THE CO-EVOLUTION OF INDUSTRIES, SOCIAL MOVEMENTS, AND INSTITUTIONS: THE CASE OF WIND POWER

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ABSTRACT

We examine processes of emergence and change in the U.S. wind energy sector from a dialectical, co-evolutionary perspective. We first generate insights from a case study in Colorado, finding that social movements and entrepreneurs mutually influence each other. We then demonstrate such mutual influence through a longitudinal quantitative study of the U.S. wind energy sector which also finds that the formation of these specialist social movement organizations has important repercussions on the types of institutions that emerge and the visibility and subsequent growth that the industry experiences.
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The process of industry emergence and change has often been described as an evolutionary process in which firms generate new variations of processes and products, and those which fit the demands of the environment are selected and retained (Aldrich, 1999; Hannan & Freeman, 1977; Nelson & Winter, 1982; Van de Ven & Poole, 1995). Industry emergence and change also have been described using a life cycle model, which depicts the change process as constituted by predictable and even immanent sequences of events (Van de Ven & Poole, 1995). According to this model, industry emergence and development follow an organic pattern in which a proliferation of competing technologies and products supplied by many competitors is followed by a shakeout and the emergence of a dominant design, which then diffuses (Geroski, 2003; Gort & Klepper, 1982; Jovanic & MacDonald, 1994; Klepper & Graddy, 1990).

In recent years scholars have also begun to take a dialectical perspective on industry emergence and change. Dialectical perspectives emphasize the role of power, politics, and conflict in processes of change. They depict the outcomes of these processes as collective achievements that emerge from contestation among partisan actors, rather than as the creations of particular actors (Hargrave & Van De Ven, 2006; Seo & Creed, 2002; Van de Ven & Poole, 1995). Dialectical perspectives on industry emergence have borrowed from and built upon social movement research, noting that like social activists, entrepreneurs build coalitions and mobilize symbolic and material resources in an effort to build legitimacy and support for their ideas, products, and technologies. As they have described industry emergence as resembling a social movement, scholars have begun to give attention to the role of actual social movement organizations (SMOs) in the industry emergence process. Scholars in this area suggest that the
involvement of SMOs in the development of new industries is more likely when new industries mitigate market failure conditions that bring about societal benefits derived from their practices and offerings (Rao, Morrill, & Zald, 2000b). They find that social movements can play an important role both in deinstitutionalizing existing logics, practices, and arrangements and in institutionalizing new ones (Rao, 1998). Through discursive and other political activities, they foster values that challenge existing institutions and help lead to the creation of new ones. These new institutions provide a favorable context for new firm foundings and the emergence of new industries (Haveman, Rao, & Paruchuri, 2007; Lounsbury, Ventresca, & Hirsch, 2003; Sine & Lee, 2009).

We welcome this increasing attention to the influence of SMOs on industry emergence and seek to extend the literature on this relationship. We do so by taking a co-evolutionary perspective. Co-evolution “refers to the simultaneous evolution of entities and their environments” and “encompasses the twin notions of interdependency and mutual adaptation” (Porter, 2006). Co-evolutionary processes are characterized by multidirectional causalities within and between system elements at multiple levels of analysis, and they involve non-linear relationships, positive feedback loops, and path-dependence (Lewin & Volberda, 1999). Although the co-evolutionary perspective has been used to study processes of change in macro-level technological-industrial systems (Geels, 2005; Malerba, 2002; Murmann & Homburg, 2001; Ruttan, 2000), relatively few have heeded the call of Lewin and colleagues (Koza & Lewin, 1998; Lewin, Long, & Carroll, 1999; Lewin & Volberda, 1999) for a more co-evolutionary perspective on organization-environment interactions. This is reflected in the literature on industry emergence. Further, and despite the fact that Lewin and colleagues call social movements one of the important co-evolutionary “forces of change that are ushering in the postindustrial age” (p. 544), the few studies that do take a co-evolutionary view of industry
emergence (Djelic & Ainamo, 1999; Jones, 2001; Van de Ven & Garud, 1993) have not given attention to the role of social movements.

In this research, we engage in an illustrative case study of the evolution of the wind power sector in Colorado, which confirmed the co-evolutionary nature of change in the industry. We subsequently conduct a quantitative analysis of the hypotheses derived from the case on a sample of the 48 contiguous U.S. states. In doing so, we apply a co-evolutionary perspective to the dialectical change processes that took place in the wind energy sector. We suggest that in the process of industry formation, not only do social movements impact the entrepreneurial activity in an industry (Sine & Lee, 2009), but that the growth of the industry itself also triggers fundamental changes in the structure of the social movement industry that lead to the creation of more specialized SMOs. This process has very important implications for the types of institutions that are further developed in favor of the industry, the visibility that the industry enjoys, and the subsequent growth that it experiences.

By studying the co-evolution of industries and movements, we hope not only to inform understanding of industry emergence, but also to help explain the dynamics of SMO populations. Social movement scholars have long noted the heterogeneity in SMOs’ goals and tactics (Gerlach & Hine, 1970; King & Cornwall, 2005). Soule and King (2008) find that this heterogeneity results from SMOs’ efforts to avoid competing with each other (thereby supporting resource mobilization theory (McCarthy & Zald, 1977)) and to carve out specialized niches not occupied by and available to dominant actors (thereby supporting resource partitioning theory (Carroll, 1985)). In the course of this study we examine a complementary explanation: That SMOs become more specialized in response to industry growth and changes in the institutional environment. We further suggest that the presence of specialist SMOs influences the character
of the institutions that support the industry and the visibility that the industry enjoys. By unfolding these processes, we contribute to the literature on industry emergence (Aldrich, 1999; Anderson & Tushman, 1991; Geroski, 2003) and to social movement theory (Gerlach & Hine, 1970; McCarthy & Zald, 1977; Soule & King, 2008).

In sum, we extend a dialectical view of industry emergence by taking a co-evolutionary perspective on the relationship of entrepreneurial firms, institutions, and SMOs. Whereas past studies have told a unidirectional causation story, we want to begin to tell the larger, multidirectional story. To best characterize this process we employ a mixed methods approach. We first offer the illustrative case of the evolution of wind power in Colorado. By engaging in this exercise, we were able to refine our perspective on the process through which institutional and industry level change unfolds in emerging fields. We then use insights from the case to inform the development of hypotheses that we subsequently test on a larger sample.

This manuscript is organized as follows. The first section summarizes the findings from the case of wind power in Colorado. Following this, we integrate insights from the case study with extant theory to present a set of testable hypotheses and a comprehensive theoretical model. Subsequently, we present the methodology employed for the quantitative analysis and the results obtained. Finally, we conclude with a discussion of our results and opportunities for future research.

**WIND ENERGY IN COLORADO: SMOS, ENTREPRENEURS AND GOVERNMENT**

To better understand the process of change created through the co-evolution of public and private actors, we engaged in an in-depth case study of the wind energy sector in Colorado. The
wind energy sector has experienced significant growth in U.S. markets in the past years (EIA, 2010; Real de Azua, 2007). Indeed, the recent spike in national renewable energy consumption has been primarily driven by a 60% increase in wind energy consumption between the years 2007 and 2008 (EIA, 2010). Furthermore, the wind energy sector is particularly appropriate for this research because of its associated social welfare implications, which enables the examination of the role of social movement organizations in helping to build the industry and the repercussions of such actions. Environmental SMOs in this context have brought the energy debate into the public eye, often promoting renewable energy as a solution to climate change and other societal challenges.

In choosing Colorado, we have followed the process of theoretical sampling described by Eisenhardt and Graebner (2007) in which the case is selected because it is suitable for elaborating on the relationships between constructs. We chose Colorado for several reasons: 1) Colorado presented an interesting example in which early activity by environmental SMOs was followed by entrepreneurial entry and subsequent new SMO creation, 2) Colorado offers a view of how the wind industry evolved both at a policy and industry level, and 3) from the period of 1999 to 2008 Colorado added over 1067 MW of wind energy (AWEA, 2010) a time period which coincides with our dataset on entrepreneurial entry, policy changes and SMO activity. While single case studies generally are not a strong basis for creating theory (Eisenhardt & Graebner, 2007; Yin, 2002) they can richly describe the existence or pattern of a phenomenon (Siggelkow, 2007). In examining the rise of wind power in Colorado our intent is not to offer evidence to support our theory, but to provide an illustrative example of how the co-evolutionary change process we examine in this study occurred in one state.
For this case we collected data from three sources. First, we conducted semi-structured interviews with activists, entrepreneurs and government employees involved in wind power during the time period of 1999-2008. Next, we engaged in analysis of 546 newspaper articles related to the key terms “wind energy” from the Denver Post, the largest newspaper in Colorado. Finally, we supplemented our analysis with secondary sources such as book chapters, organizational websites and government reports concerning wind energy in Colorado. Once we had obtained these documents, and transcribed the interviews, our first step was to construct a timeline of the major events that led to wind energy adoption in Colorado. We then verified this timeline with participants and made revisions based on their feedback. Once our time line was completed, we began the process of coding both our interviews and secondary sources for both key events and emergent themes utilizing qualitative analysis software. We considered four stakeholder groups in writing this case: the electricity industry (primarily Xcel Energy, the dominant utility in Colorado), social movement organizations (both environmentally motivated groups and those focused on renewable energy), the state government, and entrepreneurial firms (Komor, 2006).

