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When the Wind Blows: Incumbents' Sourcing Strategies for Wind Power

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***Abstract*—While extant research on sustainability transitions discusses how innovations are nurtured in protective market spaces before causing change in established industries, we know less about how characteristics of these protective market spaces, policy, and resource endowments impact incumbents' sustainability transition pathways for a new technology. We distinguish between incumbents' choice to embrace innovation by contracting for wind power or direct ownership of windfarms. We contribute to recent calls in the literature to open the "black box" surrounding the heterogeneity in incumbents' responses to sustainability transitions. In a sample of 801 windfarm transactions over a 14-year-time period (2004–2017), we find that characteristics of protective market spaces affect incumbents' response: incumbents facing less experienced niche actors (windfarm developers) and acquiring greater capacities of the innovation (wind power) are more likely to own a windfarm than contract for wind power. Moreover, if the innovation has greater physical distance from incumbents' operations, ownership is the incumbent's likely response to innovation. As policies for the innovation persists, incumbents are more likely to own a windfarm than contract for wind power. However, that relationship is weakened for firms more established in existing technologies. We contribute to the literature by demonstrating that market characteristics and policy impact heterogeneity in incumbents' sustainability transitions.**

***Index Terms*—Incumbent response, policy, renewable energy, sustainability transition pathways, wind industry.**

I. Introduction

RESEARCH on sustainability transitions focuses on how technological innovations develop in protective market spaces and then transform established industries, such as energy, transportation, or water supplies [1]. The fundamental shifts of sustainability transitions occur at three levels as follows.

1) Protective market spaces that shield innovation from selection pressures and are often referred to as niches in sustainability transitions [2], [3].
2) Incumbents that operate in socio-technical regimes ripe for sustainability transition.
3) Socio-technical landscapes comprised of institutions and policies [3], [4].

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Niche actors defined as new entrants and outsiders to the established industry, or socio-technical regime, develop and refine the innovation in protective market spaces. Incumbents in sectors such as utilities or transportation deploy and use innovation rather than developing it [1], [5]. *Incumbents* are defined in this article as established entities in the regime (established industries) whose primary expertise and business is not the niche innovation (wind energy in our article). While prior research focuses on niche dynamics and niche actors providing necessary inputs and complements to incumbents [1], [6], [7], our article turns to incumbents' adoption strategies to "set a foot" into the innovation, thereby ushering in change in their socio-technical regime.

Recent work in sustainability transitions has suggested that the focus on the role of the challengers–so-called niche actors–rather than incumbents in sustainability transitions [8] has led to a narrow view of incumbents [9] and regimes being "black boxed" [1]. Therefore, researchers have called for studies explaining the heterogeneity of incumbents' responses in sustainability transitions [1], [5], [10]–[12]. Rather than viewing incumbents as stuck in established socio-technical regimes with limited agency [13] and resisting change [10], incumbents may contribute to niche development [5] and pursue different strategies regarding innovation. Incumbents can bring about sustainability transitions by reallocating their resources to push innovations from niche status to full market acceptance [4]. But the factors that affect incumbents to respond differently remain less clear.

We contribute to these calls in the sustainability transition literature by studying how policy and niche characteristics impact incumbents' transition pathways for the same innovation, namely wind power. In doing so, we add to research on transition pathways [4]. Acknowledging that transition pathways can be studied at different granularity levels [4], [13], our article tries to shed new light on why incumbents may draw their adoption strategies from different transition pathways. For example, prior research shows that countries differently embrace low-carbon electricity transitions: The U.K. chose a transformation pathway marked by incumbents implementing large-scale renewable technologies, while Germany picked a substitution pathway reflected by new entrants deploying small-scale renewable technologies [13]. Our article takes the view of transition pathways to a more microlevel by considering why some incumbents within the same industry may choose different paths: contracting with new entrants for access to the niche innovation or owning both new and old technologies. We suggest potential explanations for why incumbents' choices of how to deploy an innovation can vary within the same industry.

