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HOW DOES A GRAND CHALLENGE BECOME DISPLACED? EXPLAINING THE DUALITY OF FIELD MOBILIZATION

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"Grand challenges" are complex problems with far-reaching societal implications that lack a clear solution. To make progress, diverse communities often coalesce around an ambitious field goal. However, many field initiatives fall short of their initial objectives. When fields mobilize for a grand challenge, what inhibits them from realizing their intended ambitions? This is a critical question not only for grand challenges, but also for institutional theory, which tends to focus on field mobilization rather than on how goals are pursued over time. Field scholars often assume stable participants with goals that easily translate into actions, but fields are dynamic and unlikely to comply with these assumptions. With a longitudinal, multimethod study of the nanotechnology field, we examined how five communities mobilized and pursued the grand challenge of creating molecular manufacturing from 1986 to 2005. We identify a key duality of mobilization: the very strategies employed to successfully mobilize diverse participants to support the grand challenge actually helped displace it with less ambitious goals. We develop a grounded theoretical model explaining goal displacement in the context of grand challenges, and, in so doing, contribute a dynamic political understanding of field-level strategic action.

> It was very hard to get funding. Even though we helped get the National Nanotechnology Initiative going, it was immediately hijacked by people who wanted to do the near-term stuff. I often say it would be as if Kennedy had said, "I have a vision for going to the moon and back and we're going to have a big space program, we're going to open up the space frontier and develop space industry and space resources," and Boeing or Lockheed say, "Well, you know, we're in the space business, we go from Miami to LA, fund us."
>
> (Peter Johnson, contributor to the National Nanotechnology Initiative grand challenge)

"Grand challenges" are ambitious problems that lack a clear single solution, and encompass incomplete, contradictory, or changing requirements that often unfold in complex systems (e.g., Churchman, 1967; Ferraro, Etzion, & Gehman, 2015; Rittel & Webber, 1973). Grand challenge initiatives such as developing a malaria vaccine, combating climate change, and reducing poverty unfold in organizational fields composed of participants from multiple disciplines and communities (e.g., Ferraro et al., 2015). Making progress depends on a concerted effort among diverse participants who bring different skills to the problem, but who also face "special challenges and opportunities with respect to collaboration" (National Science Foundation, 2011: 71). Government, private, and nonprofit organizations pour billions of dollars per year into initiatives designed to address grand challenges like decoding the human genome, curing cancer, and reducing waste (e.g., Kates & Dasgupta, 2007). However, many field initiatives fall short of their initial goals. So, when fields successfully mobilize support for a grand challenge, what inhibits the realization of these initial ambitions? This is a critical question not only for grand challenges, but also for institutional theory, which tends to focus on how fields mobilize in the early stages of a grand challenge rather than on how participants pursue field-level goals over time.

"Organizational fields" are a set of organizations "that partake of a common meaning system and whose participants interact more frequently and

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fatefully with one another than with actors outside the field" (Scott, 2000: 56). In other words, fields are relational spaces where organizations have the opportunity to involve themselves with one another on affairs that mutually affect them (Wooten & Hoffman, 2008). To address grand challenges, diverse communities often coalesce to further ambitious field-level goals (Evans & Kay, 2008; Hoffman, 1999). For example, the Human Genome Project mobilized the world's largest biological collaborative to identify and map the human genome (Collins, Morgan, & Patrinos, 2003). Thus, grand challenges typically unfold not within a single organization, but at the field level, where actors and actions are more distributed, diverse, and more difficult to govern than they are within organizations (Powell, 1990; Powell, Koput, & Smith-Doerr, 1996). This distinction is not inconsequential, as fields often lack an overarching authority, and any understanding of a shared issue is likely to be continuously (re)negotiated (e.g., Schüssler, Ruling, & Wittneben, 2014).

Scholars have shown that, when fields mobilize, they build a broad base of political and social support, garnering legitimacy and resources—signs of cumulative energy within a field to propel participants toward a common goal (McAdam & Snow, 1997; McCarthy & Wolfson, 1996; McCarthy & Zald, 1977, 2001) that one organization could not achieve on its own. What is less appreciated is that a "broad tent" can also stretch or test the integrity of a field's initial goals. Theorists tend to assume that mobilizing a broad base of support for a common goal will provide a source of a strength in spurring action toward that goal, without considering how potentially divisive interests nestled within that base of support can affect the sustained integrity of a field's goals.

Institutional scholars have examined how diverse communities mobilize to address grand challenges such as recycling waste (Lounsbury, Ventresca, & Hirsch, 2003), curing HIV/AIDS (Maguire, Hardy, & Lawrence, 2004), alleviating poverty (Mair, Martí, & Ventresca, 2012), and improving the sustainability of animal farming practices (Kates & Dasgupta, 2007; Weber, Heinze, & DeSoucey, 2008). This research shows how diverse communities converge on what constitutes a grand challenge, mobilize support, and garner resources to address it (e.g., Hoffman, 1999; Lounsbury et al., 2003; Weber et al., 2008), but not how these mobilization strategies affect a field's ability to realize its goals. For example, while Sine and Lee (2009) predicted that U.S. states with more environmentalists are more likely to support renewable energy and thus attract wind power project filings, they did not examine which projects become implemented, a process often fraught with contestation (e.g., Guo, 2014). While mobilizing attention and resources is critical (e.g., McCarthy & Zald, 1977, 2001), taking action on complex, ambitious, field-level goals can become difficult over time given the political dynamic of field participants. The existing literature does not always recognize the political realities of field dynamics that can unfold after fields mobilize and attempt to make progress on grand challenges.

What is needed is a more dynamic appreciation of field-level strategic action that takes into account how the political realities of fields affect progress on evolving issues. Without examining how participants' rhetoric and underlying interests evolve as they take action and dynamically try to influence progress toward a field goal, we cannot explain what affects progress on grand challenges. In the present study, we conducted an inductive, multimethod, longitudinal study of the nanotechnology field's grand challenge: to create molecular manufacturing.[1] Molecular manufacturing first held the promise of creating desktop manufacturing systems capable of producing anything atom by atom, eliminating waste and reducing energy usage. It was presumed that it would revolutionize human life by generating cheap, small super-computers and targeted therapies against cancer (Drexler, 1986). Although the goal of molecular manufacturing achieved great momentum and support from two U.S. presidential administrations, with $5.2 billion invested from 2001 to 2005, this ambitious goal became displaced over time by a less ambitious (albeit still important) goal. The nanotechnology field had successfully mobilized both financial and political support toward a common grand challenge—so, why didn't they achieve it?

To answer this question, we examine how five different communities mobilized and pursued the nanotechnology field's grand challenge from 1986 to 2005. During the first phase (1986–2001), communities actively reframed the grand challenge to enlist interest in the possibilities associated with molecular manufacturing. Formerly uninvolved communities became engaged through goal grafting: layering the grand challenge onto their existing interests

[1] In this paper, in order to distinguish the field from the grand challenge, we use the term "molecular manufacturing" to refer to the grand challenge, and "nanotechnology" to refer to the field. This mirrors a similar word usage by early field participants.

while preserving disparate underlying interests. These mobilization efforts were by all indications successful, leading to the creation of a national initiative dedicated to making molecular manufacturing a reality. However, we identify a critical duality of mobilization: while mobilization strategies produced success, they came at the cost of introducing misalignment between the grand challenge's initial ambitions and participating communities' underlying interests. As field participants began to pursue the grand challenge, some shifted from supporting the initial ambitions of the grand challenge to acting in alignment with their underlying interests. By unpacking the political realities of field-level strategic action, we explain the process by which an ambitious grand challenge became displaced by a less ambitious goal, and discuss the implications of this for grand challenges overall and for theories of field dynamics.

ADVANCING GRAND CHALLENGES

Mobilizing Support for Field Goals

For a problem to become recognized as a grand challenge, participants within a common organizational field must mobilize around a shared issue or cause (Fligstein & McAdam, 2012; Hoffman, 1999). Mobilizing participants for a grand challenge fosters progress for a common concern in three ways. First, it allows diverse participants to identify a common goal in the face of potentially diverging interests. Etzion and Ferraro (2010) showed how diverse stakeholders used analogies to financial accounting to create and legitimize a common framework for sustainability accounting. Second, field participants' engagement on a common issue can help attract resources, as funding agencies can envision a specific outcome that will be achieved when resources are deployed. Maguire and colleagues (2004) detailed how institutional entrepreneurs in Canada created a field of diverse stakeholders to help legitimate HIV/AIDS treatment, foster societal acceptance, and stimulate funding to help combat the disease. Third, when diverse participants in a field are engaged in a common cause, they can foster collaboration across disciplines in ways that a single discipline or community could not (Collins et al., 2003; Garud, 2008). Lounsbury and colleagues (2003) showed how both recycling activists and waste management professionals leveraged rhetorical frames to transform recycling from a waste activity to a mainstream commercial one.

Addressing a grand challenge requires mobilizing multiple communities, or "voluntary collection[s] of actors whose interests overlap and whose actions are partially influenced by this perception" (O'Mahony & Lakhani, 2011: 7), and who all have disparate interests for wanting to participate. For example, a field can involve entrepreneurs driven by wealth creation (Thornton, 2004), scientists driven by making scientific progress (Gieryn, 1983), and government officials interested in the functioning of the state (Friedland & Alford, 1991). Where diverse community interests align, disparate interests can be bridged (e.g., O'Mahony & Bechky, 2008) to create a groundswell of support. However, generating *support* for a field-level goal differs from agreeing on how to make *progress* on a field-level goal. In the early stages of constructing a grand challenge, there may be excitement and momentum, but this can dissipate as a field matures and becomes more heterogeneous, fragmented, and complex (Greenwood et al., 2010). For example, in the early days of satellite radio, competitors cooperated to legitimate the new technology, but, in later stages, they competed (Navis & Glynn, 2010). As diverse participants enter a field, consensus on how to achieve a common goal may become more difficult to achieve. While much research has focused on how field participants use rhetorical strategies to mobilize consensus on a common field-level goal (Wry, Lounsbury, & Glynn, 2011), it is the later stages, during which action is required, that can be more complicated.

From Mobilizing Support to Acting on Field Goals

What is missing is an understanding of what happens after mobilization, when diverse field participants take action to address field-level goals in dynamic environments. Scholars have shown that field participants who maintain diverging or incompatible interests can find ways to collaborate substantively by creating trading zones or boundary organizations (Galison, 1997; Kellogg, 2014; O'Mahony & Bechky, 2008). But, this research has not considered how these arrangements become vulnerable when participants attempt to attack grand challenges in dynamic environments. Grand challenges are not static, but are subject to feedback loops, phase shifts, and tipping points as they evolve (Ferraro et al., 2015). We identify three assumptions in the literature that limit our understanding as to why it can be difficult for fields to realize grand challenges.