From this coding we compiled a narrative account of the events described in our timeline, paying particular attention to four processes. First, we sought to understand how the activities of environmental SMOs provoked the initial foray into wind energy by Colorado’s major utility. Second, we looked at how these same environmental SMOs influenced policy related to wind energy. Third, we looked at the emergence of new SMOs and firm foundings in the Colorado
wind power sector. Finally we examined how the activities of these emergent organizations created additional policy changes, thus creating an even more hospitable institutional environment for potential wind energy entrepreneurs. We begin our case by examining an early collaboration between Colorado’s major utility and a consortium of influential environmental organizations.

**Early Days: Environmental SMOs and Xcel Energy**

Colorado is a state with a wealth of energy resources. Ten of the largest natural gas fields and three of the largest oil fields in the U.S. are within the state (Energy Information Administration, 2010). Colorado is also a top coal-producing state, producing about 32 million tons annually (Energy Information Administration, 2010) and coal is the major source of power for the state. Because of the state’s heavy reliance on fossil fuels, the case for wind power adoption was hotly contested by multiple parties.

However, Colorado is also rich in renewable energy resources, primarily wind energy. Much of Colorado’s eastern plains have class 3 or 4 wind, which is considered viable for commercial development (Fortson, 2010). While these are rich resources, in 1997 it was far from assured that wind energy would play a major role in Colorado’s energy future.

Throughout the 1990’s Xcel energy, the largest utility in Colorado, was engaged in a series of battles with environmental groups over renewable energy. The most active and well funded of these environmental groups was a Boulder-based environmental advocacy organization Western Resource Advocates (WRA) (Komor, 2006). WRA was originally founded in 1989 under the name Land and Water Fund of the Rockies with the goal of protecting the land, air and water of the western United States. Environmental groups, led largely by WRA, were lobbying the state
government to force Xcel to explore and fund the adoption of wind. Although Xcel had instituted a voluntary donation program for renewable energy support as early as 1993, the program had little success and was widely perceived as ineffective (Mayer, Blank, Udall, & Nielsen, 1997). In 1996 deregulation of the utility industry was a popular trend in the U.S. that had major implications for Xcel’s competitive future (Delmas, Russo, & Montes-Sancho, 2007). In 1997 the threat of deregulation was very real, with the Colorado Public Utility Commission (PUC) scheduling a number of hearings on the issue. The PUC has direct jurisdiction over investor-owned utilities in the state and PUC hearings acted as the battleground where environmental groups advocated for wind energy.

In 1996, environmental groups were largely frustrated by their inability to move renewable energy adoption forward in Colorado and believed that they could rebuild relationships with the utility through a collaborative effort (Mayer, Blank, & Swezey, 1999); on the other hand, Xcel was feeling pressure from the looming threat of deregulation and wanted to diversify its resource base to demonstrate that it could meet the needs of all of Colorado’s constituents. These dual forces combined to create an unlikely partnership and the creation of the Windsource voluntary green power pricing program. This type of programs offers utility customers the option to pay a price premium to purchase some, or all, of their power from renewable sources. In 1996 such programs were virtually unknown, and provided a mechanism to demonstrate demand and support for renewable energy (Komor, 2006).

Environmental groups, including the Boulder Energy Conservation Center, the Colorado Renewable Energy Society (CRES), and the Sierra Club were coordinated through the WRA to work on joint marketing, press releases and pricing points with Xcel. This partnership led to a very successful first foray into wind energy for Xcel; although the utility originally anticipated
building 10MW of new wind farm capacity, demand was far greater than expected, and by 2001 60 MW of wind capacity had been installed (Komor, 2006). By 2004 Windsource was the most successful green pricing program in the country with 29,032 customers (Proctor, 2005). While Windsource demonstrates how environmental groups may influence the adoption of wind energy through partnership, this interesting alliance was somewhat short-lived. As one WRA member described it:

I think there was like a flip in the utility relationship, that all of a sudden we started working together to solve problems. And it went way beyond wind … and then it broke down in the 2000s; there was a big fight over Amendment 37.

**Winds of Change: The Push for Policy**

After Windsource the next major event in the history of Colorado wind power was a key decision in 2001 by the PUC. Following a lengthy analysis and debate, the PUC required Xcel to purchase wind energy for its new power generation needs. Xcel’s 1999 resource plan included a request for proposal (RFP) process for new electricity supply. Among the received bids was a proposal for a 162 MW wind farm located near Lamar, Colorado. Despite the rising cost of natural gas, the wind farm proposal was excluded from consideration. Xcel explained that wind was an unreliable resource; excluding the plant was an “…economic decision based on the cost of power” according to Xcel spokesman Mark Salley (Booth, 2001).

Wind advocates, including WRA and CRES offered their own analysis and arguments for considering the wind project in the January 2001 PUC hearings. Their analysis showed that wind power could be generated at 3 to 3.5 cents per kilowatt-hour compared to the 5 cents per kilowatt-hour cost of a new natural gas plant (Raabe, 2001). PUC commissioners sided with
environmental groups and concluded that the wind farm was more cost effective than Xcel had proposed.

In the Lamar case, the same environmental groups that worked with Xcel to introduce and promote the Windsource program opposed the utility and fostered regulatory action that forced the utility to engage in further adoption of wind energy. Environmental groups were encouraged by their victory in the Lamar plant case, and by the Windsource program, but continued to advocate for more stringent, government-enforced standards for wind energy adoption. The focus of this effort was largely to implement a renewable energy portfolio standard (RPS) for the state of Colorado that would require Xcel and any other utility in the state to generate a defined percentage of its energy portfolio from renewable sources. While Xcel was open to “market based” approaches, the utility was opposed to having a standard for energy sources dictated and enforced by the state government. In Colorado, the struggle to implement a RPS would take over three years, with numerous failed attempts before implementation was finally achieved.

The first attempt to create a RPS in Colorado was introduced by State Senator Terry Phillips (D) in the 2002 legislative session and was notably supported by WRA, a variety of wind project developers and the Rocky Mountain Farmers Union, a small organization of family farmers whose goals included environmental protection (Komor, 2006). Environmental groups also began evolving their arguments based on the success of the Lamar plant project decision. For example, Colorado Public Interest Research Group, an environmental SMO, released and promoted a report outlining the economic argument for wind energy stating that wind development “would bring $230 million in additional property tax payments to rural counties in the next 18 years, plus $76 million in royalties to farmers and ranchers” (Raabe, 2002). Despite
passing the Senate and House, the bill failed when the Senate and House failed to reconcile differences in the versions of the bill before the legislative session ended. A second attempt to pass a RPS in 2003 failed, largely due to opposition from Xcel and the Colorado Rural Electric Association.

While the opponents of the RPS created lobbying groups such as Citizens for Sensible Energy Choices, entrepreneurs and clean energy groups began to join the fray as well. For example, the Interwest Energy Alliance was created in 2002 as an alliance of industry representatives and non-governmental advocacy groups to “support state level policies that harness the West’s abundant – and inexhaustible – renewable energy and energy efficiency resources” (Interwest Energy Alliance, 2010; Raabe, 2003). When a third attempt to pass a RPS seemed likely to fail in 2004, wind advocates decided to switch tactics; they decided to pursue passing an RPS requirement by ballot initiative, or direct vote by the citizens of Colorado.

Environment Colorado, an environmental activism group, led the charge for Amendment 37, which would require Xcel and other utilities to acquire 10% of their energy from renewable sources by 2010 and 20% by 2022. Many other proponents were involved in the collection of the 60,000 required signatures to get Amendment 37 on the ballot including various cities in Colorado, economic development councils, unions and the ski industry (Komor, 2006). An activist who was involved in the grassroots campaign described the effort as follows:

…that’s Amendment 37. And if you pin it on one organization, you could pin it on Environment Colorado. Another group that is very important is Boulder-based Western Resource Advocates…and they were working very closely together with the Solar Energy Industries Association and Colorado Renewable Energy Society…about four, five, six, seven organizations all pretty much rolled up their sleeves together in 2004. They were the ones that had been lobbying unsuccessfully by very close votes to get us to have Colorado be on the list of states that have a renewable portfolio standard.
…we just got frustrated. And because we have a record in Colorado of taking the issues that the legislature is not dealing with directly to a vote of the people…There was no hand on the part of corporations or government that was helping one iota on that. It was all NGOs.