Specifically, we study how niche characteristics may influence incumbents' adoption strategies. Rather than niche actors replacing incumbents, incumbents may supplement their core activities by diversifying into an innovation [1], [5], [14]. We distinguish three niche characteristics in this article: niche actor experience; physical distance of the innovation from incumbents' operations; and capacity size of the investment the incumbent makes in the innovation, as important factors influencing incumbents' pathway. We build on [1] who suggest that in order to understand incumbents, such as utilities, as technology deployers, we need to understand their technology suppliers. In this article, we focus on windfarm developers as suppliers and their experience level in affecting incumbents' sustainability transition pathway. We go beyond [1] by considering not only the supplier, but also the characteristics of the innovation, i.e., the windfarm physical location and capacity. We find that incumbents facing less experienced niche actors (windfarm developers) or acquiring greater innovation capacity (wind power) are more likely to own a windfarm than contract for wind power. If the innovation (windfarm) has a greater physical distance from regime players' established operations (conventional power plants), ownership is the more likely choice of incumbents for diversifying into the innovation.

Furthermore, we consider policy influences, and their joint effect with incumbents' resource endowment on sustainability transition pathways. Endowment in established technologies can determine firms' future strategies [15] and influence the effectiveness of policy instruments. We focus on policies that facilitate the deployment of innovation among incumbents [2], such as renewable portfolio standards (RPS) in the U.S. electricity industry. Particularly, we study the persistence of such policies, which, in turn, creates a more predictable policy environment. Our work, thus, relates to prior research on the central role of policy in shaping sustainability transitions [16]–[18]. We find that as the persistence of policies pushing the innovation increases, incumbents are more likely to own a windfarm than contract for wind power. However, that relationship is weakened for incumbents with greater existing technology endowments.

In sum, we contribute to better understanding the role of incumbents in sustainability transitions. Incumbents play a central role in scaling up renewable energy technologies and driving the much-needed change in the unsustainable legacy energy system [19]. First, we propose that firms within the same industry pursue different sustainability transition pathways. We, thus, suggest that the concept of pathways not only exists at the industry and system level [4], [13], but also is meaningful at the firm level. Heterogeneity in transition pathways occurs at the firm level in addition to the industry or system level. This article focuses on niche properties, policy, and resource endowments as factors that may shed insights in the heterogeneity of firm responses to innovation.

Second, we contribute to the policy role in sustainability transitions [2] by studying persistence of policy environment as driver of different pathways. Policymakers should not only consider system-level factors, but also adopting firms' strategies in facilitating sustainability transitions. Third, while much research on sustainability transitions relies on theoretical frameworks, detailed case studies, and interviews of small firm samples to provide valuable insights, e.g., [13], [18], few large sample statistical analyses exist in this literature stream. This article complements prior work using a sample of 801 windfarms over a 14-year period.

The empirical context is the U.S. wind industry (2004–2017) and a sample of 801 windfarms. We study the strategies of 183 U.S. utilities and 254 nonutilities to own a windfarm or contract for wind power from an independent third party. In the wind industry, future cash flows are secured in an "offtake agreement." This agreement is between the windfarm and the party either buying the energy that the windfarm produces or acquiring to own the windfarm. The primary form of an offtake agreement is a power purchase agreement (PPA). Utilities and corporate customers initiated almost 9000 MW power purchase agreements in 2019 [20]. The U.S. wind industry installed 16 836 MW of new wind capacity in 2020. As of 2020, there was a total of 121 955 MW of cumulative installed wind capacity in the U.S., capable of meeting the electricity needs of more than 32 million homes. GE Renewable Energy and Vestas captured a combined 87% of the U.S. turbine market for new installations during 2020 [21]. The U.S. wind industry has evolved since its emergence in the early 1980s, and U.S. wind power capacity now makes up over 10% of the electricity generation in 16 U.S. states and over 30% of electricity generation in five U.S. states (Iowa, Kansas, Oklahoma, North Dakota, and South Dakota) [21].

II. Conceptual Development

A. *Dynamics Between Niche and Incumbents*

The strategic niche management (SNM) perspective has established that niches play an important role in developing new technologies, shielding new technologies from market forces, and providing protective spaces for learning (e.g., [2], [7]). Early research in the SNM perspective views niche actors as new entrants and outsiders to the socio-technical regime, and incumbents as resisting change [6]. Yet, more recent work has acknowledged that incumbents may participate in niches [1], [5], [11], [12], [14]. Niches are, thus, not only the seeds of change but can also compete with established technologies [22] or combine with regimes in symbiotic fashion as incumbents embrace an innovation [4]. For example, Berggren *et al.* [5] used case studies to investigate the role of incumbents in sustainability transitions in the heavy hybrid-electric powertrains industry. Within the transportation sector, incumbents develop existing and niche technologies simultaneously by incremental innovation and diversifying into the niche innovation. Berggren *et al.* [5] found that incumbents pursued quite different strategies with implications for sustainability transitions. We add to this literature stream. A big part of firms' transition strategy is deciding how to adopt an innovation, namely sourcing it from a niche actor or bringing the innovation in-house through ownership. We are only aware of [5] two case studies that tackle the sourcing decision in sustainability transition research.