First, while several studies show how disparate participants move in and out of fields over time, how this fluidity shapes a field's ability to advance its goals has not been adequately considered (e.g., Dunn & Jones, 2010; Lawrence & Phillips, 2004). For example, while Hoffman (1999) showed how more participants became involved in environmentalism over time, he did not examine how this evolving diversity of participants affected the field's ability to reduce polluting chemicals. With new entrants, fields become more complex and the issues under consideration can multiply, making it difficult to focus on hard-to-reach goals (Schüssler et al., 2014). For example, as new participants add to the environmental issues up for negotiation, some countries have withdrawn from the Kyoto Protocol in disagreement over the appropriate emissions targets needed to reduce climate change (Hoffman, 2011; Schüssler et al., 2014). Often, to make progress, grand challenges require collaboration from diverse communities over a sustained period of time, but, in reality, given their long-term nature, participation is likely to ebb and flow. What has not yet been explained is how participants' ebb and flow affects a field's ability to realize ambitious goals.

Second, the literature tends to assume that grand goals can easily be decomposed into concrete actions, but it is more likely that this transformation will involve translation work (e.g., Carlile, 2004). Often, broad ambiguous goals facilitate mobilization by creating wide-ranging appeal (Benford & Snow, 2000; Ferraro et al., 2015; Gioia, Nag, & Corley, 2012). But, for diverse communities to make collective progress on a grand challenge, the problems that constitute it need to be translated in ways that contributors from disparate backgrounds can operationalize (e.g., Carlile, 2004; MacCormack, Rusnak, & Baldwin, 2006). Few grand challenges can be pursued wholesale, but, rather, need to be decomposed into achievable actions in the near and long term (Weick, 1984). This process of problem decomposition is not obvious (Lifshitz-Assaf, 2014). Translating goals into concrete actions can be fraught with disagreement, as disparate communities have their own culture, language, practices, and standards of excellence that influence them to favor divergent courses of action (O'Mahony & Lakhani, 2011; Van Maanen & Barley, 1984). Diverse communities may desire to contribute to a grand challenge, but have disparate underlying interests and their own approach for making and assessing progress (DiMaggio & Powell, 1983; Dunn & Jones, 2010; Greenwood, Diaz, Li, & Lorente, 2010). For example, while many of the communities promulgating green chemistry agree on the merits of this goal, they disagree on how to reach it: while some value the moral elements of green chemistry, others are more pragmatic (Howard-Grenville, Nelson, Earle, Haack, & Young, 2017). What is not yet clear is how diverse approaches affect participants' ability to realize a field's complex grand goal over time.

Third, scholars tend to assume that field participants' rhetoric on common goals accurately reflects their underlying interests (Lounsbury et al., 2003; Maguire et al., 2004; Mair & Hehenberger, 2014; Wry et al., 2011). For example, Lawrence and Phillips (2004) showed how a change in rhetoric from whales as creatures of destruction to friendly foes advanced the Canadian whale watching industry. Often, a broad construction of a field-level goal can help recruit even those who once disagreed with the field's direction (e.g., Jones, Maoret, Massa, & Svejenova, 2012). Weber et al. (2008) showed how participants changed the connotations of "grass-fed beef" from a technical term of inferior quality to a premium product, thereby stimulating demand. Such studies explain how field participants leverage broad rhetorical strategies to align diverging interpretations with a common goal. What is less clear is how fields fare when participants transition from mobilization efforts to making progress on those goals—a far more daunting task.

Field participants' alignment with field-level rhetoric may not be stable over time, and, when fields transition from rhetoric to action, underlying interests can surface and diverging paths emerge (e.g., Zbaracki, 1998). Agreement with a field's rhetoric does not always reflect underlying interests (Fisher, Ury, & Patton, 2011). While participants may hold various positions on an issue, they are more likely to act in alignment with their underlying interests (Fisher et al., 2011). Although people may initially give voice to support a grand challenge, they might interpret the goal differently when the need for action arises. What is required is an approach that considers how "new actors can enter the field over time, increasing diversity of not only constituents but also in their preferred goals and means" (Zietsma, Groenewegen, Logue, & Hinings, 2016: 38–39). Drawing on a multimethod, inductive, 20-year study of the nanotechnology field, we traced how five communities mobilized support for and took action to advance the grand challenge of developing molecular manufacturing. We identify a previously underappreciated duality of mobilization: the strategies that were successful in mobilizing support for the field's grand challenge also introduced misalignment between the initial ambitions of the grand challenge and communities' underlying interests. Over time, the far-reaching, ambitious goal of molecular manufacturing was displaced by the less ambitious goal of making near-term progress in existing domains. We unpack how the nanotechnology grand challenge evolved over several decades and develop a theoretical explanation of how the duality of field mobilization can generate goal displacement within fields.

METHODS

Nanoscale research had been present since the early 1970s and 1980s, but a grand challenge did not form until 1986, when an MIT PhD student, Eric Drexler, laid out the goal of molecular manufacturing in his popular book *Engines of Creation: The Coming Era of Nanotechnology.* From Drexler's perspective, molecular manufacturing—atom-by-atom control over matter to construct "objects to complex, atomic specifications . . . directed by nonbiological molecular machinery" (Drexler, 1992: 1)—could help address other grand challenges such as hunger, poverty, and climate change by reducing the cost of production (Drexler, 1986). To further this goal, he created a nonprofit organization called the Foresight Institute and recruited others interested in seeing molecular manufacturing come to fruition (Granqvist, Grodal, & Woolley, 2013; Kaplan & Radin, 2011). Ultimately, the Foresight community succeeded in mobilizing a large coalition to support molecular manufacturing, which led to the creation of a multibillion-dollar national initiative to accelerate pursuit of this grand challenge in 2000.

We chose to study the grand challenge of creating molecular manufacturing for several reasons. First, this setting provided a rich data set, starting in 1986. All of the communities involved in the creation of the grand challenge left elaborate paper trails that we were able to identify and collect, producing a rich archival data set. Furthermore, we were able to collect ethnographic interviews (see Spradley, 1979) and observation data with field participants in 2003 to 2005, and again in 2016, while field participants were actively struggling with how to advance molecular manufacturing. This allowed us to interview participants and observe conferences and events as they unfolded, rather than *ex ante*, and permitted us to triangulate and take advantage of multiple methods. Second, we chose to study molecular manufacturing because it was an ambitious grand challenge that attracted billions of dollars in funding across multiple federal agencies and private investors. With that many resources dedicated to the grand challenge, we were interested in understanding how progress unfolded. Third, the grand challenge of molecular manufacturing attracted a diverse set of communities, which raised the question of how diversity from within the field would affect pursuit of the grand challenge.

Data Collection

We used theoretical rather than representational sampling to guide data collection (Eisenhardt, 1989). We entered the field with the broad goal of studying how diverse field participants approached a grand challenge. As our data collection and analysis progressed, we became interested in why progress on the grand challenge of molecular manufacturing was stymied despite the successful mobilization of powerful and resourceful participants. As data collection proceeded, we asked increasingly specific questions regarding this conundrum (see Langley, 1999). While we present these analytic phases chronologically, in practice, they overlapped at the boundaries.

Phase 1: Ethnographic observations. We began data collection by conducting 25 ethnographic observations at conferences and events focused on nanotechnology. During ethnographic observations, we recorded presentations and took notes on the activities and conversations of participants. We started with the belief that scientists and entrepreneurs were the primary communities within the field, but soon realized there were five different communities participating in the field (futurists, government officials, service providers, entrepreneurs, and scientists). The underlying interests of these communities diverged. The interest driving the futurist community was to see molecular manufacturing created, while that driving the government community was to increase U.S. competitiveness in science and technology. Service providers (e.g., lawyers, venture capitalists, and journalists) were interested in making short-term profits by selling their services. The entrepreneurial community was interested in furthering their existing businesses and increasing short-term profits. The scientific community was interested in advancing their existing research agendas and generating funding for their labs, PhDs, and postdocs. These communities did not engage in the grand challenge at the same time, only becoming involved when they perceived it to be in their interest.

Phase 2: Interviews. In the next phase, we conducted interviews with representatives from each community. Initially, we contacted interviewees at conferences and events. We then used snowball sampling to identify additional informants. Efforts were made to ensure that informants interviewed were involved in the grand challenge throughout all phases of its evolution. From 2003 to 2005, we conducted 77 interviews (13 with futurists, 11 with government officials, 18 with service providers, 24 with entrepreneurs, and 11 with scientists). Table 1 provides an overview of the five communities and shows how the data were distributed.[2]

Phase 3: Archival research. To track progress on the grand challenge and avoid retrospective bias, we conducted extensive archival research. Initially, we examined the grand challenge since its beginning in 1986 up to the year 2005, later adding supplemental data through 2016. This archival material covered historical articles and significant books written on the topic. We collected a systematic data set for each of the five communities by identifying a data source in which community members conversed about nanotechnology, as shown in Table 1. For the futurists, this was their monthly newsletter *The Foresight Update*; for government officials, it was congressional hearings; for service providers, it was the business press; for the entrepreneurial community, it was press releases; and, for the scientific community, it was the journal *Science*. We generated a list of search words that we used to identify articles relating to each community, totaling 9,011 articles over the period 1984–2005. In addition, we collected 3,762 articles from the top 50 U.S. newspapers to examine the field's discourse on the grand challenge holistically. From this data set, we sampled articles to analyze qualitatively. We collected the qualitative sample by identifying two articles every month from each community: the first article of the month and the first article published after the 15th of the month. If less than one article existed in a particular month, we over-selected articles in the following months to obtain 24 articles per community per year. In total, we analyzed 938 articles qualitatively.

Phase 4: Assessing the grand challenge. Eleven years after our initial data collection, we reentered the field to track progress on the grand challenge and establish comparison across equivalent time periods. During this 2016 data collection effort, we conducted eight additional interviews (for a total of 85 interviews), coupled with ethnographic observations from a one-day nanotechnology conference. We also collected 14 reports published between 2006 and 2016 that assessed progress on the grand challenge.

Data Analysis

We uploaded all ethnographic observations, interviews, and archival data in ATLAS.ti. Because we started with the broad question of how participants approached the grand challenge, we drew upon the methods inherent to developing process theory (Langley, 1999). A core focus of our analysis was to identify the events that unfolded in the field over time and the participants in those events (Langley, 2009). We started analysis by creating a temporal map detailing events critical to the formation of the grand challenge that became central to our analysis. As we progressed in our coding, we updated the map to reflect current understandings, including key events and changes in funding. Figure 1 shows some of the events identified.