This combined coalition was finally successful in creating a RPS for Colorado when Amendment 37 passed by 54-46 percent in November of 2004, the first RPS created in the U.S. through a ballot initiative.

While there was clearly opportunity for entrepreneurs in Colorado wind energy prior to Amendment 37, few would dispute that the establishment of an RPS reduced the uncertainty for wind power adoption in the state. One of our interviews with a leader in both social movements and government roles described the co-evolution of policy, SMOs and entrepreneurship:

… that (entrepreneurship) followed … you know, it was entrepreneurship that got it going…there’s a lot of entrepreneurship now around the clean energy space…it was policy that came from the people that led. So entrepreneurs have been very important at the more recent end of this story.

New Entrants and new SMOs

Entrepreneurship in the area of wind energy-related products and services, including installation, consulting, manufacturing and training has steadily increased in Colorado since the passage of Amendment 37 (CORE & Evenson, 2009). Directly after the new legislation Xcel began reviewing bids for 17 new wind-power projects, including a bid from Prairie Wind LLC, a “group of five farmers, ranchers and landowners who have been working towards locally owned wind energy in Southeast Colorado since the first of 2004” (Prairie Wind Energy LLC, 2010; Raabe, 2004).

Prairie Wind was far from the only startup initiated to reap the harvest of wind power ensured by Amendment 37. A recent study by the Connected Organizations for a Responsible
Economy (CORE) found that over 261 firms were founded in a variety of clean technology fields, including wind power, since 2005 (CORE & Evenson, 2009). Wind energy firms locating in Colorado included large manufacturers such as Vestas and Juwi, but also smaller start-ups. One entrepreneur described his motivations as both financially driven, but also connected to his roots as an environmental activist:

I’m a lawyer and an economist. Spent 10 years running the energy work for a non-profit trying to promote clean energy in six western states. One of the things we did was have customers pay a little bit more on their energy bills, to promote...to buy wind energy.

…and that led to a very successful cutting-edge national program in Colorado…my partner and I took that Colorado experience and tried to move it back east to a competitive electric market where customers were switching away from their electric supplier, and turn it into a viable…a viable business.

**Summary**

By combining lessons from the fight for wind legislation in Colorado with business models that became less risky with the adoption of wind energy by Xcel, entrepreneurs found multiple niche markets that leveraged the supportive climate in Colorado. Renewable Choice Energy, a Boulder-based start-up initiated in 2006, was an early leader in the trading of renewable energy credits that allow existing firms to offset their use of conventional power. Existing heavy industry companies such as TIC moved into wind turbine projects and multiple energy efficiency firms initiated consulting initiatives focused on renewable energy (CORE & Evenson, 2009). Small wind, the installation of wind turbines for homes and small businesses, was explored by start-ups such as Mobile Energy Solutions beginning in 2004 (Jackson, 2006). While these small firms were not direct beneficiaries of the mandatory policies for renewable energy in Colorado, the regulatory legitimacy (Scott, 1995) that these policies provided likely reduced the risk perceived by potential entrepreneurs in the wind energy field. One wind
development entrepreneur described the impact of regulations on his business as influencing where to initiate projects:

… we have a long history in those communities and fairly deep relationships, from multiple avenues. So we came out of those communities, my partner and I, and have done nothing but deepen our relationships in our core markets. And we tend to start in markets where we have a successful track record… it’s an enormous competitive advantage in a regulatory, policy-driven business, it’s an enormous advantage.

Previous studies have established the role of social movements (Hiatt, Sine, & Tolbert, 2009; Rao, 2004) and social norms (Meek, Pacheco, & York, 2010) in encouraging and initiating new industries, including wind power (Sine & Lee, 2009). The effect entrepreneurial action may have on altering the structure of social movements is far less understood. In examining the case of Colorado, we found that the story of wind energy did not end with the entrepreneurial opportunity created through the policy and informal actions of social movements, but the entry of new firms into Colorado also signaled opportunities for institutional entrepreneurship on the part of emerging, clean-energy focused SMOs. Indeed, from 1998 to 2009, the number of registered clean energy SMOs in Colorado more than doubled from 9 to 25 (from author’s data compiled from the National Center for Charitable Statistics). As one activist described it:

Well, there’s been no let-up in the NGO activism. I don’t know if there’s an actual quantification where there’s been formation of new NGOs. But I think there has been. … some of these NGOs are … differentiated from what you’ve seen in the past…. the classic environmental organizations in the past have been made up of citizen activists …. who are doing things for the betterment of the common wealth. But I think that the new type of NGOs are verging more on kind of associations that represent the interests of their constituents. So it’s migrating more towards almost a trade association as the type of NGO.

The emergent SMOs in Colorado tended to be more focused on energy efficiency and renewable sourcing of energy as their sole issue to promote. Because of this refined focus, and
due to the successes of earlier environmentally focused SMOs, these organizations have tended to work to foster greater legitimacy and institutional support for the wind energy industry rather than creating mandatory requirements for utilities to comply to. For example, in 2006 the Interwest Energy Alliance began to engage in promoting reports that showed transmission to be a major impediment to the further adoption of wind energy (Raabe, 2006). Community for Sustainable Energy is a small SMO founded by an environmental activist in 2006 to champion low interest loans for energy efficiency at the county level (Community for Sustainable Energy, 2010). A government representative attributed the current level of new legislation to action by these interest groups saying:

… they know how to connect the dots. They can see that policy is very important. But you’ve got to have the... you’ve got to have the right markets. You’ve got to have the right kind of technology out there ... what they do is they, uh, they interact closely with legislators

The net effect of these efforts has been to further enhance the business environment for wind power initiatives in Colorado. Since 2006, 57 separate pieces of legislation related to energy efficiency or renewable energy have been passed in Colorado, 16 of which were related to wind energy (DSIRE, 2010; Office of the Governor of Colorado, 2010). This legislation has ranged from tax incentives for firms producing renewable energy equipment, to rebates for the installation of renewable energy systems, to $656,000 in grants statewide to advance renewable energy projects (Office of the Governor of Colorado, 2010). While the story of wind energy may be exceptional, it provides an illustration of recursive evolution of social movements, entrepreneurial entrants and state level policies to promote a new industrial segment. Early efforts of environmental SMOs drove initial actions by the utility and drove changes in policy. These changes strengthened the opportunity of wind energy for both new firms and SMOs.
THEORETICAL DEVELOPMENT

The case of the wind energy sector in Colorado demonstrates that the process of institutional change and its repercussions on the development of an emerging industry is co-evolutionary in nature (Lewin & Volberda, 1999; Porter, 2006). It shows that there are interdependencies amongst the actions of the different parties that seek to change industry-level institutions—that is, the informal (e.g., norms, conventions) and formal (e.g., government policies) set of incentives that drive behavior (North, 1990). Mutual causality seems to explain the notion that while the environmental social movement was important in shaping the fate of the industry, the establishment and growth of the industry itself led to the creation of more specialized types of SMOs, which transformed the structure of the social movement and the institutions (i.e., policies) in the field. Furthermore, this process of change appears to have been driven by dialectical mechanisms (Hargrave & Van De Ven, 2006; Van de Ven & Poole, 1995) that explain the engagement of key actors in political behavior. Namely, the SMOs that actively participated in the transformation of institutions (e.g., new policies and standards) often engaged in collective action by means of political contestation and social mobilization to promote their desired end. The policies proposed by these groups, and eventually enacted by the state, emerged from conflict and a dialectical political struggle between the SMOs and the electric utilities involved. This example is well aligned with the theoretical premises of social movement theory (McCarthy & Zald, 1973; McCarthy & Zald, 1977), which characterizes social movements as collective organizations of individuals with shared identities and goals (Blumer, 1969). Through collective organization, these movements often engage in contentious politics (McAdam, McCarthy, & Zald, 1988); including protest activities as a means to convince or influence those in power (Fendrich, 2003).
Below we describe in greater depth how these co-evolutionary and dialectical processes may explain changes in institutions, the structure of the environmental social movement, and the development of wind energy in the case of Colorado. We derive theoretical explanations for such and provide hypotheses that can be tested for generalizability.