B. Transition Pathways

The interaction between niche and regime is captured in the multilevel perspective as different transition pathways (e.g., [4], [13]). Transition pathways vary due to the nature and timing of interactions between niche, incumbents, and the landscape [4]. In substitution pathways, innovation replaces existing technologies. In transformation pathways incumbents adapt to innovation whereas in reconfiguration pathways incumbents engage in architectural adjustments to incorporate an innovation [4]. In reconfiguration pathways incumbents may form sourcing relationships with new entrants to adopt an innovation [23]. Geels *et al.* [13] emphasized the need for agency in transition pathways and the potential to switch between pathways. Pathways can, thus, be fluid, implying that a system is not locked into one single transition pathway.

Transformation pathways imply that incumbents alter their search routines and processes, maybe even their business model, as they begin to incorporate an innovation to operate or develop old and new technologies side-by-side [13]. By embracing an innovation in their operating processes, incumbents add competencies in that space to their internal operations. Steen and Weaver [1], for example, suggested a transformation pathway for the Norwegian energy industry.

We suggest that the concept of transition pathways also applies to the individual firm level. Although there may be a dominant transition pathway pursued by incumbents within an industry, system, or country, there is likely to exist heterogeneity among incumbents, due to agency, in terms of their transition strategies. While some incumbents adopt an innovation sooner than others, they are also likely to vary in the extent to which they integrate the new technology or have access to experienced niche actors to contract with. Furthermore, incumbents' response is likely influenced by their supplier relationships, resource endowments, cognitive routines [24], and the policy landscape [18].

C. Policy Promoting Innovation Among Incumbents

Policies and socio-technical systems coevolve over time [25]–[27]. Policies play a key role in sustainability transitions by enabling an innovation's early commercialization before it can compete on its own merits in the mainstream market [2], [7], [16]–[18], [28]. For example, in the U.S. electric utility industry RPS are state-level policy mandates that push utilities to adopt renewable energy sources, such as solar and wind. Since policies affect the pathways that sustainability transitions follow [4], we consider the role of policy. Policy can, thus, be viewed as the "rules of the game" [29] in which transitions unfold.

III. Hypotheses Development

A. Policy Persistence in Promoting Innovation

The policy effect on promoting innovation is impacted by the persistence of policy prescriptions. Policy impacts the legitimacy of innovation [17] and the support for existing technologies [11]. The consistency of policy correlates with its effectiveness in promoting innovation [18], [30], [31]. The longer a policy has been in place in a socio-technical regime, the longer firms have been exposed to the demands of the policy [2], and the further along the sustainability transition may be [3]. The persistence in policy offers strong signals for the sustenance of the sustainability transition. As the policy becomes more entrenched, the likelihood of industry-wide transition increases. For example, state policies play a role in directing the location and amount of wind power development. From 1999 through 2010, 63% of wind power capacity built in the U.S. was located in states with RPS; in 2010, this proportion was 58%. As of 2017, RPS programs existed in 29 states and Washington D.C. Utility resource planning requirements, voluntary customer demand for green power, state clean energy funds, and state and regional carbon reduction policies also play a role in supporting wind energy deployment.

We propose that the longer a policy promoting an innovation has existed in a socio-technical regime, the more likely incumbents are to deploy the innovation internally through ownership. Regulatory policy affects the returns that firms can expect from their resource investments by creating demand for a resource or setting output prices, so that a resource's value is substantially less in the absence of policy than in its presence. The persistence of regulatory policy, thus, influences contractual hazards [32], [33]. The repeal of a regulatory policy may strand a firm with investments specific to the policy [31]. For example, RPS foster investment in renewable electricity generation capacity such as windfarms [34] by requiring that utilities have a minimum percentage of renewables in their energy generation mix [35]. Since firms can satisfy RPS mandates by either owning or purchasing renewable power, regulatory persistence of the policy is likely to affect firms' willingness to commit to asset ownership. For example, [36] finds, consistent with [31], that firms invested less in new assets in states that had previously passed and then repealed legislation to restructure the electricity industry, indicating that regulatory persistence increases new investment.