While constructing the temporal map, we became puzzled as to why progress on the grand challenge was not as expected. Guided by this puzzle, we engaged in open coding to identify what inhibited field participants from realizing the grand challenge. During open coding, we used *in vivo* codes, which mirror the language used by informants as much as possible (see Corley & Gioia, 2004). We developed a long list of codes as our initial attempt to understand how the grand challenge was mobilized over time. We, for example, generated the code: "Assessing nanotech relative to other revolutions" to mark a point at which participants voiced comparisons between the grand challenge and other scientific and technological revolutions.

Next, we engaged in axial coding and searched for relationships between our initial codes (see Strauss & Corbin, 1990). For example, we found that several codes related to how communities entered the field without abandoning their existing interests. We labeled this second-order theme "goal grafting: enrolling proponents". Because we were interested in how field participants engaged in the grand challenge over time, we constantly related the codes identified to Figure 1 by adding and elaborating on the map (see Kahl & Grodal, 2016). We grouped similar themes into eight overarching categories. For example, we found that two second-order themes, "goal grafting: enrolling proponents" and "goal grafting: enrolling skeptics," both constituted a single overarching mobilization strategy *goal grafting* (the layering of a shared goal on top of existing interests

[2] The 24 interviews with entrepreneurs were also used in Granqvist et al. (2013), and the data were used in Grodal (in press).

TABLE 1
Multimethod Data Sources

	Futurists	Government officials	Service providers	Entrepreneurs	Scientists
Community interests	Achieve the grand challenge of molecular manufacturing	Strengthen U.S. competitiveness through investments in science and technology	Sell their services and make short-term profits	Develop high-growth businesses with near-term profits	Pursue their existing research interests and fund their labs, PhDs, and postdocs
Ethnographic data					
Ethnographic observations (n = 26)					
Ethnographic interviews (n = 85)					
2003–2005 (n = 77)	13	11	18	24	11
2016 (n = 8)	2		1	1	4
Archival data					
Archival data source	*The Foresight Update*	Congressional hearings	*Fortune*, *Forbes*, *The Wall Street Journal*, *Business Week*	Press releases	*Science* (journal)
Archival data years	1987–2004	1991–2005	1984–2005	1988-2005	1956–2005
Articles analyzed quantitatively (n = 9,011)[a]	926	925	494	4,157	2,509
Articles analyzed qualitatively (n = 938)[b]	204	142	189	170	23

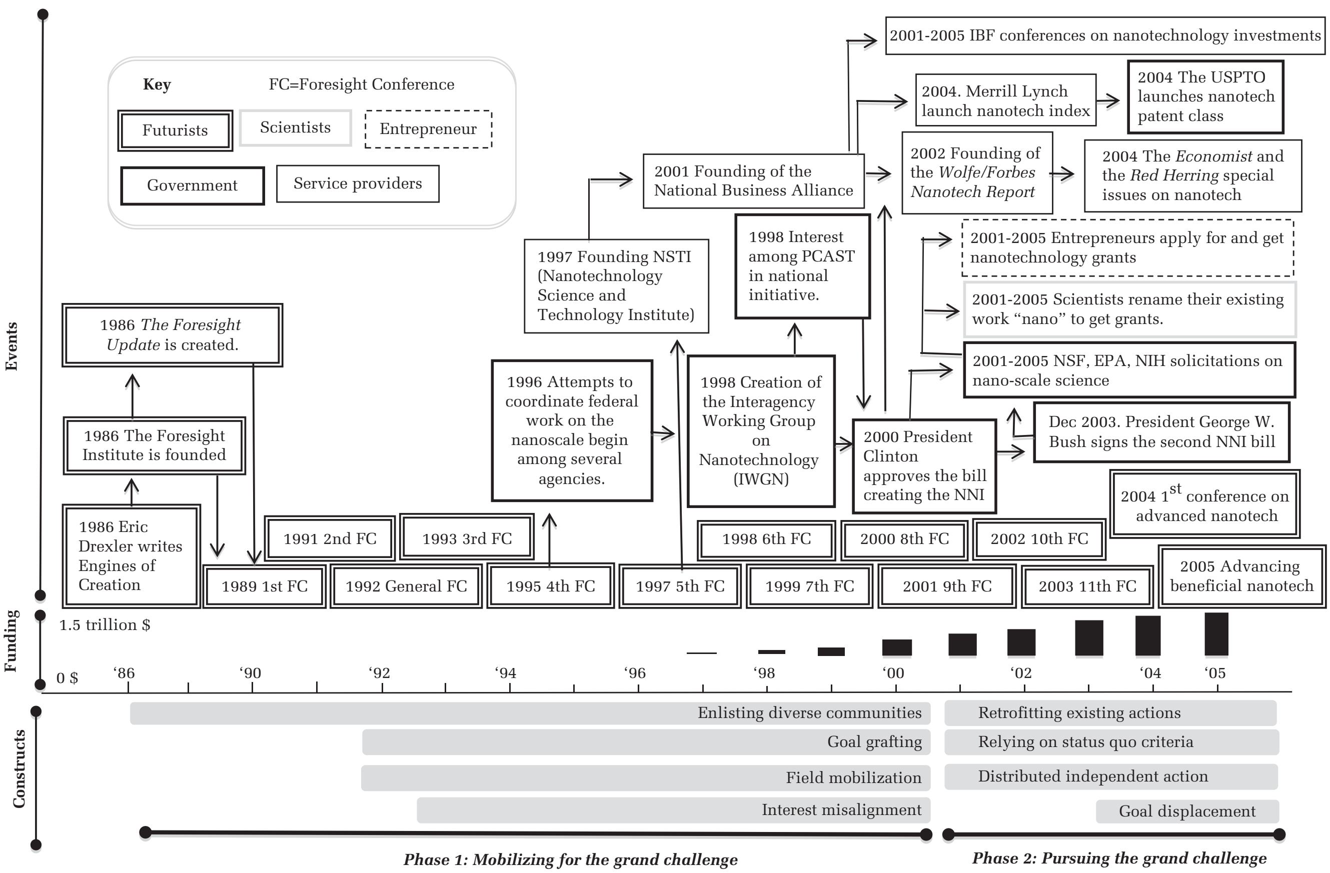
Notes: Discourse data = 3,762 newspaper articles from the top 50 U.S. newspapers covering the trajectory of the grand challenge (1986–2005).
[a] The archival data listed above were supplemented with additional important documents pivotal in the development of nanotechnology.
[b] Many of the articles were only one or two paragraphs in length.

while preserving potentially disparate underlying interests). Likewise, we found that several second-order themes, such as "all-encompassing relevance," "drawing analogies," "scientific presentation," and "emotional language," all constituted a mobilizing strategy of *enlisting diverse communities*, the process by which individuals recruited the support of others to advance the grand challenge. While enlisting and goal grafting helped mobilize a broad base of support, we also identified a duality as these two strategies produced *interest misalignment*, whereby some participants' underlying interests were only partially aligned with the initial grand challenge.

In addition to these two mobilization strategies, we coded three categories of action. *Retrofitting existing actions* occurred when current or prior programs or projects were renamed to fit within the parameters of the grand challenge. *Relying on status quo criteria* happened when communities drew on existing evaluation metrics when deciding which projects to solicit and fund. *Distributed independent action* took place when actions aimed at addressing field goals were taken independently within each community without efforts to integrate across communities. Lastly, when our informants distinguished between the initial ambitions of the grand challenge and the goals that were actually pursued, we coded this as *goal displacement*.

After identifying the eight overarching categories, we returned to our temporal map to see how these categories mapped onto different time periods. We identified two distinct phases: "mobilizing for the grand challenge" and "pursuing the grand challenge." The start and end points of these phases were chosen where there was clear "continuity in the activities within each period and . . . certain discontinuities at [their] frontiers" (Langley, 1999: 703). Mobilizing for the grand challenge was more prevalent before the National Nanotechnology Initiative (NNI) was announced in 2000 and began distributing funds in 2001 than after this time period, leading us

FIGURE 1
Mapping Key Events in Nanotechnology (1986–2005)



to designate the first phase as starting in 1986 and ending in 2000. During this phase, field participants focused on mobilizing diverse participants and resources to advance the grand challenge. During the second phase, "pursuing the grand challenge," participants focused on taking action to achieve the grand challenge, given the resources mobilized. While our initial data set was from 1986 to 2005, with the supplementary data collected in 2016, we were able to assess progress on the grand challenge across two roughly equivalent time periods: 1986–2000 and 2001–2016.

After discovering evidence of goal displacement in our ethnographic data, we used the automated search tool Docparser to examine the field's discourse in nanoscience articles in the top 50 U.S. newspapers to understand how the grand challenge evolved. We noticed a shift after 2001, the year the NNI was funded, when the usage of words reflecting grand ambitions plummeted. As this was surprising, we revisited the analysis and distinguished between ambitious goals, with references to "robot," "machine," or "artificial intelligence" elements essential to creating molecular manufacturing, and less ambitious goals in near-term domains, with references to "cosmetics," "textiles," "consumer electronics," "batteries," "golf balls," or "pants." After tracing the evolution of both types of goals over time, in conjunction with the qualitative analysis, we realized that the grand challenge had gradually become displaced by less ambitious goals. Oddly, this happened after a period of relatively successful mobilization efforts. To understand this better, we reanalyzed the mobilizing strategies and realized that there was a duality to mobilization. While the mobilization strategies used helped broaden support for the grand challenge, they also generated misalignment between some field participants' underlying interests and the original ambitions of the grand challenge. This misalignment planted a seed for participants to act in line with their existing interests in near-term goals, displacing the original ambitions of the grand challenge.

EXPLAINING THE DUALITY OF FIELD MOBILIZATION IN NANOTECHNOLOGY (1986–2005)

We traced how the five communities approached the grand challenge of molecular manufacturing in two phases: (1) mobilizing for the grand challenge (1986–2000), and (2) pursuing the grand challenge (2001–2005). By qualitatively analyzing the interests and actions of each community and identifying when and how each engaged in the grand challenge, we show how participants and resources were mobilized and how this affected progress with respect to the grand challenge.

Mobilizing for the Grand Challenge (1986–2000)

The communities that engaged in the grand challenge of creating molecular manufacturing were not all mobilized at the same time. Early participants *enlisted diverse communities* and *goal grafted*, which *mobilized the field*, but also sowed the seeds for *interest misalignment*. Table 2 defines and provides additional data on these two strategies and their effects on the field.

