually advancing science was “more important” than crafting a common goal:

Deciding upon a goal for nanotechnology will be “helpful” said Under Secretary of Commerce for Technology Phil Bond. But in the end, he said, its more important for the nanotechnology industry to ‘do our blocking and tackling’ (July 9, 2003, *Solid State Technology*)

While early in the field, communities spent considerable effort building consensus around field goals, this activity received less attention once communities began focusing on means and pursuing local action. The lack of attention to field goals meant that the goals the different communities associated with nanotechnology began to drift toward each community’s more immediate goals. Four out of five communities’ goals for the field of nanotechnology drifted from the field’s founding goals between 1986 and 2005 towards more immediate goals. The only community to remain steadfast to the grand vision previously articulated for nanotechnology was the futurists.

While the futurists still saw the goal of the nanotechnology field as the creation of atom-by-atom control to build microscopic assembler robots, this was no longer true for government and service provider communities. Most government officials were content as long as monies were furthering scientific research on nanotechnology materials and tools. Service providers were content as long as there was demand for their services. One futurist, Sam Mallort, complained about how the other communities no longer wanted to engage in discussions 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.... 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's formation, the three founding communities crafted consensus on the overall goals for nanotechnology, these same communities were no longer in agreement. While the futurists clung to the field's founding goals, the government and service provider communities broadened their goals to accommodate the goals of scientists and entrepreneurs. These two founding communities became reluctant to discuss field goals for nanotechnology out of concern that it would disrupt the current focus on scientific and entrepreneurial activities – where progress on near term activities was actually being made. Figure 3 shows the field's shift from a focus on the grand goal towards more immediate goals.

Insert Figure 3 about here

Field Fragmentation

We consider a field to be fragmented when there are many constituents who lack agreement on common goals and on the means to reach them. Table 7a provides evidence of fragmentation within the nanotechnology field across the five communities with regards to the goals of the field and Table 7b shows fragmentation across the five communities with regards to the means.

Insert Table 7a and Table 7b about here

By 2005, of the ten possible pairwise relationships among the five communities with regards to their goals for the nanotechnology field, six were misaligned, two mixed, and only two aligned. When examining the ten possible pairwise relationships with regards to the means of the five communities, four were misaligned, two mixed, and four aligned. The government's means aligned with service providers and scientists; while the service providers means aligned with entrepreneurs. Of note, the founders of the field and initial articulators of the grand vision, the futurists, were not aligned on the means pursued by any other community. While there was initially consensus on common ends in the early stages of field formation, the field had fragmented by the end of 2005. Our analysis indicates that the process of means-ends decoupling was responsible for this shift.

From Consensus to Fragmentation – Means-end Decoupling within Organizational Fields

This paper offers one explanation of why grand challenges have difficulty achieving their stated goals by unpacking the process through which initial consensus on field goals becomes disrupted and fragmented once a field converges on a common grand challenge. The theoretical model in Figure 4 depicts a generalizable model for how the process of means-ends decoupling unfolds.

Insert Figure 4 about here

Initially communities engage in the process of generating common ends to help field participants realize the interests they hold in common early in the field's formation. Two mechanisms support this process: crafting goals for the field as a whole and coordinating collectively with all founding communities in the same venues at the same time. These two mechanisms help produce general consensus on the goals of the field, but this consensus does not necessarily endure.

Three triggers help set the process of means-ends decoupling in motion. First, the introduction of new resources devoted to a field's grand challenge marks a point of transition in a field's evolution, because, with money in hand, the field's participants begin to consider how to use those funds to achieve the field's goal. Second, translating grand goals into actions requires integrating these goals with existing institutionalized practices. In our case, this occurred within scientific and entrepreneurial communities where new advances can actually take shape. The need to coordinate within existing institutionalized work contexts hinders focus on the field's goal as these work contexts are set up to achieve more immediate goals rather than the field's grand challenge. Third, the introduction of new resources attracts more participants to join the field, expanding the diversity of participants in the field. In our case, the founding communities courted new participants who had the necessary skills to progress science and technology to achieve the grand challenge but this also introduced new interests within the field and made consensus more difficult to achieve.