Hypothesis 1: The more established the policy promoting the innovation is in a state, the more likely incumbents are to own the windfarm than to contract for its wind power.

B. Experience of the Niche Actor – Windfarm Developer

Niches are places where niche actors develop and refine new technologies [2], through activities such as "knowledge development and diffusion, articulation of visions, entrepreneurial activities, market formation, guidance, and search activities, mobilization of resources, creation of legitimacy and overcoming of resistance to change" [37]. Thus, niche actors become experts in technical capabilities and finding market opportunities pertaining to the innovation. Steen and Weaver [1] described niche actors as developers and experts of an innovation and established firms as deployers of the innovation. In the context of the wind energy niche, windfarm developers as niche actors orchestrate windfarm component manufacturers, such as turbine and blades manufacturers, to install windfarms ready to push wind power onto the electrical grid. Windfarm developers also perform the permitting and siting process for windfarms, and sometimes continue to operate the windfarm.

Windfarm developers gain experience as the niche becomes more established. First, windfarm developers, by repeatedly developing and building new windfarms, obtain valuable knowhow and expertise [38]. The developer's focus on the niche gives the developer the depth of expertise that incumbents lack in the innovation. Therefore, the competency scale becomes tilted toward the niche actor whose capabilities have accumulated over time through asset investments in windfarms. The incumbent's competency lies in deploying the innovation via its complementary assets, for example, distributing electricity (utility) or using electricity in value-generating processes in other industries (nonutility). Thus, the incumbent is likely to focus on its own expertise and contract for wind, the more experienced the developer. This view is consistent with [39] who stress that as the market for a new technology develops, incumbent firms with complementary assets to bring a technology to market, may see benefits sourcing the new technology from more experienced partners on the supply-side. Greater niche actor experience may, thus, increase the likelihood that incumbents form new alliances with niche actors as highlighted in reconfiguration pathways [13]. Lacking strong internal firm knowledge may favor buying a component from a more experienced partner.

Second, windfarm developers not only gain capabilities in building windfarms over time, but also in contracting relationships for wind power. As the wind industry evolves from niche to more niche-regime interaction, contracting norms for the commodity of wind become more established and standardized, which is likely to reduce contractual hazards. Technological uncertainty that may initially contributed to contract uncertainties declines as uncertainties regarding a technology's viability and functioning decline [40]. As a technology diffuses, the availability of suppliers for the technology increases. As a result, market search costs decline [41] and standardized interfaces between value chain activities become more established [42]. Firms gain contractual knowledge as contracting becomes more widespread across the industry [43]. These trends are likely to reduce contractual hazards over time [30], and thereby make contracting for wind power an attractive option for incumbents in the presence of experienced niche actors.

Hypothesis 2: The greater the experience of the windfarm's developer (niche actor), the more likely incumbents are to contract for wind power than to own the windfarm.

C. Incumbent Capacity Acquisition of the Innovation – Wind Power

Does the incumbent make wind power a big investment or is the incumbent just 'tapping its feet' into wind power to maybe appease a constituency or satisfy an RPS mandate? Windfarm size, or more generally the capacity of wind power that an incumbent acquires is likely to influence the transition pathway chosen. Greater diversification into the innovation (greater wind capacity) requires incumbents to make greater financial investments than small explorations into the niche. While small explorations like trials and pilot programs in a new technology space enable a firm to learn about a new technology while limiting risk [44], larger scale investments require greater skills in the innovation. Therefore, the skills of niche actors become more central to incumbents' making larger scale investments in the niche. Thus, arguments of comparative capability advantages [45] may dominate in the presence of larger new technology investments. The experience of the actors in catalyzing the transitions is important, especially in the case of transitions to low-carbon technologies [46]. Incumbents diversifying to a greater extent into the niche innovation may, therefore, be more likely to contract with niche actors (e.g., enter wind power purchase contracts), instead of internally operating the innovation themselves.

Hypothesis 3: The greater the capacity of wind power (innovation) that the incumbent acquires, the more likely the incumbent is to contract for wind power than to own the windfarm.