Enlisting diverse communities. The futurists were not equipped to develop molecular manufacturing on

TABLE 2
Mobilizing for the Grand Challenge

Enlisting diverse communities	*The process by which individuals recruit others to support a field-level goal*	We must understand the consequences of assemblers, disassemblers, and nanocomputers. They promise to bring changes as profound as the industrial revolution, antibiotics, and nuclear weapons . . . in one massive breakthrough. (Drexler, 1986: 20) [W]hen he came out with *Engines of Creation*, I got the book, and I and my colleague . . . were persuaded that he was really onto something. We sent three or four hundred copies out to everybody in our network. (Mike Bentson, futurist) 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. (Karoub, 2005)
Goal grafting	*The layering of a shared goal on top of existing interests while preserving potentially disparate underlying interests*	[Y]ou bring . . . hundreds of people to NSF to talk . . . to come up with a consensus report . . . you start going to Congress . . . the House . . . the Senate and . . . the Clinton administrational . . . it eventually became the NNI." (Bill Moore, government official) [T]here's a sense in which [NNI] is highly political, in that the administration and the people in Congress are very interested in doing things that they think in the long run will improve the competitiveness of the U.S. (Brian Hanover, government official) [W]e jump on radical technologies and ride them to find the business opportunities. We try to get in front in the waves. We did that with the Internet, and that is our thesis with nanotechnology. (Frank Farmingham, venture capitalist)
Mobilizing the field	*The mobilization of participants and dedication of resources to a field-level goal*	[T]he government pumps a lot of funding into this area. So that's good for the whole field . . . since more and more people [are] coming in these areas. (Jackson Chu, scientist) The NNI generated interest . . . I began to see a lot more people at the [nano] conferences. (Matt Hutchinson, scientist) The nanotechnology field is growing rapidly . . . Funding, people, . . . there is a buzz about nano. (Jeff Brown, entrepreneur)
Interest misalignment	*Lack of congruence between participants' underlying interests and grand challenge*	We do not have a definition [of nanotechnology] . . . We think all of our processes we have in place for developing and evaluating products will serve nanotechnology just like it would serve all the other nanotechnologies [sic] that are involved in products we regulate. (Tim Walter, government official) [I]n the nanotechnology area, you have this issue that there are different segments of the population with different resources and needs that have very radically different views of what they think nanotechnology is and what they think it isn't. (Anders Valentin, entrepreneur) I work for investment banks, so my business is to focus on the practicalities of the company, how they are going to make money to investors . . . I look at a lot of complex nanotech and [the return to investors] is not going to happen in the short term. (Jason Sanders, investment banker)

their own and recognized the need to enlist diverse communities who could contribute specialized expertise to make the grand challenge a reality. Maria Perkins, an early organizer, explained how she and others strategized to enlist diverse experts:

> One of the key ways [we strategized] was actually the question of . . . how do you engage people? How do people become interested? How do you get the field to gain momentum? . . . So we did a bunch of stuff together on this, whether it was the question of fund-raising or . . . [which] groups to target, who to communicate, how to communicate.

Enlisting was a mobilizing strategy used to recruit diverse participants from the government, scientific, entrepreneurial, and service provider communities. We identified four different rhetorical techniques used to enlist participants from these communities in the grand challenge: (1) *all-encompassing relevance*, (2) *drawing analogies*, (3) *scientific presentation*, and (4) *emotional language*.

First, the futurists used rhetoric with *all-encompassing relevance*—that is, they made the grand challenge of molecular manufacturing appear relevant to as many communities as possible by highlighting expansive application areas and casting the implications of the grand challenge broadly. For example, Drexler described how nano-assemblers could fulfill a wide variety of general purposes, affecting multiple industries and domains:

> Because assemblers will let us place atoms in almost any reasonable arrangement . . . they will let us build almost anything that the laws of nature allow to exist. The consequences of this will be profound . . . Assemblers will open a world of new technologies. Advances in the technologies of medicine, space, computation, and production—and warfare—all depend on our ability to arrange atoms. With assemblers, we will be able to remake our world or destroy it.
>
> (Drexler, 1986: 14)

The futurists emphasized the endless scientific disciplines and technological areas that could be advanced with molecular manufacturing, hoping to gain support from multiple communities.

Second, futurists mobilized diverse communities by *drawing analogies* to prior technology and scientific revolutions. They, for example, wrote that "the idea of molecular nanotechnology is now about as well accepted as was the idea of flying to the Moon in the pre-space age year of 1950, nineteen years before the *Apollo 11* landing and seven years before the shock of *Sputnik*" (Drexler, Peterson, & Pergamit, 1991: 10). Analogies helped justify the feasibility and the importance of molecular manufacturing and enticed other communities to join "the next technological revolution."

Third, to court those skeptical of these claims, the futurists used *scientific presentation* of their ideas. While the grand challenge might have seemed ahead of its time, the futurists anchored this goal in present reality and legitimated it with references to the existing scientific literature. For example, the futurists suggested that a path to developing molecular manufacturing would be to build molecular machines in the same way that proteins were at that time created:

> Proteins *could* be designed from the start with the goal of making their folding more predictable. Carl Pabo, writing in the journal *Nature*, has suggested a design strategy based on this insight, and some biochemical engineers have designed and built short chains of a few dozen pieces that fold and nestle onto the surfaces of other molecules as planned.
>
> (Drexler, 1986: 10; italics in the original)

Lastly, the futurists used *emotional language* to excite participants about the grand challenge, but also to incite fear as to what could happen if the wrong people gained control over molecular manufacturing. The futurists stressed the hope and excitement that molecular manufacturing could bring, but also warned that, without the appropriate expertise, molecular manufacturing could pose a danger to humanity. Indeed "assemblers and thinking machines pose basic threats to people and to life on Earth . . . Unless we learn to live with them in safety, our future will likely be both exciting and short" (Drexler, 1986: 171). The futurists used emotional language with both positive and negative valence to convince other communities of the urgency and need for their participation.

By using these four rhetorical strategies—all-encompassing relevance, analogies, scientific presentation, and emotional language—the futurists attempted to enroll diverse communities to support the grand challenge. However, not all of these strategies were initially successful. At first, the futurists did most of the enlisting, inviting targeted communities to forums dedicated to the grand challenge. As one of the organizers, Ellen Paulson, explained: "People were talking about it [molecular manufacturing] mainly starting in our conferences starting in 1989. That was the place that you came to talk about these things. There was not really anywhere else to go." Both government officials and service providers attended the founding event and were intrigued by the possibility of molecular manufacturing. One participant recalled that "it was an exciting time . . . we were all engaged in discussing our future." Initially, rhetorical strategies resonated with the service provider and government communities when they saw alignment with their existing interests. Once they became proponents of molecular manufacturing, they too drew upon similar rhetorical strategies to enlist others, in venues specific to their own communities. However, the scientific and entrepreneurial communities were initially immune to these strategies and remained skeptical of the grand challenge's merits.

Goal grafting. Both the service provider and government communities were intrigued by the potential of molecular manufacturing and essentially grafted this goal onto their existing interests. We define "goal grafting" as the layering of a shared goal on top of existing interests while preserving potentially disparate underlying interests. Goal grafting permits mutualism, allowing field participants to support a field-level goal without substantially abandoning their underlying interests. The futurists' rhetoric appealed to service providers interested in making short-term profits from organizing conferences, publishing magazines, and selling their consultative services. Service providers grafted the grand challenge of molecular manufacturing onto their existing interests when they saw opportunities to capitalize by supplying competitive information and services. As a patent lawyer stated:

> [Nanotechnology] is now and will continue to be a very lucrative area for patent lawyers. . . . 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 . . . be sort of the household name in nanotechnology. . . . So getting in early is good.

By engaging with the field's grand challenge and becoming known for his services, this patent lawyer aimed to secure a first-mover advantage and increase his firm's profitability.

In response to the futurists efforts to enlist a broad base of support, the U.S. President's Council of Advisors on Science and Technology (PCAST), tasked with helping the President of the United States develop science policy, discovered that the goal of molecular manufacturing was compatible with their interest in appearing as leaders of the next scientific revolution and increasing U.S. competitiveness. As Carl Yaniv, a central government official, explained: "The important thing is developing a series of grand challenges that are compelling and exciting, to explain the ultimate pay-off to society if these goals are reached." PCAST members grafted the grand challenge onto their existing interests and tried to convince Congress to invest in making molecular manufacturing a reality. PCAST members and a newly formed Interagency Working Group on Nanotechnology mobilized multiple federal agencies (e.g., the National Science Foundation [NSF], the National Institute of Health, the Defense Advanced Research Projects Agency [DARPA], etc.) to create a national initiative focused on molecular manufacturing. As one PCAST member explained: "The whole initiative was put together and structured by holding quite large-scale workshops that brought the community in from all over. That's how the field got defined."

One government official, Ben Kaznik, explained how he enlisted other agencies by translating "incomprehensible" scientific talk into goals government officials could get excited about; all-encompassing relevance, analogies, and emotional language were key to this effort.

> These were some examples of grand challenges: storing the Library of Congress in a device the size of a sugar cube, detecting cancerous tumors before they are visible to the human eye, making materials that are stronger than steel at a fraction of the weight, etcetera. . . . So, in all of these cases, there was something that I could point to where a researcher said . . . here is where we could see it heading to in 10 years. Then what I would do, since I'm not a scientist . . . I would try to translate that into terms that were accessible to a reporter, a politician, or a member of Congress. Then I could have these conversations with everyone else in the White House because . . . if I had said, "We really need to put more money into condensed metaphysics and material science," I wouldn't have gotten anywhere. But I said, "Gee, there is this new area called nanotechnology and what it is going to mean is we might be able to in the future do x, y, and z." That could be the hallway conversation. So, that was enough to get people excited.

Together, with a set of core government officials, Kaznik built support for a national initiative by helping agencies converge on a common understanding of molecular manufacturing that they could graft onto their existing interests. PCAST worked with the Interagency Working Group on Nanotechnology to mobilize, as Kaznik said, "a group of people from academia and industry," and, within this group, they explored questions such as "What is nanotechnology?," "What should we be doing as a country?," and "What should we be funding?" As Kaznik explained, "So it is a consensus process . . . Our job was actually to bring all these experts and learn from them . . . as to first the definition of nanotechnology and then what are the grand challenges that actually nanotechnology can address." Permitting diverse communities to graft onto the grand challenge allowed them to pursue their interests in advancing science in existing domains while supporting the national initiative.

To push forward, PCAST "developed a detailed budget proposal and a rationale for specific levels of investment" and presented the initiative to President Clinton, who received it favorably. As explained by one PCAST member: "We were essentially asking to double the federal investment in nanoscale science and engineering ... There was strong bipartisan support." President Clinton announced the creation of an NNI on January 21, 2000. He affirmed that "my budget supports a major new national nanotechnology initiative worth $500 million" and, repeating PCAST's analogies, explained the projected benefits to humanity: "Just imagine ... shrinking all the information at the Library of Congress into a device the size of a sugar cube; detecting cancerous tumors that are only a few cells in size." (Clinton, 2000: 3)

Mobilizing the field. With the creation of the NNI and a projected infusion of new resources, members of PCAST renewed their attempts to enlist members of the scientific community who had been previously skeptical about nanotechnology. One scientist, Klinger, highlighted a view originally held by many in the scientific community: "Most people think [Drexler] is kind of crazy." PCAST co-chair Kaznik explained how he attempted to convert scientists skeptical of molecular manufacturing to work toward the grand challenge: "This [scientific community] is a totally different community. This is convincing the research community ... that there are a set of legitimate research topics in the field that are interesting, that are a good high-quality science." With the promise of new resources, Kaznik found the scientific community more eager to listen than prior to the establishment of the NNI.