**Hypotheses Development**

In describing the process of change that took place in the wind energy sector in Colorado, it is worth emphasizing that the sequence of events seems to have been triggered by the intervention of environmental SMOs and their objective to promulgate change in the practices of electric utilities in the state. Motivated by their inability to accomplish such goals, environmental SMOs pushed state authorities for support and eventually turned to voters to force electric utilities to increase their reliance on renewable energy. In doing so, environmental SMOs seemed to have been interested in targeting centralized and powerful actors, such as electric utilities (as opposed to promoting other market incentives for renewables, for example), that were easy to identify and monitor, highly visible, and vulnerable to public scrutiny. Perhaps their motivation to target electric utilities was also based on the ability of electric utilities to bring about significant changes to the electricity mix of the state which, once legitimated, could create opportunities for further growth in wind power and other renewable sources. The need to convince large and powerful centralized authorities with policies such as RPS, which demand great resources and are relatively high risk, commands the intervention of large and broader movements (McAdam et al., 1988). Hence, it seems logical to suggest that organizations in the broader environmental social movement, which has been highly professionalized (Van der Heijden, 1997) and who have become larger and more powerful in the last decades (Straughan &
Pollak, 2008), would engage in the design, promotion, and implementation of mandatory policies geared towards changing the practices of powerful actors.

While the literature in environmental policy classifies public policies in this domain as: command and control, market-based incentives, and voluntary incentives and programs (Hatch, 2005; Kraft & Vig, 2009; Press & Mazmanian, 1999), we suggest that the broader environmental social movement is more likely to be involved in command and control mechanisms (which we refer to as “mandatory rules and standards” in the context of the wind energy sector).

Particularly, in the early stages of an industry and in the context of environmental mitigation, these mandatory rules tend to force incumbents into new practices that are necessary for the legitimization and economic support of a new industry. They also require the experience and resources available to large SMOs with more general environmental objectives. Hence, we hypothesize:

**H1**: There is a positive relationship between the participation of environmental SMOs in a state and the incidence of mandatory rules and standards related to wind power in that state.

When examining the entire range of policies and incentives that state governments in the U.S. have enacted in the wind energy sector, a classification similar to the one proposed in the environmental policy literature emerges (Hatch, 2005; Kraft & Vig, 2009; Press & Mazmanian, 1999). These incentives are best categorized as: 1) mandatory rules and policies that require firms to comply with certain practices or offer specific products; 2) industry development incentives whereby state governments provide grants and other financial assistance to foster new businesses and related research and development; 3) financial or market-based incentives that
provide individuals and businesses with subsidies or tax credits that spur demand for wind energy technology. The implementation of these incentives could enable the appropriate market and social conditions that incent new firms to enter the wind energy sector. This was illustrated in the case of Colorado where entrepreneurial activity was observed and increased steadily after the passage of a RPS in the state. These policies and incentives not only remove market barriers for business activity in wind energy, but also deliver sociopolitical legitimacy—acceptance of key constituents of an industry’s practices, outputs, or goals (Aldrich & Fiol, 1994; Scott, 1995). The latter is particularly important to firms in emerging industries, which often confront the liability of newness (Stinchcombe, 1965), and must gather support from powerful actors to gain normative acceptance (Zimmerman & Zeitz, 2002; Zott & Huy, 2007). The passage of favorable policies for wind energy signals government sanctions through legal endorsements that enhance the legitimacy of the sector. This in turn increases the survival chances of firms and their ability to access critical resources (Zimmerman & Zeitz, 2002; Zott & Huy, 2007). The latter further creates incentives for new firm foundings. Consistent with this, we hypothesize:

**H2a:** There is a positive relationship between the incidence of mandatory rules and standards in favor of wind energy in a state and the number of wind energy firm foundings in that state.

**H2b:** There is a positive relationship between the incidence of industry development incentives towards wind energy in a state and the number of wind energy firm foundings in that state.

**H2c:** There is a positive relationship between the incidence of financial incentives in wind energy in a state and the number of wind energy firm foundings in that state.
Following the timeline of events in Colorado, as the wind industry began to grow, a greater population of specialized “clean energy SMOs” emerged. These organizations undertook initiatives that were more focused on the specific needs of the renewable energy industry at this stage. In explaining this phenomenon, we posit that just as the role of SMOs in public policy processes changes with each stage in the process (King & Soule, 2007), the population of SMOs also will change. Whereas initially the social movements following a particular issue are motivated by the general proposition that it is socially beneficial for a new industry that corrects market failures to emerge and grow, once firm foundings have increased and the industry has gained legitimacy, SMOs will switch into a new mode of aiding the nascent industry. Thus we make the dynamic argument that the increased specialization of SMOs follows from the industry life cycle, as well as from high intra-SMO competition, as resource mobilization theory would predict (McCarthy & Zald, 1973; McCarthy & Zald, 1977). This is also consistent with the premises of resource partitioning theory (Carroll & Swaminathan, 2000; Carroll, 1985), which predicts the rise of specialist organizations in the later stages of an industry as the outcome of consolidation of large generalists (the broad environmental SMOs in this case). However, as our case reflects, the change in the structure of the environmental SMOs was not only internally driven by the competition dynamics within the SMO population as resource partitioning theory would predict, but by the growth of the wind energy sector as well. Hence, the growth in the population of clean energy SMOs is not solely a result of the changes in the structure of the social movement industry, but of the rise of wind power itself. Accordingly, we suggest:

**H3:** There is a positive relationship between wind energy firm foundings in a state and the participation of clean energy SMOs in that state.
As the case of Colorado illustrates, not only did the population of clean energy SMOs rise after the resurgence of the wind energy sector, but these organizations also began to take a different role in addressing the needs of the industry. For example, some of these specialist SMOs took initiatives to resolve issues related to the transmission of wind power and the availability of financial resources for wind projects. Hence, the presence of these clean energy organizations began to shift the focus from the broader goals of the general environmental social movement towards industry-specific needs. Because to some degree this requires specialized knowledge and capabilities, a new sub-population with such skills was likely necessary. Existing generalist SMOs cannot play this role because they have broader agendas and capabilities and may not possess the absorptive capacity (Cohen & Levinthal, 1990) needed to engage in specific issues. They may also be constrained by prior resource commitments and path dependencies (Teece, Pisano, & Shuen, 1997) that prevent changes in their overall mission and objectives. Instead, specialist SMOs could focus on the issues at hand and work together with industry participants in crafting solutions to market failure and other industry development challenges. In doing so, they are likely to promote the creation of policies and incentives that seek to provide financial stability and demand for the industry, as well as to foster new business creation; which as described in hypothesis two above, can propel further industry growth and change. Following this rationale, we hypothesize:

\( H4a: \) There is a positive relationship between the participation of clean energy SMOs in a state and the incidence of industry development incentives related to wind power in that state.

\( H4b: \) There is a positive relationship between the participation of clean energy SMOs in a state and the incidence of financial incentives related to wind power in that state.
The rise of specialized SMOs may also bring more visibility and exposure to the industry that it intends to promote. Because clean energy SMOs often engage in the task of educating society about the benefits of renewable energy and raise the discussion of these benefits to the public arena, they assist not only in promoting public policy, but in expanding the visibility that the industry enjoys. This type of exposure could in turn enhance the legitimacy of the industry, delivering a greater sense of familiarization and embeddedness with social norms and expectations (Chiu & Sharfman, 2009). The latter has important implications for the subsequent growth of the wind energy sector. Industry legitimacy can increase access to critical resources and capital for entrepreneurial firms (Aldrich & Fiol, 1994; Zimmerman & Zeitz, 2002). It can also engender the appropriate environment for collective learning that boosts founding rates in the initial stages of an industry (Hannan & Carroll, 1992). Hence, an industry may enjoy significant benefits from the increased visibility and exposure that are accompanied with the rising population of specialized SMOs. Indeed, it is the structural changes in the population of SMOs towards specialization that trigger these positive externalities. Following this, we suggest:

**H5: There is a positive relationship between the participation of clean energy SMOs in a state and the visibility that the wind energy sector enjoys in that state.**

Taken together our hypotheses illustrate the complex, co-evolutionary relationships between SMOs, the wind energy sector, and the institutions (i.e., policies) that influence the sector. Hypothesis 1 refers to the influence of social movements on institutions, while Hypotheses 2a-c refer to the influence institutions then have on industry. Hypothesis 3 captures the recursive influence of industry back onto social movements, while Hypotheses 4a, 4b, and 5
capture the ongoing nature of co-evolutionary processes by referring to a new round of social movement influence on institutions. Figure 2 below provides an illustrative depiction of these relationships and the process of industry evolution that unfolds.