D. Physical Distance of the Niche Innovation From Incumbent Operations

Incumbents' transition pathway choices are also driven by regime-to-niche activities where incumbents offer proximity advantages [11] or cospecialized assets [47]. Incumbents may provide niche actors with cospecialized complementary assets needed to deploy a niche innovation in the market. For example, in the utilities industry, transmission lines are cospecialized assets to generation facilities. Transmission lines are site-specific complementary assets, if they are specifically designed to move the electricity from a specific plant to load centers. The wind industry as a niche largely depends on utilities with transmission lines. The absence of transmission lines in proximity to a windfarm presents an impediment to wind power deployment because sites with good wind resources are often distant from load centers [48].

In physical-asset intensive industries such as the electric utility industry, telecommunication, or railroads, physical asset site-specificity becomes central. Site specificity refers to relationship-specific investments that lose much of their value if deployed in ways other than originally intended [49]. Generation facilities tend to be colocated with transmission lines, railroads tend to link cities and industries, and sawmills tend to be collocated with forests. The physical location of the niche relative to physical complementary assets needed to bring an innovation to market influences transaction hazards for both incumbents and niche actors.

The desire to safeguard investments in the niche may lead incumbents to prefer one transition pathway to another, i.e., sourcing the innovation from a niche actor versus integrating the innovation directly inside the incumbent's operations. Economic organization is mainly an effort to "align transactions, which differ in their attributes, with governance structures, which differ in their costs and competencies, in a discriminating (mainly, transaction cost economizing) way." [50]. Simply put, transaction cost considerations explain how firms choose, from the set of feasible organizational alternatives, the arrangement that best mitigates contractual hazards. A firm's desire to safeguard and facilitate cospecialized asset investments across value chain stages tends to lead to integration [47].

We suggest that prior related, geographically proximate operational investments by the incumbent can reduce the site-specificity associated with complementary asset investments to bring an innovation from the niche to market. Thus, incumbents' complementary assets sit at the intersection of the niche and regime, necessary for innovation to diffuse and bring about regime change. For example, in the context of wind energy, the existence of transmission lines that connect to conventional power plants in proximity to new windfarms make those transmission lines less site-specific to the niche. If one plant disconnects, the grid is still used for another, thereby reducing its site-specificity. Proximity of the niche to the regime's operations is, therefore, likely to influence incumbents' transition paths.

We, thus, propose that the greater the physical distance of the niche from the incumbents' operations, the greater the likelihood that the incumbent adopts the innovation through ownership. A niche that is further away from incumbent operations is less able to benefit from existing complementary assets. For example, windfarms that are more distant from existing conventional generation may require the building of transmission line segments specifically for the purpose of connecting a respective windfarm into the grid. Such investment is relationship-specific to a windfarm and will likely raise transmission costs [51], especially the further away such is located. To justify such investment, the incumbent may want to own the windfarm to avoid site-specific hold-up in the relationship with a niche actor and secure the value of its complementary asset investment. Problems with grid access are likely to become more severe for more distant windfarms.

Hypothesis 4: The greater the physical distance of the windfarm (innovation) from existing conventional power plants (incumbent operations), the more likely incumbents are to own the windfarm than to contract for its wind power.

E. Incumbent Establishment in Regime Technologies and Policy Promoting Innovation

Incumbents' transition paths are a function of not only niche characteristics and niche actors, but also their own resource endowments. Incumbent response is far from homogenous [8], [52] due to factors, such as variance in commitment to existing regime norms or capabilities. Firms internalize activities along the value chain where they possess superior capabilities and outsource activities where the market has a comparative capability advantage [42], [45], [53]. That is, firms are heterogeneous in their capabilities [53], their knowledge of energy technologies [54], and therefore, the distribution of capabilities across firms beyond scale alone influences transition strategies. Incumbents with less prior related capability in a niche innovation are more likely to contract with niche actors than own the innovation. For example, utilities with mainly fossil fuels may choose to contract for wind power rather than own wind power assets.

An incumbent's experience with existing technologies (substitute to the innovation) may result in local search to further exploit existing strengths rather than engage in distant search [55]. As a result, core rigidities may arise [56]. However, regulatory pressure to engage in distant search may result in incumbents exploring a new technology. Given the lack of capabilities in the new technology's domain, incumbents may prefer to contract rather than own activities related to the new technology. Contracting, thus, enables incumbents to access new capabilities without having to incur extensive adjustment costs to their internal operations [57], [58].