Molecular manufacturing had seemed implausible to many scientists, but now they identified an opportunity to advance existing research that had been under way for some time. As a photonics scientist working on solar cells explained:

> No one should think that nanotechnology started in 2000 and that changed everything. The fact is there had been people working at that scale prior to [1993] and nothing really changed when nanotechnology came in ... But they just didn't have the term "nanotechnology." Material scientists have always just pushed to smaller and smaller. There is nothing new about that.

Now that pursuing the grand challenge might benefit their labs with funding for PhDs, postdocs, and equipment, scientists grafted the grand challenge onto existing research programs in the hope of increasing funding opportunities. As one scientist, 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 the [national nanotechnology] initiative had that effect."

Like the scientific community, the entrepreneurial community had been skeptical of the possibility of creating molecular manufacturing. Analogies to massive scientific revolutions, which could take years to manifest, did not align with entrepreneurs' interest in near-term returns. Eric Wanger, CEO of a nanotechnology startup, viewed the futurists' rhetoric as science fiction: "Maybe [the futurists] should just worry about their science fiction novels. I don't get those guys. ... They have such a bizarre thinking." However, with the promise of new resources from both the venture capital and government communities, many entrepreneurial firms now saw how grafting onto the grand challenge could further existing interests. Peter Ibsen, CEO of a nano-electronics firm, explained, "We often use 'nano' now [post NNI] to explain what we are doing ... it drives funding." As one entrepreneur explained, few investors were interested in the time frame estimated for molecular manufacturing to develop: "This thing [molecular manufacturing] is supposed to happen 10 years from now, and, if I could do something and make it happen in five years, I'm going to hit the home run. So you see a bunch of investors taking on that route." Investors and entrepreneurs were more interested in applications with short-term relevance than in furthering the grand challenge.

Interest misalignment. With the creation of the NNI, two communities previously skeptical of molecular manufacturing (scientists and entrepreneurs) grafted onto a broad interpretation of the grand challenge without substantively modifying their underlying interests. Grace Peabody, a futurist, marveled at how quickly skeptical scientists had converted to become "true believers":

> They hated nanotechnology, they hated the whole damn thing and the reason was because they saw this [as] a potential funding rival. And so they went from active warfare to one day they realized that ... they had failed to succeed in killing it. So, overnight, all of these people became nanotechnologists. They were still doing the exact same [thing] they were doing before but now they were nanotechnologists. So it was ... fascinating ... watching how the definition of what this thing was supposed to be [became] hijacked in such a variety of directions.

The same scientists that had worked on complex molecules, single-layer depositioning, and mezzo-physics for years and had been disdainful of molecular manufacturing were now interested in connecting their existing research with the aims of the NNI. While this broad base of apparent support furthered mobilization efforts, it also increased *interest misalignment*; that is, a lack of congruence between participants' underlying interests and the ambitions of the grand challenge. As one futurist explained: "We do not want the same things. They are just here to do near-term stuff."

After the NNI's launch, the underlying interests of those newly enlisted were more committed to existing near-term goals than to the grand challenge. As Brown, an entrepreneur, observed, the grand challenge had broadened to include "business as usual": "There is no agreement about what nanotechnology is. You have all of these people claiming to do 'nano,' but they are just doing their own thing. They are just doing business as usual." With enlisting strategies, the futurists had made molecular manufacturing palatable to a diverse audience, mobilizing proponents and skeptics to graft this grand challenge onto their existing interests. Creating a broad groundswell of support fostered the mobilization of resources, but also created a growing misalignment between communities' underlying interests and the original ambitions of the grand challenge. The field's collective mobilization strategies were by any account successful, earning financial and political support from the highest levels of government and spurring the creation of a national initiative. However, these mobilization strategies came at a cost. Effectively, the field had recruited new participants whose underlying interests were only partially aligned with the original goal of the grand challenge.

Pursuing the Grand Challenge (2001–2005)

In 2001, with an infusion of resources, the field transitioned from rhetoric to action: from mobilizing support for the grand challenge to creating "atom-by-atom control over matter" through molecular manufacturing. The NNI committed \$5.2 billion to the grand challenge from 2001 to 2005. According to the *Economist*, this was "the largest federally funded science initiative since [the U.S.] decided to put a man on the moon . . . well over twice as much as it did on the Human Genome Project at its peak" ("Small wonders," 2004; see also U.S. Department of Energy, 2015). The NNI, one of the only federal programs continued by the Bush administration, was considered a sign of successful mobilization. With this degree of financial and political support, great advances were possible. The grand challenge had mobilized diverse supporters, but, in this phase, participants began to take action on these goals in ways that reflected their underlying interests. We identified three types of actions—(1) *retrofitting existing actions*, (2) *relying on status quo criteria*, and (3) *distributed independent action*—which gradually produced *goal displacement*. Table 3 defines and provides additional data on these three actions and their effects on the field.

Retrofitting existing actions. Retrofitting existing actions occurred when current or prior programs or projects were relabeled to fit the parameters of the grand challenge regardless of their substantive fit. Retrofitting took place within the government community largely because the NNI encouraged it. Following existing budgeting practices, the NNI decided to distribute \$5.2 billion dollars based on agencies' prior budgets in areas related to nanotechnology. This created an incentive for agencies to retrofit existing programs with the NNI's broad criteria in the hope of increasing the chance of receiving funds. Thus, funds to further the grand challenge were allocated not according to an idea's ability to further molecular manufacturing, but according to how well each agency strategically retrofitted existing resource allocations with the NNI's stated goals. A top government official explained that "they [NNI] say to the agency, 'Okay, now go back and tell us how much of the existing programs is nanotechnology,' 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." Even though, in prior years, those funds might have been for "single-layer depositioning" or "mezzo-physics," to align with NNI funding parameters, these programs were now relabeled as "nanotechnology." Frank Bashra, a government official, explained how this practice made tracking NNI funding dynamic even retrospectively:

> The numbers [awarded to the NNI] are hard to track because they change in real time. Even asking what the budget was two years ago for nanoscale science and engineering, you might find tomorrow that number is different than it was yesterday. There's a lot of redefining and correcting the books.

As Bashra explained, agencies "redefined the books" to retrofit their prior budgets with the NNI's parameters so that existing projects could be included under the broadening tent of "nano." By 2007, more

TABLE 3
Pursuing the Grand Challenge

Retrofitting existing actions	*Relabeling and reframing past actions to align with a field-level goal*	[I]n academia . . . when people are actually trying to fight for some funding, people can twist a definition to suit their needs . . . If there is a startup company which wants to go IPO . . . then they can twist things to their needs. Or an existing company, actually, if they want their stock price to go up, you know how they can hype things up. (Ian Melrose, government official) [E]verybody who wants funding has to find a way to call what they're doing nanotechnology. (Bob Brown, entrepreneur)
Relying on status quo criteria	*Drawing on existing evaluation criteria when deciding which projects to solicit and fund*	But the key thing was to put this in the context of 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. (Will Cockburn, venture capitalist) We are looking for companies that will actually get to revenue in 18 to 24 months from inception. This will not be the case across the board, but generally it will. (Brandon O'Neil, venture capitalist) To do our first research solicitation on nano . . . we directed it toward application in nanotechnology and funded research in sensors, in remediation and treatment, in green manufacturing . . . (Steve Green, government official)
Distributed independent action	*When actions aimed at addressing field goals are taken independently within each community*	Often, agencies will do a lot of nanotechnology on their own that's related to their particular mission. Certainly, I [NNI] don't tell them what to do. I provide more of a facilitating and coordination function. (Damon McAdam, NNI government official) Different government agencies allocate funds to "nanotechnology" without much oversight. (Ezra Benson, futurist) Congress [does not control] the actual appropriation of funds . . . the committee that developed that law . . . only had jurisdiction over five agencies but there are thirteen agencies . . . spending money on nanotech. (Ryan West, government official)
Goal displacement	*When ambitious goals are supplanted by near-term goals in existing domains*	My recollection when the thing was sold to Congress was it was portrayed as including the Drexler vision in terms of the products that would be given, and it's not true. They didn't fund it. (Mark Greenwood, futurist) The NNI if anything slowed down molecular machine systems by falsely making it look like they would fund it and they didn't. (Ellen Paulson, futurist) I would be willing to bet you that there are some [lawmakers] who would be pretty surprised [about what actually got funded]. (Ezra Benson, futurist)

than 4,000 research projects in 500 institutions (300 academic and 200 in small business and government labs) in all 50 U.S. states received funding from the NNI (Roco, 2007). As this volume of projects were solicited, proposed, and funded, private entrepreneurial and business interests accelerated their involvement in the grand challenge.

Service providers like venture capitalists also retrofitted existing investments to fit the parameters of "nano" when identifying their nanotechnology portfolios. According to one seasoned entrepreneur, investors were "all claiming to have a new element, a new nanotechnology enabled performance enhancement." He recalled how, after the NNI launch, one investment fund renamed their stock ticker "TINY" to signal their focus on nanotechnology and their stock "appreciated from $3 to $20 over the last eight months . . . A classic case of the fact that investors—they'll invest in everything that has the word 'nano' in it." Lux Research estimated that investments in nanotechnology were about $900 million per year in the years 2001–2005. Several venture capital firms were successful at raising money for funds dedicated to nanotechnology, but their definition of nanotechnology was often expansive. One VC stated that "our nanotechnology investments all have some component on the nanoscale" but none of these investments related to the science or technology needed to create products atom by atom. As one venture capitalist admitted: "It is a mixed bag. Some of the companies in our nanotech fund are operating in a more traditional space . . . some are old and some were founded more recently." Both government and service provider communities relabeled existing activities to retrofit them with the grand challenge parameters as it suited their interests, regardless of substantive fit. As these communities retrofitted existing projects and ventures to fit a broadening interpretation of the grand challenge, the ambitions of the initial grand challenge became displaced by near-term goals in existing domains.

Relying on status quo criteria. Despite their espoused interest in advancing molecular manufacturing, participants from the government and service provider communities found themselves investing in research and ventures that conformed with criteria that embraced the status quo. The NNI did not delineate the need for novel approaches but devolved responsibility, stating that "each agency will use its own methods for inviting and evaluating proposals" (National Science and Technology Council, 2000: 16). Left to their own devices, agencies ultimately favored scientific and technical advances that complied with proven scientific criteria and could be demonstrated in the near term, rather than with the requirements of molecular manufacturing.