Insert Figure 2 about here

QUANTITATIVE ANALYSIS AND METHODOLOGY

Sample

We conduct our quantitative analysis on the U.S. wind energy sector. Consistent with our findings in the case of Colorado, the broader environmental social movement has been actively involved in shaping the fate of the wind power sector across the country. In addition, the total number of SMOs in the U.S. dedicated to renewable energy and energy conservation has exploded in the last decade (Straughan & Pollak, 2008). In fact, between 1989 and 2006 the total revenue of this subsector increased over 14-fold, even as revenues for environmental organizations as a whole were steady (Straughan & Pollak, 2008). These organizations often craft specific goals to combat climate change and educate consumers about the benefits of renewable energy. In sum, there is a considerable representation of broad environmental SMOs, as well as specialized clean energy SMOs across the US that endorse the practices of the wind energy sector. This delivers a unique context in which to explore how the wind energy sector has coevolved with these distinct populations of social movement organizations.

This research is conducted in the context of the wind energy sector across all 48 contiguous U.S. states. It explores how the actions of SMOs that operate within the boundaries
of a state are related to the growth of the state wind energy sector (and vice versa) and the repercussions of such on a variety of state-level policies and incentives that impact the subsequent fate of the sector. As such, the state is regarded as the central unit of analysis. This selection is based on various factors: first, legislative action in favor of wind energy technologies has mostly taken place at the state level (Rabe, 2006). Indeed, state authorities are responsible for most initiatives sponsoring renewable energy programs. Second, a great number of environmental SMOs are organized by geographic and jurisdictional limits that seek to target state-level initiatives. Together these factors validate the choice of state level analysis, particularly since variability in the constructs of interest is expected at this level.

We test our hypotheses through a longitudinal study for the years 1999-2008. The period between the late 1990s and the early years of this new century has been characterized by an increased number of state-level legislative action in renewable energy; specifically the implementation of Renewable Portfolio Standards (Rabe, 2006). Moreover, this period witnessed the drastic rise of renewable energy technologies in the U.S. In the U.S., this period has delivered the highest growth in the history of the wind industry (AWEA, 2007). Thus, the resurgence of renewable energy since 1999 provides opportunities to understand the factors contributing to the growth of the wind energy sector.

**Measures**

**State Mandatory Rules and Standards.** To measure state-level mandatory rules that impact the production of wind energy, we track the cumulative number of instances in which a state passes a law that mandates electric utilities to take action over explicit renewable energy issues. Specifically, our measure includes a sum of the instances in which a state has enacted a RPS, mandatory green power options, or generation disclosure rules. An RPS mandates that a
certain percentage of a state’s electricity sales be generated from renewable energy sources by a specified target date. Under such standards, electric utilities are obligated to update the mix of their electricity generation profile to account for the necessary percentage originating from renewables. In addition, states with mandatory green power rules require electric utilities to offer customers the choice to buy electricity that is generated from renewable energy sources. Finally, generation disclosure rules mandate that utilities disclose full information regarding fuel mix percentages and pollution discharges to utility consumers. Under such provisions, consumers become fully aware of the weight that renewable energy sources have on the total generation capacity of electric utilities. Data for each of these rules were gathered from the Database of State Incentives for Renewables and Efficiency (DSIRE), which contains information on a variety of regulatory measures (e.g., subsidies, tax credits, laws) for each state in the renewable energy industry. The final measure of this variable (as well as for other policies and incentives such as industry development incentives and financial incentives) required a square root transformation that assisted in reducing the effects of heteroskedasticity related to its distribution. Further robustness tests were carried out in relationship to this and are explained in the “Robustness Analysis” section of the appendix.

**Industry Development Incentives.** Our measure of industry development incentives is based on the sum of the cumulative instances in which a state passes an industry recruitment incentive or a public benefit funds rule. The former is based on financial incentives provided by the state in the form of grants or tax credits that sponsor job creation and further development of the local renewable energy sector (with some specific to wind energy only). The latter refers to a rule under which the state requires a small surcharge on electricity consumption that is further used to sponsor the development and growth of research, loan, and education programs often
geared towards alternative forms of energy. Data from DSIRE were also collected to construct this measure.

Financial Incentives. To measure state-level financial incentives in wind energy we constructed a measure of the cumulative number of instances in which a state enacts a statute that provides personal, corporate, sales, or property tax credits towards the purchase or production of wind energy technology. Data for this measure were also compiled from the DSIRE database.

Wind Energy Firm Foundings. We follow the tradition in organizational ecology to consider the use of industry directories in assessing organizational foundings (Baum & Singh, 1994; Caroll & Hannan, 2000). This literature usually assumes that the first year in which an organization appears in an industry directory is indicative of its founding date (e.g., Baum and Singh, 1994). Thus, to estimate annual foundings, we construct a count measure of the number of wind energy firms that appear for the first time in the World Directory of Renewable Energy Suppliers and Services for a particular year and state (based on the state in which the firm is headquartered). This directory represents the official and sole annual publication dedicated to providing a yearly summary of the renewable energy industry’s trends and participants.

Participation of Clean Energy SMOs. This research uses data from the National Center for Charitable Statistics (NCCS) to create a measure of clean energy SMO participation. Used by extant research in social movements (McVeigh, Welch, & Bjarnason, 2003), the NCCS data provides records of all registered nonprofits in the U.S. within pre-specified classifications. One such category includes “Environmental and Conservation Organizations”, which has further sub-sectors, including the “Renewable Energy and Energy Conservation” group. We used data from the latter group to create a count of the number of organizations that are registered in a state for a given year.
**Wind Energy Sector Visibility.** To capture the extent to which the wind energy sector gains visibility and public exposure, we use an annual count of the number of articles within the top newspaper publication in every state that cover wind energy topics on a yearly basis. The newspaper selection was based on the top circulated newspaper in a state for all 48 states as reported by the Audit Bureau of Circulation. Following a detailed assessment by multiple renewable energy experts, a variety of keywords were selected and used to identify the articles of interest. We constructed a final measure entitled “Ratio of Newspaper Articles” that is based on the annual number of newspaper articles with wind energy topics in a state as a proportion of the average length of the newspaper.

**Participation of Environmental SMOs.** To measure the participation of environmental SMOs in a state, we also relied on data from NCCS to construct a variable of the number of registered “Environmental and Conservation” non-profit organizations within a given state and year.

**Control Variables.** We used a variety of controls for each dependent variable of interest. First, for the equations that predict state-level policies and incentives (i.e., mandatory rules and standards, industry development incentives, and financial incentives) we control for the political climate of a state relative to environmental causes. To do so, we employ a measure of a state’s annual League of Conservation Voters scores (from House and Senate), which awards points on the basis of how members of Congress vote on environmental measures. These data were obtained from the League of Conservation Voters.

Additionally, to consider the effect that state political ideologies may have on the sponsorship of renewable energy technologies, we control for whether a state legislature is controlled by the Republican Party, the Democratic Party, or neither (split). This measure comes
from the National Conference of State Legislature. We constructed two categorical variables with contrast codes to represent each of these groups. The first one is coded as “-2” for split and “1” for Democratic and Republican dominating legislatures. The second one is coded as “0” for split, “-1” for Democratic, and “1” for Republican controlling legislatures. Furthermore, to control for the effect that the competitiveness of markets can have in the relationships of interest, this study includes a categorical control variable at the state-year level that is coded as “-1” for regulated states and “1” for deregulated ones. Data for this variable comes from the Energy Information Administration. This study also controls for the size of the sector in a state through a measure of organizational density—the total number of organizations of a particular type (e.g., Carroll and Hannan, 1989; Hannan and Carroll, 1992). Organizational density is measured as a count of the total number of wind energy companies known to exist in a state for a given year (Carroll and Hannan, 1989; Hannan and Carroll, 1992). Moreover, we control for the educational attainment of a state based on data from the U.S. Census Bureau. This variable is measured as the percentage of a state population that has a bachelor's degree or higher education.

Furthermore, we include controls for the natural wind energy potential of a state. We use a measure of the percentage of total electricity consumption in a state that could be produced with wind power (Elliot and Schwartz, 1993). This measure considers the number of acres in a state that have a wind class greater or equal to 4 and excludes urban and environmental land in a state that cannot be used for wind power purposes. It also discounts forest and agricultural lands that for similar reasons cannot be considered for the development of wind power. These data were not available for the states of Hawaii and Alaska, which prevented the inclusion of these states in the analysis. Second, when wind energy firm foundings is the dependent variable, we also employed the following controls: the league of conservation voters score, the regulatory
environment for electricity markets in a state, the natural wind energy potential of a state, and the organizational density of wind energy firms. In addition, we included controls for the median income in a state as reported by the U.S. Census Bureau as well as a control for the existing number of megawatts of wind power capacity owned by utilities for a given state and year. The latter was constructed from information available from the American Wind Energy Association. Third, when conducting the analysis for the participation of clean energy SMOs we included controls based on the league of conservation voters score, the natural wind energy potential of a state, and the average educational attainment of a state. Finally, our model that predicts the visibility of the wind energy sector applied controls for the political environment in relation to environmental issues as measured by the league of conservation voters score, the natural wind energy potential of a state, and the organizational density of the wind energy sector for a given state and year.