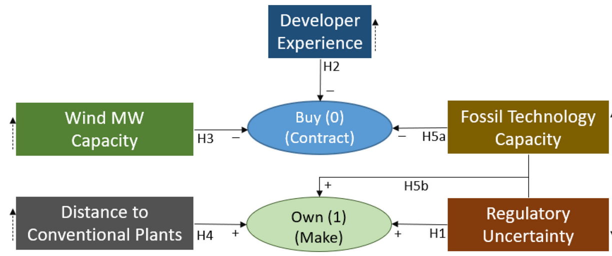

Fig. 1. Snapshot of the hypotheses structure.

Hypothesis 5a: The greater the percentage of an incumbent's established technology endowment in its energy generation mix, the more likely the incumbent is to contract for wind power than to own the windfarm.

Persistence of a policy promoting an innovation indicates that policymakers are committed to a sustainability transition. Such policy persistency is likely to reduce firms' hesitancy to commit significant capital to transforming their assets [59]. Firms' investment hesitation is often justified when assets are long-lived and investments are irreversible, with tenures that outlive regulatory prescriptions [31]. Firms' hesitation to make significant capital outlays may be driven not only by policy uncertainty but also the dependence on existing infrastructure. A policy's technology specificity shows that the value of the investment is higher in the presence rather than absence of such policy regime [60]. Thus, the longer a policy exists, the more institutionalized it becomes [61] as firms acclimatize to the policy's stability [62]. A reinforcing cycle emerges: as more firms satisfy policy requirements, the policy's persistence increases, which, in turn, allows more firms to embrace the sustainability transition [63], [64]. This reinforcement cumulatively adds economic support to the decision to own wind power even for firms with capabilities strongly embedded in the existing technology. Thus, as policies for renewable technologies becomes more entrenched, existing fossil-dominant firms are likely to see increased value and economic rationale to own windfarms.

Hypothesis 5b: Incumbents with a greater endowment in the established technology are more likely to own a windfarm than to contract for wind power, the more established the policy promoting the innovation is in a state.

F. Relationships Among Hypotheses

This article sheds light on the dynamics in wind energy, a niche for the socio-technical regime of electric utilities that is undergoing a sustainability transition toward renewable energy generation. Fig. 1 presents an overview of the article's hypotheses.

The persistence of policies is instrumental in transition pathways (H1). The windfarm developer experience contributes to the incumbents' sourcing decision (H2). Aiding the contracting decision is the wind power capacity that the incumbent invests in (H3). In contrast, the more distant the windfarm is from conventional technology, the more likely the incumbent is to own the windfarm (H4). The incumbent's likelihood to contract for the windfarm's output is influenced by its established technology endowment (H5a). The ownership decision is further strengthened the greater the policy persistence in the presence of the incumbent's greater endowment in established technologies (H5b).

IV. Empirical Context and Data Sources

This section discusses the dynamics of the wind energy niche: the processes involved in the development of a windfarm, the financial transactions involved, the duration and stages in the life-cycle of a wind system, regulatory mandates, and how the energy industry sector has evolved over the past decades.

A. Empirical Setting – the U.S. Wind Energy Sector

Our empirical context is the U.S. wind energy sector with emphasis on utilities and nonutilities that are offtakers for wind. Electric utilities include investor owned or publicly owned entities. Nonutilities are commercial and industrial entities, schools, political subdivisions, and power marketers. Electricity generation and transmission segments are complementary parts because the generated electricity is transmitted at high voltages over long distance power lines from areas of generation, which are often far away from consumption locations, to the downstream distribution systems with assets for voltage step down.

1) Wind Energy and Its Capacity Growth in the U.S.: A windfarm or wind project, oftentimes, consists of a large number of wind turbines built close together and acting as a single power plant that either sends electricity to the grid or has its electricity output consumed locally. In some cases, the windfarm's collective output is moved over transmission lines to distribution networks and then to consumers. In other cases, the output of a windfarm is consumed locally. The two major benefits of wind power are reduced greenhouse gas emissions and a diversified energy supply.