First, scientific and governmental communities solicited proposals using existing scientific language rather than the rhetorical language used to frame the grand challenge. For example, in 2003, the Environmental Protection Agency (EPA) sought NNI research proposals for "research on nanoscale science," a broader and less ambitious goal than the initial grand challenge. Calls for proposals did not create the expectation that research break from the status quo. As one scientist confided, "The old open secret in the scientific community is that what you put in your [grant] proposal is the stuff we've already done, and, when you get the grant, you bootleg 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." Without uprooting this occupational norm, NNI funds were allocated to existing research streams in related areas rather than to projects that could directly further molecular manufacturing.

Second, proposals were selected for funding using status quo criteria. Within the government, grants were allocated based on peer review and the scientific community's determination of what constituted the best science. Although the scientific community was initially skeptical of the grand challenge, their technical expertise now gave them a strong voice in determining what research should be funded. As one scientist observed, "The scientific peer review process, it's a very conservative process. Period." An EPA official, Dr. Anna Balunski, explained how her department chose which nanotechnology proposals to fund, as follows:

> 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.

The EPA had an interest in funding the best science as defined by the scientific community's peer review process, rather than in funding projects that directly furthered molecular manufacturing. Dr. Balunski readily admitted that her agency was "not really looking at nanotechnology," but rather "the implications of nano materials," which was basic material science. Some proposals might support the grand challenge, others might not. Molecular manufacturing was not actually the EPA's underlying interest. In the end, most proposals funded by the NNI were not allocated to molecular manufacturing, but to near-term scientific questions such as how nano materials interact with water.

Venture capitalists also drew on status quo criteria when deciding which ventures to fund. They were excited about molecular manufacturing, but, when it came to allocating their investments, their underlying interest was in high-growth companies that could yield a reasonable return within four to six years. For example, William Peterson, a prominent venture capitalist described how he had initially been taken with the grand challenge of molecular manufacturing, but later adapted his investments to align with his firm's existing funding criteria:

> We are not going to invest in Eric Drexler's little machines and little submersibles. 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 . . . for the most part, the stuff that we've looked at investing in are some [nano] materials, some firms that use carbon nanotubes or [nano] powders or whatever.

Venture capitalists like Peterson supported the grand challenge during mobilization, but now acted in alignment with their firms' underlying interests in short-term, high-growth areas, focusing on nanotechnology tools, a less ambitious version of the initial grand challenge.

Service providers also aligned their work with status quo criteria, targeting industries in which a commercial market for innovations at the nanoscale already existed. Martin Langwood, a founder of one of the biggest nanotechnology service organizations, explained that "our feeling is that—the final application of where all of these technologies are going . . . [is] into existing industrial markets and so there's societies that represent most of those existing industrial markets and so we try to partner with them as best we can." Service providers' underlying interest was in existing domains like materials science and chemistry that could be accomplished in the near-term, rather than developing molecular manufacturing per se. By relying on status quo criteria, government, service provider, scientific, and entrepreneurial communities veered toward projects, programs, and ventures that furthered near-term goals, displacing the initial ambitions of the grand challenge.

Distributed independent action. Participants from each community were empowered to pursue the grand challenge independently without oversight or coordination. The NNI did not question participants' alignment with the initiative's original goals and retained only modest consultative powers, without the oversight of a granting agency. Rather than ask each agency to redirect existing efforts in support of molecular manufacturing, the NNI explicitly allowed agencies to invest in areas in which they could graft existing interests onto the grand challenge, stating that, "Each agency will invest in those R&D projects *that support its own mission as well as NNI goals*. While each agency will consult with the NSET Subcommittee, the agency retains control over how it will allocate resources" (National Science and Technology Council, 2000: 16; italics added). There was no requirement to focus on the initial ambitions of the grand challenge and the NNI had little power over other federal agencies. Coordination of interagency activities was more superficial than integrative: providing a website clearinghouse of nanotechnology activities within each agency, rather than guiding the activities of those funded into a coherent framework. Grace Peabody observed a disconnect between the NNI's intent and how the initiative was eventually legislated: "Lawmakers don't administrator things. They pass legislation ... to fund a program and then it's carried out by other people."

The futurist community argued for a more ambitious path, wanting to see a unifying framework to advance the original goal of molecular manufacturing, but their voice did not have the power that it had during the mobilization phase. One futurist lamented that their perspective now carried less weight, saying: "It's very hard to do it [grow something] unless you interact in an informed, sophisticated way with the whole DC apparatus. We, at that time, we just weren't good at it." The futurists were skilled orators but lacked the technical expertise to empirically advance molecular manufacturing. As explained by one government official, "The problem is that nonprofits are not up to speed on [the science]." As creators and evaluators of funding proposals, the scientific and entrepreneurial communities had the technical expertise to suggest potential technical solutions, carry out science according to existing standards, and assess what was feasible. They now gained a bigger voice, shaping the grand challenge to fit their underlying interests. Some believed that molecular manufacturing was not achievable but still accepted funds for research at the nanoscale. As Nobel Prize winner Richard Smalley bluntly asserted in his 2001 *Scientific American* article, "How soon will we see the nanometer-scale robots envisaged by K. Eric Drexler and other molecular nanotechologists? The simple answer is never." (Smalley, 2001: 76)

Given the way participants grafted the grand challenge onto their existing interests, some were only partially aligned with the grand challenge. Thus, when participants engaged in distributed independent action, concerns for the initial ambitions of the grand challenge were displaced by interests in near-term goals. The scientific and entrepreneurial communities who had grafted onto the grand challenge were now highlighting near-term achievements such as growing a nanotube on a silicon substrate rather than developing molecular manufacturing. By 2005, only the futurists and some of the government officials who had led the funding of the NNI clung to the initial ambitions of the grand challenge, while other communities worked toward less ambitious goals. Instead of funding existing research, the futurists wanted the government to fund "proof of concept" molecular manufacturing—to show that creating technologies atom by atom was possible and generate a road map others could build upon. Originally, the NNI included funds earmarked for this purpose, but, during the legislative process, these provisions were removed—an act 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-assembly" ... which is a meaningless term because it is already done all the time.

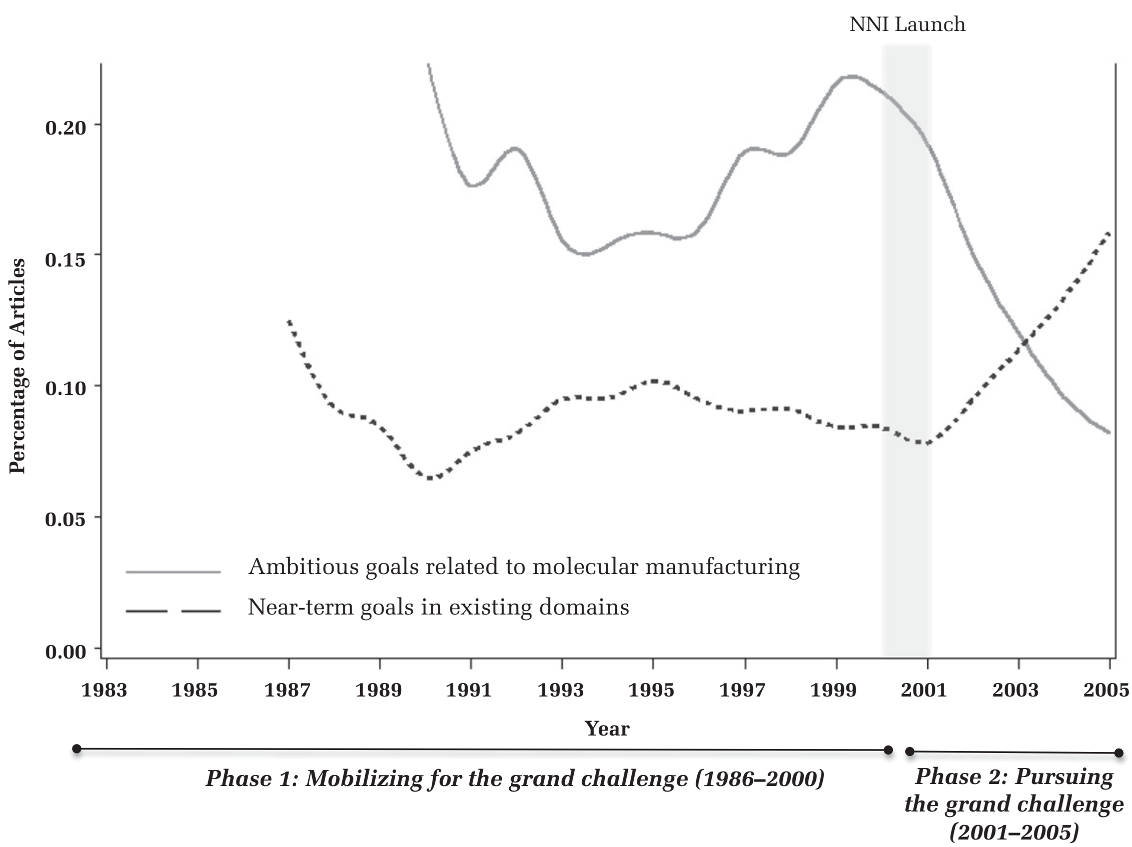
Funds dedicated to the initial grand challenge were now supporting basic research in existing domains such as materials science, applied physics, chemistry, and biotechnology without a project demonstrating the grand challenge's original ambitions. The demonstration project cut from the 2003 legislative bill never gained traction.

The Grand Challenge Displaced

During the mobilization phase, the founding communities built a broad coalition of participation around the grand goal of creating microscopic robots with artificial intelligence, but, in the years that followed the creation of the NNI, this goal was discussed in very different terms. As shown in Figure 2, after 2001, the field's rhetoric shifted from ambitious discussions of molecular manufacturing with microscopic robots to near-term advances at the nanoscale in existing domains such as cosmetics and stain-resistant pants. These near-term advances lacked the capacity for societal transformation that had originally mobilized participants. Rather than amplify discourse on the grand challenge, with the launch of the NNI, discourse on the grand challenge became displaced by discussions of near-term advances at the nanoscale in existing domains.