DISCUSSION

Our research began by examining why grand challenges fall short of their stated goals. This is not just a practical problem, but a question with consequences for policy and theory that

institutional theorists can help answer. While institutional theorists have examined how early communities reach consensus on an emerging field's goals (e.g. Maguire, Hardy & Lawrence, 2004; Mair & Hehenberger, 2014), less attention has been paid to understanding what happens when communities transition from the rhetoric of crafting goals to engaging in the activities that will accomplish these goals. This is problematic, because if we want to understand how to make progress on grand challenges, we not only need to understand how goals are set, but how real progress towards these grand challenges are made.

Lessons from the Kyoto protocol in 1997 teach us that consensus on a field goal (like binding emissions targets) is not enough to constitute progress toward a grand challenge. Grand challenges require lengthy periods of time for progress to happen and thus, we need to understand how a field's goals evolve as fields mature. Mature fields display a high degree of heterogeneity and fragmentation (Greenwood et al., 2011), which can inhibit progress on grand challenges. However, little research explains how this happens. Bromley and Powell (2012) explain what means-ends decoupling is and how it can undermine the good intentions of organizations, but little research has examined the mechanisms behind this process at the field level. Without understanding what stands in the way of grand challenges, scholars and policy makers are helpless to eradicate barriers to progress.

Our research uncovers the mechanisms behind the process of means-end decoupling and shows how initial consensus on common goals became fragmented over time to the neglect of the grand challenge. In doing so, this paper makes several contributions. First, we contribute a theoretical explanation of why grand challenges are difficult to achieve. Second, we add to theories of field emergence by explaining how the initial consensus that establishes a new field becomes fragmented through the process of means-end decoupling. Third, we identify the mechanisms that facilitate means-end decoupling as well as the triggers that set the process in motion. Lastly, our findings reveal endogenous sources of institutional complexity.

Making Headway on Grand Challenges: How Do Organizational Fields Evolve from Consensus to Fragmentation?

Grand challenges involve making progress on some of the world's most pressing problems like combating global warming (Howard-Grenville et al., 2014), addressing world poverty (Kates & Dasgupta, 2007), or developing cures for deadly diseases (Daar et al., 2007). Advancing these grand challenges, by definition, necessitates inventing new to the world solutions or technologies (Churchman, 1967; Rittel & Webber, 1973), which benefit from the contributions of diverse participants. Management scholars have made little leeway in applying organizational theory to explain why grand challenges are difficult to achieve. This paper takes a step in this direction.

The existing literature on field emergence can explain how field founders create consensus on the meaning and goals of nascent fields (Lawrence & Phillips, 2004; Lounsbury et al., 2003; Weber et al., 2008; Wry et al., 2011). However, this literature says less about what happens after consensus has formed. Fields change and as they evolve, so do their participants, goals and the means to achieve those goals. For example, Wry et al. (2011) theorize about the process through which initial field participants mobilize and the strategies they use to increase participation within the field without inducing too much heterogeneity. However, this theory assumes that a field's founding communities can control who joins the field. Few fields are bounded and can be orchestrated in that manner. Second, this theory does not take into account the ways in which the dynamics of the field might change once consensus has been reached on field goals. As fields grow, their members are likely to become more diverse and with this growth in constituents, their goals and means broaden in turn. What affects a field's ability to sustain consensus on a grand challenge or vision over time?