The modern era of wind energy began with the passage of the Public Utilities Regulatory Policies Act (PURPA) in 1978 [65], [66]. The first windfarms in the U.S. were built in California in the early 1980s, but the early "wind rush" stopped in the mid-1980s as tax credits expired. Wind power activities picked up again in the late 1990s, and more recently, as technology improvements have significantly reduced the cost of wind power generation. The American Wind Energy Association (AWEA) reports that "compared to building a new, conventional coal facility, renewable energy contracts are significantly lower in price and also less than any newly built generation including new natural gas combined cycle plants" [20].

2) Wind Energy Industry Ecosystem: Windfarm developers consult with turbine manufacturers on the make-up of the turbines needed to achieve a certain wind capacity target. A project's suitability is informed by strong and consistent wind flows, availability of large, open spaces that are often agricultural with minimal to no risk to wildlife and community acceptance. Relevant features are the developer's experience, the states the developer works in and the turbine manufacturers they engage with. Turbine manufacturers may also double as windfarm developers. For example, Nordex, a German wind turbine manufacturer, has installed 21 GW of wind power globally [67]. Fig. 2 shows the major players in the wind energy ecosystem.

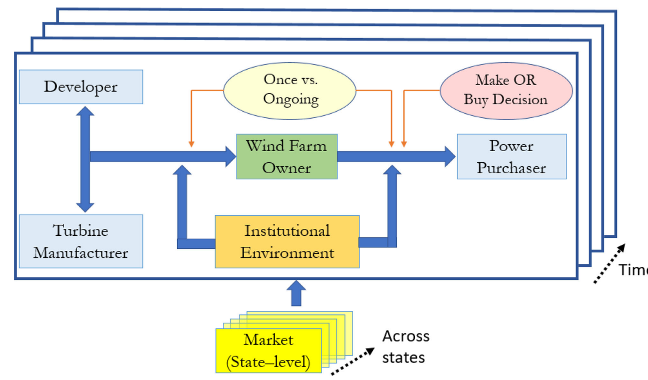

Fig. 2. Wind energy ecosystem.

Fig. 3 shows the typical time line and duration for each stage in the development of a windfarm. From the stage of market assessment, resource review for siting and land leases, turbine, or equipment providers with power offtake negotiations, financing, actual construction to project operation, the building of a wind project takes between 3 and 4 years. Incumbent utilities often own the projects or are the power purchasers. Pertinent to the examination in this article is the information on the power offtake namely ownership or contracting, capacity of the windfarm, state of operation, and windfarm age.

Of critical importance is the process of seeking financing. As shown in Fig. 3, financing for wind generally lasts between three to nine months. There are three main sources of capital for wind projects: sponsor equity, tax equity, and debt. In many cases, the final capital structure is a blend of each of these capital sources. While sponsor equity is the investment of an equity investor in the initial project, tax equity usually offered by banks anticipates access to tax credits through depreciation. Debt capital is strictly a loan with a lower-risk and certain financing protections such as fixed payment plans and the provision of a collateral [68]. These alternatives are cognizant of the expected cash flows. We note, nonetheless, that the method of project financing is a source of heterogeneity as incumbents source project funding in different ways. The paucity of data limits an exploration into this sourcing heterogeneity.

The institutional environment is reflected by RPS in the offtaker's state. The RPS mandates utilities to either invest in renewable power generation or purchase renewable power [69]—see Fig. 4 for states with RPS as of 2018.

This context is suitable for understanding the transition pathways that incumbents choose in their bids to decarbonize their operations and respond to rising calls for cleaner energy generation [71]. The deregulation of the U.S. generation segment following PURPA in 1978 opened the gateway for competitive