The variables that are potentially sensitive to the size of a state were normalized by the annual population of a state. These are: the measure of wind energy firm foundings, the number of clean energy SMOs in a state, the number of environmental SMOs in a state, and the organizational density of the wind energy sector. For the normalized variables that were included as dependent variables, a logged transformation was applied to reduce the potential for heteroskedasticity. In addition, we include year and state dummy variables that enable us to control for any unobserved heterogeneity that may remain at these levels of analysis.

**Data Analysis**

Given the presence of reciprocal causal relationships in our theoretical model and consistent with parallel research in organizational processes of change (Garud & Van de Ven, 1992), we constructed a system of simultaneous equations that allows us to model the
endogeneity inherent in this process (Greene, 2003). Our system of equations consists of the following:

\[
\text{MandatoryRules\&Standards} = f_3 (\text{EnvironmentalSMOs, EnergySMOs, } Z_3, \epsilon_3) \quad (1)
\]
\[
\text{WindFirmFoundings} = f_1 (\text{MandatoryRules, IndustryIncentives, FinancialIncentives, } Z_1, \epsilon_1) \quad (2)
\]
\[
\text{EnergySMOs} = f_2 (\text{WindFoundings, } Z_2, \epsilon_2) \quad (3)
\]
\[
\text{IndustryDevelopmentIncentives} = f_4 (\text{EnvironmentalSMOs, EnergySMOs, } Z_4, \epsilon_4) \quad (4)
\]
\[
\text{FinancialIncentives} = f_5 (\text{EnvironmentalSMOs, EnergySMOs, } Z_5, \epsilon_5) \quad (5)
\]
\[
\text{WindSectorVisibility} = f_6 (\text{EnvironmentalSMOs, EnergySMOs, } Z_6, \epsilon_6) \quad (6)
\]

where \( Z_i \) are vectors of controls and instruments particular to each dependent variable and \( \epsilon_i \) are the error terms associated with each equation. Within this system, all of the variables named above are considered endogenous, with the exception of Environmental SMOs, which together with our control and instrumental variables are treated as exogenous.

The endogeneity in our system of equations prevents the use of OLS techniques, since the latter would yield inconsistent and biased estimates when regressors are correlated with the disturbance term (Kennedy, 2003). Therefore, we conducted a three stage least squares (3SLS) analysis that allows cross-correlations between the equations of interest (Zellner & Theil, 1962). This procedure requires three steps. In the first step, the predicted values for all the endogenous variables in our system are generated using all the exogenous variables. In the second step, a two stage least squares is conducted to get residuals to estimate the cross-equation correlation matrix for the final estimation. Finally, in the last step the equations with the instrumented endogenous variables are subject to a seemingly unrelated estimation algorithm that accounts for covariances across equations (Greene, 2003).
Of great importance in 3SLS analysis is the relevance of the instruments selected. This condition requires that there is a strong fit between the endogenous variables and their respective instruments, but that the instrument does not influence the dependent variable of an equation, so as to minimize its correlation with the disturbance term (Nelson & Startz, 1990). A robust method for testing the latter condition has been proposed by Stock and Yogo (2004). This test involves calculating an F-statistic testing the hypothesis that the coefficients of the instrument equal zero in the first stage of the analysis. Stock and Yogo (2004) offer critical values that are necessary to satisfy the relevance or “strength” of instruments dependent upon the number of endogenous regressors in the model. Hence, an F-statistic higher than the critical values specified by Stock and Yogo (2004) on the basis of size and OLS bias, allows us to suggest that the instrument satisfies the condition of relevance or “strength”.

When state policies and incentives were the dependent variable (equations 1, 4, and 5 above), we included an instrument for our endogenous variable—the number of Clean Energy SMOs—based on the strength of other specialized environmental social movement organizations in a state. Specifically, we suggest that the total assets and the population of environmental “resource” and “professional” nonprofits in a state—those that are dedicated to the conservation and protection of natural resources from abuse or neglect (e.g., wildflower conservation) and to organizing local professionals in the environmental domain (e.g., professional councils) is related to the participation of clean energy SMOs in a state. This is because membership in the former organizations attracts individuals whose values or experiences are likely to be aligned with the conservation of energy resources and concerns for climate change, both of which are inherently integrated with the goals of energy SMOs. However, because the policies and incentives that we analyze are very specific to renewable energy and wind energy in particular, we do not expect
that the presence of resource conservation and professional organizations will directly influence the likelihood of such policies. We find through a Stock and Yogo test of all excluded instruments that the number of clean energy SMOs is well instrumented by the strength (total population and assets) of these other type of environmental organizations (amongst other excluded instruments) \( (F=16.08/F_{\text{crit}}=6.73 \) for the mandatory rules and standards dependent variable; \( F=15.41/F_{\text{crit}}=6.73 \) for the industry development incentives dependent variable; \( F=37.66/F_{\text{crit}}=6.73 \) for the financial incentives dependent variable). \)

For equation 2, where we aim to predict wind energy firm foundings, we instrumented our wind energy policy and incentives endogenous variables by including a variable based on the total revenues received by a state in a given year. Arguably, the financial health of a state is related to its ability to focus and enact more policies that are geared towards renewable energy. Or said differently, in the absence of resources that can be dedicated to policy formulation and implementation, states would be less likely to adopt such policies. In addition, we have no a priori reason to theorize that the financial health of a state is related with the incidence of new businesses in the wind energy sector, which strengthens its role as an instrument. Based on the Stock and Yogo test for all excluded instruments, we find support for the use of total state revenues (amongst other excluded instruments) as a strong instrument for our wind energy policy and state incentives variables (\( F=35.01/F_{\text{crit}}=6.76 \) for mandatory rules and standards; \( F=15.61/F_{\text{crit}}=6.76 \) for industry development incentives). \)

When predicting the number of clean energy SMOs in a state (equation 3 above), we include an instrument for wind energy firm foundings measured as the number of utilities that are active in a state (normalized by state population). This instrument enables us to proxy the extent to which electricity generation in a state is dispersed, and therefore, the opportunities that
may exist for new businesses in wind energy. We suggest that such patterns would not be relevant to the population of energy SMOs in a state, as the latter is more driven by social concerns as opposed to market conditions. Indeed, a Stock and Yogo test for the excluded instruments in equation 5 reveals that they are strong and relevant \( (F=12.71/F_{\text{crit}}=8.75) \). Finally, in equation 6 where we predict the visibility of the wind energy sector through a ratio of newspaper articles, we apply a similar rationale to the choice of instruments used in the first equation. In this case, we include an instrument for the number of clean energy SMOs based on the total revenues of other environmental organizations in a state, which relates to the extent to which local citizens are concerned for natural resources. The latter is likely to be related with the levels of activity by energy SMOs in a state. The presence of these other types of environmental organizations, however, should not necessarily impact the visibility of the wind energy sector through newspaper coverage; as these organizations tend to undertake other initiatives outside of the energy domain. The Stock and Yogo test for the excluded instruments in equation 6 confirms that they are relevant to the endogenous variable of interest \( (F=7.54/F_{\text{crit}}=6.46) \).

We applied a lagged data structure in the analysis. Specifically, we use a one-year lag between the independent variables (measured at time \( t-1 \)) and the dependent variables (measured at time \( t \)) of interest. For equation 4, where we predict wind energy firm foundings, we apply a three-year lag. The choice for this lag is based on the timing that is often used in the design of policies and incentives that are included in the analysis. Specifically, mandatory standards such as RPS set a target completion date in the future, often ranging from 10 to 15 years. We suggest (and empirically find) that states will begin to see an effect on firm foundings and the implementation of these policies at around the third year after the standard is enacted. We
conduct a variety of robustness tests to validate this choice and explain the results in the appendix entitled “Robustness Analysis”.

RESULTS

Table 1 reports basic descriptive statistics and correlations. We determined variance inflation factors (VIF) for all models in the study. The VIF statistic examines how much the variance of a coefficient is affected by multicollinearity. Some researchers recommend a threshold of 10 for this statistic, such that predictors with values higher than 10 are more prone to instability and unreliable results (Chatterjee & Hadi, 1988, 2006). Our analysis revealed that in no case did we exceed such threshold, suggesting that correlations across predictors are unlikely to bias our results.