Members of several communities observed this shift; some, but not all, were displeased. Mihail Roco, a government official assessing the field's progress, expressed concern about the displacement of grand ambitions, observing that "a challenge in the first years . . .with so many new

FIGURE 2
Goal Displacement in the Nanotechnology Field (1986–2005)



Notes: Figure 2 shows the percentage of nanoscience articles within the top 50 U.S. newspapers focused on grand ambitious goals related to molecular manufacturing versus near-term goals in existing domains. Ambitious goals included references to "robot," "machine," or "artificial intelligence" that were part of the grand vision to create molecular manufacturing. Less ambitious near-term goals included references to existing domains such as: cosmetics, textiles, consumer electronics, batteries, golf balls, or pants. Figure 2 was generated using the automated tool DocParser. The gray bar represents the period between the first announcement of the NNI and the distribution of funds from the NNI.

developments was maintaining consistency, coherence, and original thinking" (Roco, 2007: 3.12). McFarland, a futurist, explained: "The problem is that the money is not really going towards what Congress thought it was going towards. It is being funneled into things that are much more near-term." Yet, officially, the government viewed the NNI as a great success. In 2004, Drexler criticized what he saw as displacement of the field's original grand challenge.

> In a presentation to the President's Council of Advisors on Science and Technology on March 3, 2003, Dr. Samuel I. Stupp of Northwestern University gave as examples of nanotechnologies "pigments in paints; cutting tools and wear-resistant coatings; pharmaceuticals and drugs; nanoscale particles and thin films in electronic devices; jewelry, optical and semiconductor wafer polishing." Any connection between this miscellany of technologies and a research program inspired by the [molecular manufacturing] vision is almost imperceptible.

While smart glass and nano sheets, yarns, and powders represented important advances in nanoscience, these developments fell short of creating molecular manufacturing. Victor Henley, a scientist, explained that the technologies developed were "nanomaterials and nanoscale objects that are dumb. They don't do anything. They sit next to each other and conduct current … but it's nothing like … molecular machines and molecular manufacturing." Ellen Paulson, another futurist, expressed concerned about public expectations: "If you would ask the general public, based on these 14 years … they would say that we are developing the little machines [molecular manufacturing]. We were promised the little machines and as far as they know they are getting them. Unfortunately, it is not happening."

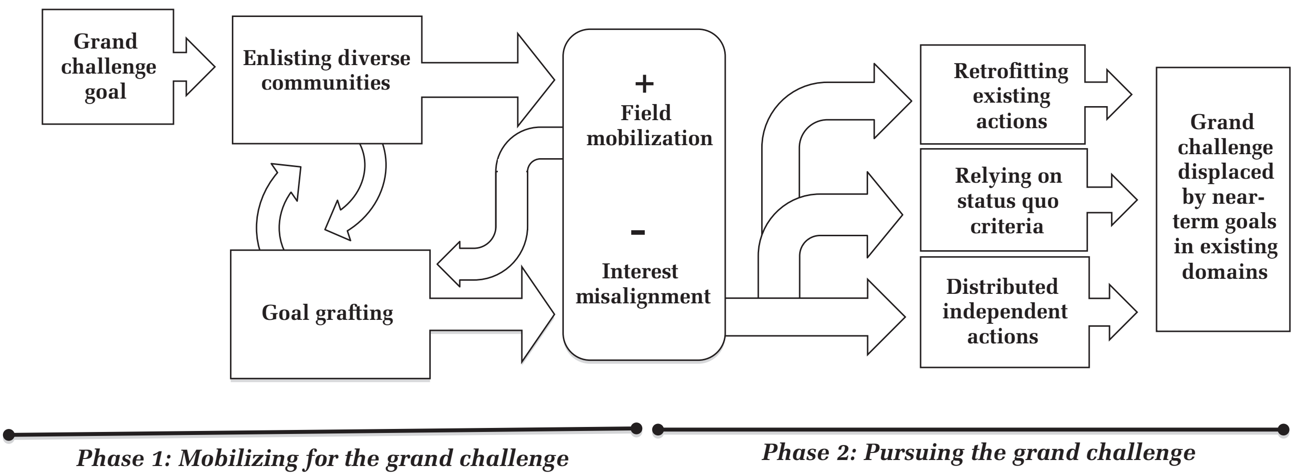
We returned to the field 10 years later and collected additional data in order to understand how the grand challenge fared across two equivalent time periods. The NNI increased its investment in 2005: a total of $24 billion was invested from 2001 to 2016. In 2014, PCAST provided a biannual assessment of the NNI, highlighting advances in nanoscience such as "light- and heat-shielding nano-coating for 'smart glass'" and "nanotube-infused clothing," concluding that the NNI was a "truly successful venture" (PCAST, 2014). The futurists agreed that progress in existing domains had been made, but without advancing the goal of molecular manufacturing. "Broadening nanotechnology to include more fields of research brought many returns … [but] rejected the heart of the field, absorbing widespread support for advancing 'the ability to work at the molecular level, atom by atom' while instead doing nothing of the sort" (Drexler, 2013: 206). Over a 30-year period, the grand ambitions for molecular manufacturing gradually became displaced by near-term ambitions in existing domains, but many considered this progress. The futurist community alone remained wedded to the original goal. Whether near-term achievements in existing domains constitute progress is in the eye of the beholder. Rather than pass judgment, we offer a theoretical explanation of how goal displacement happens, so that those who aim to retain the initial ambitions of a grand challenge appreciate how to do so.

The Duality of Field Mobilization

Institutional scholars have uniformly valued the mobilization of diverse participants to support field-level goals (Maguire et al., 2004; Lounsbury et al., 2003; Weber et al., 2008). Little research on organizational fields would suggest that mobilizing diverse communities to work toward a grand challenge could produce goal displacement (but see van Wijk, Stam, Elfring, Zietsma, & Den Hond, 2013, for suggestive evidence). To explain this, we identified a duality of field mobilization: the very strategies used to successfully mobilize support for the grand challenge introduced interest misalignment that eventually undermined the ambitions of the grand challenge. We develop a grounded theoretical model explaining how mobilization strategies that were initially successful later fostered misalignment of interests and set goal displacement in motion (presented in Figure 3).

Founding communities formulate a grand challenge to pursue societal or technological change. They cannot, however, achieve the grand challenge on their own. Founding communities use *enlisting strategies* to mobilize diverse communities. To enlist new communities, they emphasize the all-encompassing relevance of the grand challenge, draw analogies to existing and prior grand accomplishments, present the grand challenge in scientific language, and appeal to emotions. These enlisting strategies attract proponents to the field, while skeptics remain unconvinced. The proponents *graft the goal* of the grand challenge onto their existing interests and engage in enlisting strategies to involve more communities and attract resources to the field. As founding communities become increasingly successful, skeptics join the field by grafting the goal of the grand challenge onto their existing

FIGURE 3
The Duality of Field Mobilization



interests to access the field's dedicated resources. The mobilizing strategies of enlisting diverse communities and goal grafting thus positively reinforce each other to recruit diverse participants and attract dedicated resources to the grand challenge. The founding communities succeed in achieving *field mobilization*.

Field mobilization through goal grafting, however, comes at the cost of generating *interest misalignment*. When proponents and skeptics graft onto the grand challenge, they do not change their underlying interests, but, rather, only partially align with the intended ambitions of the grand challenge. This is particularly true for skeptics, whose underlying interests are farthest from the grand challenge. This duality may not manifest during the mobilization phase, when energy and enthusiasm for the grand challenge is high, and only appear as participants take action to advance the grand challenge. Yet, interest misalignment plants the seed for goal displacement to manifest when multiple communities begin to pursue the grand challenge.

When field participants transition from mobilizing to pursuing a grand challenge, rhetoric over what the grand challenge should be gives way to taking action on those goals. While the new resources produced by mobilization should, in theory, free participants to depart from existing quests to pursue novel intellectual avenues, a deluge of resources dedicated to a grand challenge can also create incentives for less committed participants to act according to their own interests. When field participants *retrofit their existing actions* with the grand challenge, they relabel current and former projects to fit the grand challenge, displacing grand ambitions with projects already underway. When funding decisions *rely on status quo criteria*, the projects and ventures selected align with existing science, displacing grand ambitions in favor of tried and true approaches. When participants engage in *independent distributed action*, underlying interests in near-term goals displace the aspirations that originally motivated the grand challenge. Cumulatively, these three actions generate *goal displacement*: the goal of the grand challenge is supplanted by near-term goals in existing domains.

Taken together, our theoretical model identifies a duality of field mobilization: while mobilization strategies broaden the support for a grand challenge, they can also introduce interest misalignment. When rhetoric transitions to action, participants may be weakly committed to the grand challenge and pursue their underlying interests in near-term goals. In this manner, grand ambitions become displaced with near-term goals by the very actions that once mobilized the field to pursue those grand ambitions.

DISCUSSION

Grand challenges often unfold in fields, rather than in organizations, where participants are more diverse in their interests and more difficult to govern (Churchman, 1967; Rittel & Webber, 1973). Grand challenges are complex and benefit from sustained focus over time, making progress an uncertain endeavor (Ferraro et al., 2015). While institutional scholars have shown how fields mobilize around common issues of concern (Hoffman, 1999) and create shared field-level goals (Lounsbury et al., 2003; Maguire et al., 2004; Weber et al., 2008; Wry et al., 2011; Zietsma et al., 2016), how field participants take action to realize grand ambitions is not well understood. When fields mobilize for a grand challenge, what inhibits them from realizing their ambitions? We examined one grand challenge that was, by any measure, successful in mobilizing support from diverse communities, culminating in significant resources and political support. In the opening quote to this paper, Johnson considered the nanotechnology grand challenge to be "hijacked." As much as he and others like him might be keen to identify a "smoking gun" responsible for displacing the field's grand challenge with lesser ambitions, the process we discovered was more subtle, but no less pernicious in effect. There was no single hijacker coopting the grand challenge. Rather, diverse communities grafted the grand challenge onto their existing interests, gradually broadening the grand challenge away from its initial ambitions. By tracing this process, we uncovered an underappreciated duality: the very strategies that helped mobilize diverse participants in the grand challenge's early stages generated a misalignment of interests and triggered goal displacement in later stages.

Overcoming the Dualities of Field Mobilization

Most institutional scholarship values field mobilization efforts without concern for how this might affect the integrity of field goals (Lounsbury et al., 2003; Maguire et al., 2004; Weber et al., 2008). Our research reveals some hidden liabilities underlying field mobilization not previously identified in the literature. Prior studies of field emergence may have truncated their research before mobilization efforts transitioned to action, or paid inadequate attention to the evolving substance of field goals. Since grand challenges are likely to require sustained attention, institutional work (e.g., Lawrence & Suddaby, 2006) may be required to maintain the integrity of founding goals. Thus, managers and policymakers advancing grand challenges cannot take the field's early apparent consensus for granted, but instead need to understand how mobilization strategies like enlisting and goal grafting can invite interest misalignment and devise ways to ensure participants' commitment as lengthy projects unfold.