This paper refines this literature by highlighting the dynamics, which take place after a field's grand challenges or goals have formed and participants shift to focus on the actual activities aimed at advancing the field. As this happens, grand goals transform and become

more immediate goals that can only take shape within existing institutional structures. What our research suggests is that grand goals are difficult to shoehorn into existing work practices. For ideas to become embedded in local understandings, they must be adapted to the specific context (Bechky, 2003). While translation is necessary for local coordination to occur (Carlile, 2004), if all field participants are allowed to accomplish their own local translations, then without collective coordination, it is easy to see how the goals of the field can drift. When people work on breakthrough innovations, differing interpretations of a single grand idea can persist, and without active coordination of the ultimate goal, the end result can drift or become incoherent (Seidel & O'Mahony, 2014).

Our research provides an eagle eye but comprehensive view of how the interactions of a variety of constituents founding a field shape its evolution. Most studies of field emergence have focused on only one or two types of participants (Lawrence & Phillips, 2004; Maguire et al., 2004; Weber et al., 2008). These studies have not investigated how coordination is achieved among multiple communities that retain divergent interests. Yet, most fields are composed of many disparate types of contributors and in fact, this is a key condition for creating a locus of innovation (Powell, Koput & Smith-Doerr, 1996), which is necessary for progress to be made on a grand challenge. By examining the shifting participation of multiple communities at the same time, we show how initial differences are overcome to support collaboration (e.g. Bechky & O'Mahony, 2008) as well as what subjugates these relationships to fracture. While new communities with new skills are necessary for a field to continue to grow, their inclusion can change the course of the field's evolution. The inclusion of divergent interests can successfully broaden the boundaries of a field (e.g. Jones et al., 2012) or fragment the field and foster its collapse. Our research identifies some of the conditions that may trigger the latter – which should be of interest to policymakers and organizational theorists alike.

Means-End Decoupling within Emerging Fields

Classic theories of decoupling have viewed decoupling as the loosening of the connective tissues that binds the formal and informal aspects of the organization (March, 1962; Tilcsik, 2010). If this was the case, in our study, field communities might have claimed to support nanotechnology, but yet not take any steps in that direction. However, an alternative form of decoupling can happen when organizations lose sight of their goals and become enamored with the means once associated with those goals (Bromley & Powell, 2012). When means-ends decoupling happens, the means become a focus of attention, even though there is “scant evidence...to show that these activities are linked to organizational effectiveness or outcomes” (Bromley and Powell, 2012:14). This form of decoupling has received less attention, but is no less pernicious in its effect. Bromley and Powell outline some of the symptoms of means-ends decoupling, but not the mechanisms that underlie it. Our research identifies both the mechanisms that foster consensus as well as the mechanisms that fracture it.

Another important debate in the literature on decoupling is the extent to which institutional pressures derive from within organizational systems or are imposed from the outside. Meyer and Rowan (1977) proposed that decoupling happens as organizations conform to rationalization pressures in the environment. Our research suggests an endogenous explanation where communities’ interests and how they navigate conflicting institutional demands are gradually disposed towards means-end decoupling. This paper examines an endogenous process in which decoupling occurs not because of the relationship between a firm and its external environment, but rather from localized and distributed demands within the field itself. While much of the existing research on decoupling has focused on how organizations signal compliance without changing their underlying practices (Tilcsik, 2010), more recent literature has investigated how organizations might not change their symbols, but alter their practices under the radar (Hsu & Grodal, 2015; Snellman, 2013).

We must consider the extent to which decoupling was detrimental or beneficial to achieving the field's grand challenge. Weick (1976), one of the first scholars to theorize about decoupling within organizations, put forward the notion that loose coupling was possibly beneficial for organizations, because it enabled grand ideas, which lacked specificity, to be implemented within existing complex work practices. Weick's (1984) view was that some degree of decoupling was inevitable and perhaps even necessary for progress on abstract ideas to be made. His theory of 'small wins' accepted the idea that the translation from grand ideas to immediate goals could be helpful in enabling progress to occur. Weick understood that what makes grand challenges difficult is the problem of where to initiate solutioning and his theory of small wins advocates decomposing larger problems into small ones, that are more easily accomplished. This may be why means-ends decoupling is most likely to be prevalent when the effects of collective action are ambiguous or difficult to measure (Bromley & Powell, 2012: 26-27). With respect and consideration for Weick, our research suggests that while means-ends decoupling may have facilitated coordination among new participants to the field in the near term, over the period of observation, means-ends decoupling became detrimental to accomplishing the grand goal the field of nanotechnology set out to achieve.