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Insert Table 1 about here
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Table 2 presents the results for the 3SLS analysis for the simultaneous equation system with unconditional fixed defects. Each model in the table corresponds to an equation from the system presented earlier. Model 1 displays the results for the model that predicts mandatory rules and standards related to wind energy. Results show that as proposed in hypothesis one there is a positive, although marginally significant, relationship between the number of environmental SMOs in a state and the number of mandatory rules and standards enacted in that state (Z=1.76; p=.078). This suggests that the level of activity of the broader environmental movement in a state can be associated with the extent to which the government in that state has put in place rules that mandate electric utilities to comply with renewable energy needs (that are
applicable to the wind energy sector) in different ways. Model 2 shows the results for equation number 2 above, which predicts the number of new firm foundings in wind energy for a given state and year. As theorized in hypothesis 2a, our findings from this model suggest that the number of mandatory rules and standards related to wind energy in a state is associated with new firm foundings in this sector ($Z=3.26; p=.001$). In addition, results from this model reveal that, consistent with hypothesis 2b, the number of industry development incentives that are applicable to wind energy businesses is marginally related to new firm foundings ($Z=1.79; p=.074$) (although these results are stronger when a two year lag is employed. See the “Robustness Analysis” on the appendix for details). Finally, the results do not support hypothesis 2c that financial incentives are not related to firm foundings in wind energy ($Z=.26, p=.794$).

Model 3 tests an important component of our theoretical framework; and allows us to conclude that as hypothesized in H3, the number of clean energy SMOs that participate in a state is associated with new firm foundings in wind energy in that state ($Z=5.31; p=.000$). Hence, entrepreneurial activity and growth in an industry are not only determined by the broader environmental social movement, but also help to shape the way in which the movement evolves and becomes more specialized as embodied in the growth of clean energy SMOs. Models 4 and 5 test hypotheses H4a and H4b respectively. Our results suggest that as proposed in H4a, there is a positive relationship between the number of clean energy SMOs in a state and the number of industry development incentives applicable to wind energy that the state enacts ($Z=2.49; p=.013$). Therefore, clean energy SMOs may play an important role in sponsoring initiatives that
may influence these types of incentives. Findings from Model 5, however, prevent us from rejecting the null hypothesis in H4b; suggesting that there is no relationship between the number of clean energy SMOs in a state and the incidence with which the state enacts financial incentives in favor of the wind energy sector (Z=1.42; p=.16). Finally, results from Model 6 reveal that consistent with hypothesis 5, the number of energy SMOs in a state is positively related to the coverage of newspaper articles in wind energy topics (Z=2.34; p=.019); signifying the ability of energy SMOs to bring wind energy to the public eye, thereby increasing the visibility that the sector enjoys.

**DISCUSSION AND CONCLUSION**

This study expands our understanding of industry emergence by examining the co-evolution of SMOs, emergent firms, and the institutional environment of an industry. We find that the broader environmental movement was successful at promoting mandatory rules and standards that subsequently fostered entrepreneurial activity in the wind energy sector. Interestingly, and as we theorized, it appears that the participation of these generalist environmental SMOs is not related with the emergence of more specialized institutions, such as market and industry development incentives, that target the needs of the industry more specifically. Our results also suggest that not only does the environmental movement influence the growth of the wind energy sector, but that the rate of wind energy firm foundings also propels the emergence of clean energy specialist SMOs that are born to address the needs of the industry in more depth and focus. While the impact of social movements on entrepreneurial activity has been explored by numerous studies (Hiatt et al., 2009; Rao, 2009; Rao, Morrill, & Zald, 2000a), to our knowledge ours is the first to suggest that entrepreneurial entry also has an impact on the structure of social movements. In addition, we find that the participation of clean energy SMOs in turn seems to
play a role in influencing the implementation of state-based industry development incentives that specifically target the commercial growth of wind energy. Furthermore, the emergence of these specialist organizations brings greater visibility to the wind energy sector that could grant legitimacy and future growth to it.

Our analysis demonstrated that the involvement of broader environmental SMOs is associated with the number of mandatory rules and standards related to wind energy, which in turn promotes firm foundings in the sector. While these findings are consistent with those of Sine & Lee (2009), it is worth noticing the differences in our approach. First, Sine and Lee’s study ended in 1992 while the greatest growth in the wind power industry has occurred in more recent years (EIA, 2010). Second, while we build on Sine and Lee’s work through showing the broader impacts of legislation beyond the founding of independent wind farms; as detailed above, our measure of firm foundings is a more heterogeneous measure of entrepreneurship which includes a wide range of firms engaged in a range of products and services related to wind power. We believe that this measure better characterizes “entrepreneurial” firm foundings as it accounts for smaller firms such as wind power consultants that do not require the large financial investments necessary for large-scale wind power generation. Third, we depart from the typical custom of using Sierra Club membership as a proxy to the broad and diverse environmental movement in the U.S. In doing so, we respond to the recent call to address the environmental social movement in its regional and focused character, as opposed to generalizing its character on the basis of the actions of a few national organizations (Straughan & Pollak, 2008). Finally, and perhaps most importantly, our approach not only examines the relationship between social movements and firm foundings, but the entire process of industry emergence and institutional change, which reveals the mutual causality in the above relationship and the important
implications of such for the subsequent institutional development and growth of the industry. This approach also led us to distinguish amongst the distinct types of SMOs involved in the process of industry emergence and the different types of tactics employed by these groups to foster institutional change.

One alternative explanation for the phenomena we explored in this paper could be attributed to unobserved variable bias. One could argue that there was a general shift towards more environmentally responsible norms and that we are simply witnessing multiple processes that were all driven by this change. However, through the use of fixed effects, rigorous controls, robustness tests, and most importantly, instrumental variables, we feel we have controlled for this explanation to the extent possible. In addition, the use of simultaneous equation models through 3SLS allowed us to embrace, and control for the inherent endogeniety in these processes. Indeed our contribution is in exploring and mapping these endogenous processes rather than disregarding them.

An important limitation of our study is that we only examined the change process for wind power in-depth in one case study. Further insight could be gained through engaging in multiple case studies of how this process emerged in various states. We gain some comfort from the recurring pattern we saw which was similar to Colorado in our larger sample, but certainly more work remains to be done in documenting the emergence of the wind industry. An additional limitation is that we have selected an industry in which the normative, and particularly environmental, ramifications of the technology are quite clear and widely known. Our results may not be generalizable in industries that are less related to environmental or social issues. Another limitation lies in the selection of the state as the unit of analysis. Clearly, many of the variables of interest such as the regulatory environment are demarcated by state boundaries.
However, other factors such as social concern for the environment may not depend on state lines. The lack of availability of such more micro data constrained this analysis. Future research in other industries may be able to address these relationships by employing data at the county or zip code level that may be more useful in distinguishing local trends towards environmental activism and attitudes. Furthermore, our measures of state incentives are based on a count of incentives that does not consider the relative differences in the terms by which these are enacted. However, we conducted a qualitative assessment (available from the authors) of the differences across states, which suggests that states with high counts of incentives do not seem to have unusually low terms in their rules (e.g., similar percentage in tax breaks or RPS targets). Similarly, states with low counts of incentives do not seem to have targets or other terms that are above average. Hence, a count measure seems to be able to capture differences in the extent to which states enact incentives in favor of the wind and solar energy sectors.

The inherent co-evolutionary process described in this study raises important questions for the study of entrepreneurship and social movements. Our finding that entrepreneurs and SMOs collaborate for common goals leads us to ask whether scholars have created a false dichotomy (Putnam, 2003) between these types of organizations. Definitions that identify social movements as engaged in protest and contentious politics (McAdam et al., 1988; Rucht, 1999) may miss important private sectors actors who help achieve social goals, while definitions that focus on shared identities and goals (Blumer, 1969) capture a wider group of actors than is generally considered in social movements research. We ask whether the definition of SMOs could be expanded to include entrepreneurs, and not only “social” entrepreneurs (Short, Moss, & Lumpkin, 2009) but entrepreneurs who are driven by a very human mixture of incentives which might include societal and environmental benefits, but also economic gain? For example, one of
our interview participants was recruited to work for an environmental SMO in Colorado and was active in the establishment of both the Windsour green pricing program and the passage of Amendment 37; however, he has also founded, sold and restarted a successful for-profit venture in renewable energy. He describes his motivations below:

I’d spent 10 years doing non-profit environmental work. So, I was a passionate believer in clean energy…sort of fell in love with the West and wanted to leave the world a better place than when I found it, or not worse…the I felt like I could do more in the for-profit world than the non-profit world in terms of raising capital…partly my second child was born and I had no way to retire or put her through school. So, a bunch of reasons…

Our example shows the shifting motivations and roles individuals take on through their involvement in an industry’s emergence. For those studying the role of passion and affect (Cardon, Wincent, Singh, & Drnovsek, 2009) in entrepreneurship our study presents an expansive model of entrepreneurial action in which mixed and shifting motivations could be studied at the individual level.