This includes the process of translation, as grand challenges are rarely pursued as formulated. While promoting ambiguous interpretations of a grand challenge may help recruit disparate audiences (Ferraro et al., 2015: 375), the goals espoused need to be decomposed into actionable tasks understood by those with present-day competencies (e.g., Carlile, 2004; Lifshitz-Assaf, 2014). Those advancing grand challenges would do well to consider how this translation process will occur. Weick (1984) understood that, when facing intractable problems, the difficulty is identifying where to initiate solutioning. Relying on status quo criteria can help stimulate identification of the "small wins" needed to initiate progress on intractable problems (Weick, 1984). On the other hand, reliance on status quo criteria can also make a grand challenge less grand, by reinforcing existing knowledge rather than creating the novelty needed for breakthrough innovations (e.g., Fleming, 2001; Hargadon, 2003). While easy to justify, status quo criteria can discourage the novelty needed to advance grand challenges.

If organizers of a grand challenge are trying to create a breakthrough innovation, they may want to think carefully when distributing resources and consider ways to free participants from the status quo. To depart from existing practices, institutional spaces where disruptive ideas can be cultivated may be useful (e.g., Christensen, 1997; Galison, 1997; Kellogg, 2009). O'Reilly and Tushman (2004) suggested that, for organizations to produce a radical innovation, they must uproot people from their prevailing circumstances to avoid reproducing existing ideas. This may be true at the field level as well. For example, contributors to the Manhattan Project were removed from their existing scientific communities and required to work in physically and intellectually novel circumstances to make grand advances in atomic energy (Rhodes, 2012). Our research suggests that, while it might seem easier to retrofit a grand challenge within structures that favor status quo criteria, this strategy can backfire if breakthroughs are expected.

Distinguishing between Rhetoric and Action within Fields

Although several studies have found that participation in field-level goals can be dynamic (e.g., Hoffman, 1999; Schüssler, et al., 2014), how a changing cast of characters affects the quality and consistency of attention to the substance of a field's goals has not been previously appreciated. We provide a dynamic and politically informed understanding of the perils fields face when moving from mobilization to action on issues of common concern, thereby extending the literature in at least three ways. First, fields are typically composed of multiple communities whose participation is not stable. However, most studies of field emergence focus on a small set of participants (Lawrence & Phillips, 2004; Lounsbury et al., 2003; Maguire et al., 2004; Weber et al., 2008), without appreciating how diverse communities' engagement on field issues ebbs and flows to affect progress on field goals. Our research provides a comprehensive view of how diverse participants pursuing a field goal shape its trajectory, from grand ambitions to near-term goals in existing domains. By examining how participation in field-level goals evolves, we show how potentially diverging interests are overcome, but also how those interests can fracture.

Second, when examining how diverse participants engage in a common issue, the literature tends to assume that participants in a common field share the same beliefs about how goals should translate into action (Maguire et al., 2004; Weber et al., 2008). However, our research shows that this transition is a minefield to be carefully traversed. Field-level goals are inevitably unspecific, which can attract a broad base of support (Benford & Snow, 2000; Gioia et al., 2012), but also invite disagreement on how to achieve those goals (e.g., Dunn & Jones, 2010; Howard-Grenville et al., 2017; Pache & Santos, 2010). We show how the translation of ambitious goals into concrete actions is influenced by underlying interests and the existing institutional structures in which translation takes place (e.g., Bechky, 2003; Carlile, 2004), bending ambitious goals toward the status quo over time.

Third, scholars tend to assume that field participants' rhetoric on common goals reflects their underlying interests (e.g., Maguire et al., 2004; Mair & Hehenberger, 2014; Weber et al., 2008; Wry et al., 2011). We show that goal grafting allows field participants to rhetorically support a grand goal without abandoning their underlying interests. Goal grafting is not the same as complete consensus on a field goal; it generates misalignment between rhetoric supporting the goal and participants' underlying interests. The concept of goal grafting can be helpful to explain why, in the presence of apparent consensus, field initiatives become stymied when action is required. For example, goal grafting may be one reason why conferences on climate change attract a growing number of participants without making progress on the issues under consideration (e.g., Schüssler et al., 2014). Our research shows when and how rhetoric on goals and action become disconnected, creating an opening for strategic action.

Achieving Field-Level Goals

When organizations do not meet their goals, we can assess why, with the expectation that organizations should have the authority to allocate resources and direct attention (e.g., Ocasio, 2005) in ways that allow them to realize their goals. However, an organization's goals can also attenuate over time, through boundedly rational (Simon, 1991) or garbage can decision-making (Cohen, March, & Olsen, 1972), or through changes in leadership, resources, or stakeholders (e.g., Battilana & Dorado, 2010; Selznick, 1949). In these cases, organizations pursue activities, perhaps with full intention, but without "evidence . . . to show that these activities are linked to organizational effectiveness or outcomes" (Bromley & Powell, 2012: 14). For example, a museum might be founded with the goal of enhancing cultural awareness, but running cafes and gift shops becomes the focus. Visitors enjoy themselves and buy coffee and posters—but the goal of cultural awareness through exhibitions is displaced by the goal of running cafes and gift shops. However, much of this research has taken place at the organizational level and not at the field level—where grand challenges usually unfold. The existing literature has focused on how founding goals can become displaced by internal concerns for organizational maintenance and survival (e.g., Cloward & Piven, 1984; Piven & Cloward, 1977; Simons & Ingram, 1997) without considering the complexity that a multitude of interests at the field level can generate.

Fields are more complicated than organizations and this has implications for grand challenges. First, fields lack centralized control over their participants. Scholars tend to assume that those crafting a grand challenge can direct the efforts of those trying to advance it. For example, Wry et al. (2011) suggested ways in which field participants use strategies to mobilize participation without over-inducing heterogeneity. However, not all field activity can be orchestrated in that manner. Second, although scholars have studied how organizations' ambitious goals can become displaced over time (e.g., Selznick, 1949), this phenomenon has been less examined at the field level, where sustaining attention to ambitious goals can be far more challenging. When organizational goals are displaced, the smoking gun is often power-hungry leaders (Michels, 1915; Piven & Cloward, 1977). How goal displacement unfolds at the field level in the absence of power-hungry leaders is not well understood. Third, fields are not bounded (Hoffman, 1999; Scott, 2000). While multiple scholars have emphasized the fluidity of organizational boundaries (Davis & McAdam, 2000; O'Mahony & Lakhani, 2011; Powell, 1990; Santos & Eisenhardt, 2005), fields are even less bounded, in that participants leave or join freely with few, if any, gatekeepers. With porous boundaries, sustaining participants' focus on a field's initial goals may be difficult. Fourth, organizational fields are subject to more heterogeneity than organizations in terms of both participants and interests, which can present multiple sources of dynamism and complexity.

The literature on institutional complexity has primarily emphasized the strategies firms use to manage complexity deriving from external sources (e.g., Battilana & Dorado, 2010; Jay, 2013; Pache & Santos, 2010), assuming that complexity is in place (Kraatz & Block, 2008; Purdy & Gray, 2009; Smets, Morris, & Greenwood, 2012) without understanding how it is created. Our research helps explain how complexity emerges from distributed demands within the field through participants' own interests and interactions rather than from external rationalization pressures (Meyer & Rowan, 1977; Tilcsik, 2010). We show that the pursuit of grand challenges unfolds in dynamic environments in which participants' engagement is fluid, taking action on ambitious goals is difficult, and participants' underlying interests can deviate from espoused rhetoric over time. The dualities of mobilization create an underappreciated source of complexity to be managed: institutional entrepreneurs (DiMaggio, 1988) need to figure out how to mobilize diverse groups without weakening the integrity of their initial ambitions. Future research might consider complexity as a construct that ebbs and flows as a function of a field's participant dynamics, and investigate how heterogeneity within communities affects collaboration across communities.

Implications for Grand Challenges

We recognize that not all grand challenges are the same and that this may affect the generalizability of our findings. Discrete grand challenges in which goals are well defined may fare differently than broad grand challenges, as progress is easier to track and field participants can easily acknowledge when the goal is met. For example, the grand challenge of sending a human to the moon was discrete and well defined (Murray & Cox, 2004), as is DARPA's more recent grand challenge to create an autonomous vehicle. Like putting a man on the moon, all can agree that this challenge is solved when a robot has navigated a 142-mile long course through the Mojave Desert in 10 hours without human intervention (Thrun et al., 2006). In contrast, broad grand challenges, such as the one we studied, are less defined and may be more susceptible to goal displacement than discrete grand challenges.

It is also possible that broad grand challenges attract more heterogeneous participants than do discrete grand challenges, creating more variance and complexity to manage. With broad grand challenges such as eradicating poverty, there may be more contestation on where to focus: while some might favor microfinance (Battilana & Dorado, 2010; Mair & Martí, 2009), others might favor direct aid (Bono, 2004). The degree of heterogeneity within the field may help determine whether a distributed approach is appropriate. With high degrees of heterogeneity, a distributed approach may be discordant if counter-veiling integrating efforts do not reign in the underlying interests of field participants. While a distributed approach might work well for discrete grand challenges such as creating an autonomous vehicle, wherein each team can make independent progress toward measurable goals (Boudreau, Lakhani, & Menietti, 2016; Thrun et al., 2006), the same approach may face difficulty maintaining the integrity of the initial ambition without a coordinating body (e.g., Seidel & O'Mahony, 2014). For example, although the Human Genome Project was globally distributed, its success was attributed to its central coordination: "The [Human Genome Project] included a set of interconnected goals as part of the original master plan that was pivotal in our constant effort to optimize outcomes . . . Not only were *these goals explicit* in a manner never before seen in biology, most of the goals were attached to a timetable and sets of intermediate milestones" (Collins et al., 2003: 228; italics added). As policymakers craft grand challenges, they need to consider the nature of the grand challenge and balance the benefits and drawbacks when designing the appropriate approach.

Our research takes the first step toward revealing a specific process that can inhibit progress on grand challenges. More research is needed. The NSF's own study of grand challenges concluded that "new ways of organizing the assets brought to bear on Grand Challenges are necessary to optimize the *community* part of Grand Challenges . . . slow progress on these coordination and executive issues is a rate limiter to progress" (National Science Foundation, 2011: 72; emphasis in the original). Collecting data on grand challenges requires multiyear commitment from scholars—time horizons that do not fit easily within university reward systems. Future research could combine data from multiple sources (Kahl & Grodal, 2016) or pursue a comparative design within or across fields (e.g., Bechky & O'Mahony, 2015). Scholars could compare multiple approaches to a single grand challenge or select multiple fields with different grand challenges that share a theoretical dimension of interest. Given the investment in grand challenges, institutional collaboration on these fronts may be fruitful.

Conclusively, this research identified previously underappreciated dualities of field mobilization: the very strategies that initially mobilized diverse participants later sowed the seeds of goal displacement. This is important as only by identifying the mechanisms that impair progress on grand challenges can we identify where interventions are most likely to be effective—which should interest policymakers and organizational theorists alike.

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