Conclusively, this paper identifies why grand challenges are so hard to achieve by investigating how means-end decoupling shifts a field from consensus to fragmentation and hinders progress towards the fields original goal. We traced the evolution of five communities participation in an emerging field from its inception through its first two decades. At this point in time it is difficult to assess what type of progress on the nanotechnology grand challenge will ultimately be made, but future research should examine how fields focused on grand challenges change through their entire institutional life-cycle as the grand challenges they are working on will also no doubt evolve.

TABLE 1
General Community Goals and Means

	Futurists	Government officials	Service providers	Entrepreneurs	Scientists
General community goal	Develop technological fields that aid humanity and saves them from the negative consequences of technology development.	Strengthen U.S. competitiveness through investments in science and technology.	Develop industry specific professional skills that can be sold as services at a high value.	Acquire capital and resources to create new markets with high growth potential.	Work within invisible colleges to generate new universal knowledge by subjecting scholarly work to academic peer review.
General community means	Organize conferences and write newsletters.	Generate government initiatives and fund scientific efforts.	Organize conference, publish trade magazines, provide consulting service and fund entrepreneurs.	Engage in product development activities.	Conduct scientific experiments.
Community's interest in nanotechnology	<p>“[Nanotechnology] is really going to happen at some point, and people deserve to know. ... And what we can do today is look at longer term issues, like control issues and things like that... The ideas really got out there to the general public...” <i>(Catherine Zimmerman)</i></p>	<p>“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” <i>(Tim Kilberg)</i></p>	<p>“[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....” <i>(Rob Peterson)</i></p>	<p>“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” <i>(Henrik Bergman)</i></p>	<p>“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” <i>(Matt Mortensen)</i></p>

TABLE 2
Overview of the Data

	Futurists	Government officials	Service providers	Entrepreneurs	Scientists
Interviews (N = 77)	13	11	18	24	11
Archival data source	<i>Foresight Update</i>	Congressional hearings	<i>Fortune, Forbes, The Wall Street Journal, Business Week</i>	Press releases	The journal <i>Science</i>
Archival data years	1987-2004	1991-2005	1984-2005	1988-2005	1956-2005
Articles analyzed quantitatively (N = 9,011)♦	926	925	494	4,157	2509
Articles analyzed qualitatively (N = 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)					
♦The archival data listed above was supplemented with additional important documents pivotal in the development of nanotechnology.					
* Many of the articles were only one or two paragraphs					

TABLE 5a Goal Misalignment within the Nanotechnology Field (2001-2005)

	Futurists	Government	Service providers	Entrepreneurs	Scientists
Futurists		Misaligned	Misaligned	Misaligned	Misaligned
Government			Aligned	Aligned/Misaligned	Misaligned
Service Provider				Aligned	Misaligned
Entrepreneurs					Aligned/Misaligned
Scientists					

White boxes represent alignment in the communities' goals. Grey boxes represent misalignment in the communities' goals. Light grey boxes represent that part of the communities' goals are aligned whereas others are misaligned.

TABLE 5b: Means Misalignment within the Nanotechnology Field (2001-2005)

	Futurists	Government	Service providers	Entrepreneurs	Scientists
Futurists		Misaligned	Misaligned	Misaligned	Misaligned
Government			Aligned	Aligned/Misaligned	Aligned
Service providers				Aligned	Aligned/Misaligned
Entrepreneurs					Aligned
Scientists					

White boxes represent that the means of the communities' were aligned. Grey boxes represent misalignment in the means of the communities. Light grey boxes represent that the means of the communities were both aligned and misaligned.