Our finding that for-profit ventures and non-profit SMOs collaborate and evolve together to create public goods raises additional theoretical and empirical questions for future research at an industry and organizational level. First, although they were not represented in our sample, it would be fruitful to further understand the role of trade associations in the emergence of new industries, particularly their role in pushing for regulatory legitimacy (Aldrich & Baker, 2001; Greenwood, Hinings, & Suddaby, 2002). How do multiple organizations with explicitly differing goals, strategies and missions come together to support institutional change? A particularly useful line for this research would be to examine the emergence of “hybrid” organizations, such as the US Green Building Council which focus on simultaneously creating economic and industry growth while fostering social and ecological benefits (Eichholtz, Kok, & Quigley, Forthcoming; Yudelson, 2007). Second, we find that early in the establishment of wind
power during this period environmental SMOs were the prevalent actors working to foster policy changes and that specifically, energy-focused SMOs appeared in later years. It would be particularly applicable and interesting to see if this pattern holds across environmentally relevant industries such as solar energy, local foods and waste management. Further generalizability could be demonstrated through examining this pattern in a more diverse range of industries as well.

By taking a co-evolutionary approach to the topic of industry emergence we have developed a model that explains how the multidirectional relationships between SMOs, new firms and institutions move an industry towards legitimacy while simultaneously shifting and expanding the roles of the relevant organizations. These processes have wide-ranging implications for entrepreneurs and activists in emerging industries, suggesting that those initiating new ventures in emergent industries would do well to align themselves with SMOs active in the institutional field. Doing so may gain regulatory legitimacy through fostering more broadly appealing arguments and coalitions for policies that support the industry both through mandatory requirements and industrial recruitment. Additional benefits, such as an increased public profile through news coverage may also be a side effect of aligning new businesses with existing SMOs.

This study is an early step towards understanding the complex, nonlinear process of industry emergence. By embracing the forces that organizations exert upon one another, we can begin to better understand how they co-evolve, cooperate and contest with each other, and in the process, create new industries.
REFERENCES


Figure 1
Timeline of Key Events in Colorado Wind Power, 1998-2008

Sources: DSIRE, 2010; AWEA, 2010, CORE & Levenson, 2010
Figure 2

Theoretical Model of the Wind Energy Industry Evolution
## TABLE 1

### Descriptive Statistics and Correlations

<table>
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<td>10 Density of Wind Energy Firms</td>
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</table>

*p<.05, **p<.01, ***p<.001
# TABLE 2

**Results for Three Stage Least Squares Analysis with Simultaneous Equations using Unconditional Fixed Defects**

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
<th>Model 4</th>
<th>Model 5</th>
<th>Model 6</th>
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<td>Number of Mandatory Rules</td>
<td>433.2+ (245.9)</td>
<td>0.326+*** (0.0965)</td>
<td>-27967 (44157)</td>
<td>0.0265 (0.0344)</td>
<td>-0.000164 (0.000735)</td>
<td>-0.0132 (0.0106)</td>
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<tr>
<td>Wind Energy Firm Foundings/Population</td>
<td>1.853*** (0.349)</td>
<td>1.86e-06+ (1.04e-06)</td>
<td>1.32e-06** (4.04e-07)</td>
<td>0.00 (3.11e-07)</td>
<td>Wind Energy Firm Foundings/Population</td>
<td>Number of Mandatory Rules</td>
</tr>
<tr>
<td>Number of Environmental SMOs/Population</td>
<td>433.2+ (245.9)</td>
<td>0.326+*** (0.0965)</td>
<td>-27967 (44157)</td>
<td>0.0265 (0.0344)</td>
<td>-0.000164 (0.000735)</td>
<td>-0.0132 (0.0106)</td>
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<tr>
<td>Number of Energy SMOs/Population</td>
<td>203792*** (58891)</td>
<td>1.37e-07** (4.51e-08)</td>
<td>1.853*** (0.349)</td>
<td>1.86e-06+ (1.04e-06)</td>
<td>1.32e-06** (4.04e-07)</td>
<td>0.00 (3.11e-07)</td>
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<tr>
<td>Wind Energy Potential</td>
<td>0.00503 (0.00451)</td>
<td>1.37e-07** (4.51e-08)</td>
<td>1.853*** (0.349)</td>
<td>1.86e-06+ (1.04e-06)</td>
<td>1.32e-06** (4.04e-07)</td>
<td>0.00 (3.11e-07)</td>
</tr>
</tbody>
</table>
| Median Income | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| Density of Wind Energy Firms/Population | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| Electricity Market Regulation | 0.0265 (0.0344) | 8.22e-09 (9.66e-08) | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| League of Conservation Voters Score | -0.000164 (0.000735) | 7.91e-10 (1.43e-09) | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| MW of Capacity of Wind Owned by Utilities | -1.12e-10 (5.55e-10) | 1.36e-09 (1.61e-09) | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| Educational Attainment | -0.0132 (0.0106) | 4.13e-08+ (2.38e-08) | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| Political Party Control 1 | 0.0218* (0.0111) | -0.000275 (0.00820) | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| Political Party Control 2 | -0.00747 (0.0287) | -0.00203 (0.0214) | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| Constant | 0.141 (0.227) | -4.20e-06** (1.48e-06) | -2.10e-11 | 0.00 | Number of Conditional Incentives | Number of Financial Incentives | Ratio of Newspaper Articles
| Year Dummies | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| State Fixed Effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Instrumented | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 334 | 334 | 334 | 334 | 334 | 334 | 334 | 334 | 334 | 334 | 334 | 334 |
| R-squared | 0.910 | 0.159 | 0.945 | 0.910 | 0.159 | 0.945 | 0.910 | 0.159 | 0.945 | 0.910 | 0.159 | 0.945 |
| Chi Square | 3698.28 | 195.03 | 5267.2 | 3698.28 | 195.03 | 5267.2 | 3698.28 | 195.03 | 5267.2 | 3698.28 | 195.03 | 5267.2 |
| Significance of Equation | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

Standard errors in parentheses
*** p<0.001, ** p<0.01, * p<0.05, + p<0.10

aLogged

bSquare Root

---

52
APPENDIX

ROBUSTNESS ANALYSIS

A variety of sensitivity analyses were conducted to verify the robustness of the results obtained in the study. First, when the dependent variables were based on the number of policies or incentives enacted in a state (equations 1, 4 and 5), we conducted an analysis for each of these equations independently using negative binomial estimation methods with unconditional fixed effects (the latter which is unavailable through the use of simultaneous equations using 3SLS). This allows us to account for the possible absence of normality and homogeneity of variance that is endemic of count models (Cameron and Trivedi, 1998; McCullagh and Nelder, 1989). We found that in all instances the relationships of interest in our hypotheses were statistically consistent with the results presented herein. Second, to verify our choice for the time lag in equation 2, where we predict wind energy firm foundings as a function of different state policies and incentives (mandatory rules and standards, industry development incentives, and financial incentives), we conducted this analysis using one, two, and three year time lags. We found that with one year lags, there is no relationship between any of the incentives and wind entry suggesting that the effect of these policies and incentives can experience a delay in fostering the formation of new businesses centered on wind energy. Our results for a two year lag, revealed that there is a positive relationship between industry development incentives and wind energy firm foundings ($Z=2.76$; $p=.006$); however, this relationship was not obtained for mandatory rules and financial incentives. Indeed, as reported earlier, the relationship between mandatory rules and standards with new entry in wind energy was statistically significant when employing a three year lag instead. We believe that these findings are consistent with the way in which these different types of incentives are designed and how they were measured in the study. To account for a particular incentive in a state, we used the date in which an incentive or policy was enacted,
not fully implemented. This could explain why a one-year lag may not be sufficient to observe the effects of these incentives on the industry. Moreover, while industry development incentives such as grants and other funds that are placed back into the industry may take a shorter amount of time to be implemented and offered to local businesses, mandatory rules like RPS have a long time span and often require much effort on the part of electric utilities to put in place or purchase new technologies and implement new programs that are very time consuming. This in turn could explain the differences in the relevant time lags for each of these distinct types of incentives. Finally, in addition to testing the strength of our instruments through the Stock and Yogo (2004) test, we ensured that our equations were not underidentified by conducting the robust Kleibergen-Paap rk LM test (Kleibergen & Paap, 2006) for all excluded instruments on each of our endogenous regressors. We were able to reject the null hypothesis in all instances, which suggests full identification.