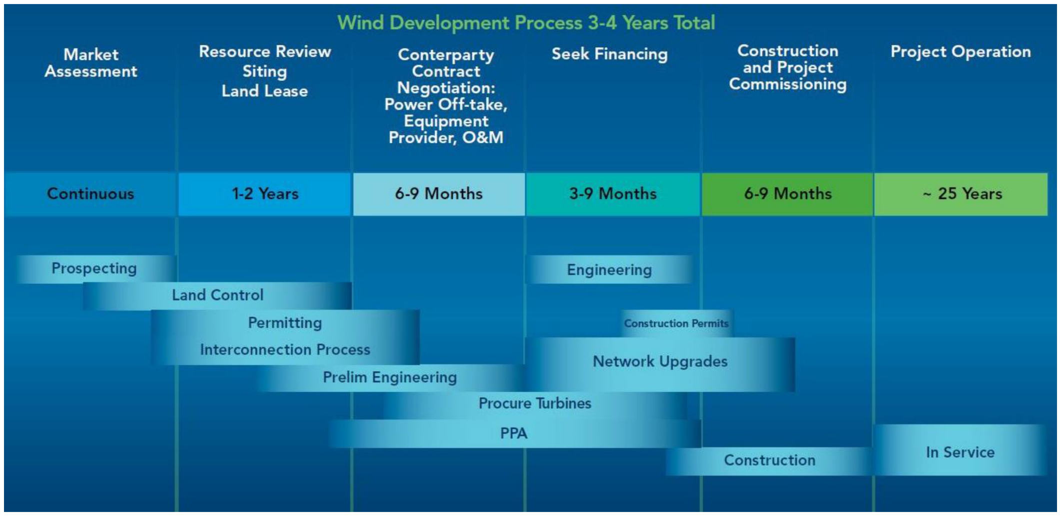

Fig. 3. Wind development process [20].

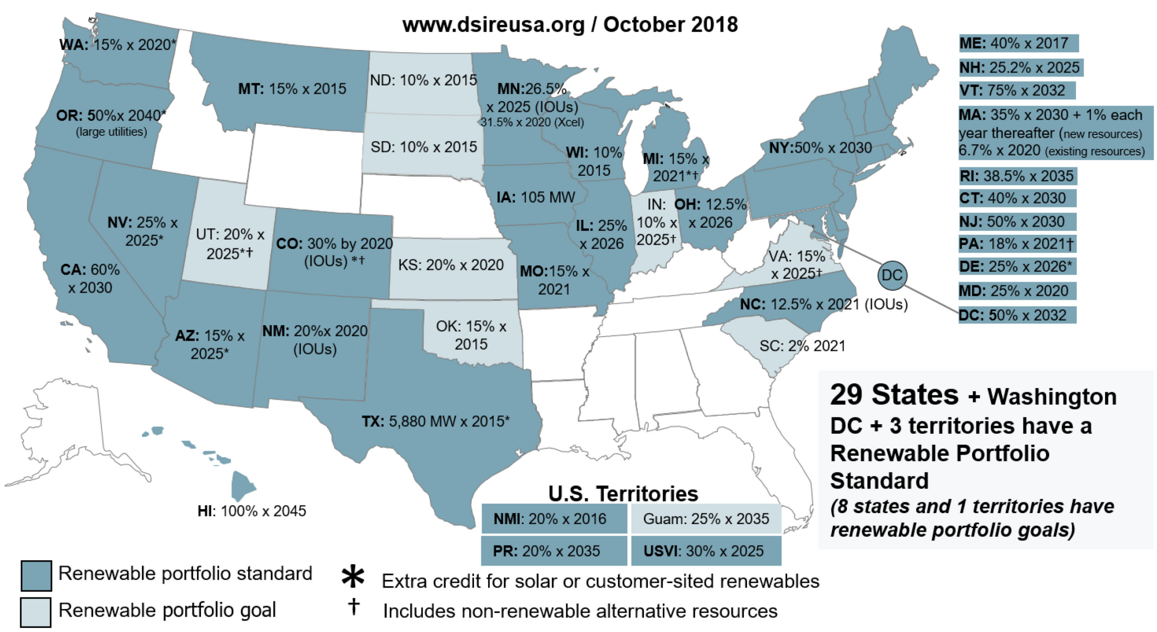

Fig. 4. RPS policy across the U.S. [70].

electricity generation by independent power producers (IPPs) [65], [66]. The Energy Policy Act of 1992 allowed utilities to own IPPs leading to more strategic options for utilities [72]. Electric utilities and nonutilities represent the regime downstream from the wind sector (the niche) choosing to either own windfarms or contract for wind power (the transition pathway) through long-term PPAs.

B. Data Sources and Sample

We collected data from various archival data sources: information on windfarms from the AWEA, Form 860 of the U.S. Energy Information Administration (EIA) for information on utilities' energy generation mix and plant locations, the Department of Energy's Database for State Incentives for Renewables and Efficiency for information on RPS, policies, and incentives [70], and the EIA for state-level data. Our data comprise windfarm information for 2004–2017. Data on resource, consumption, and legislation come from DOE's Office of Energy Efficiency and Renewable Energy on their wind exchange program, and state legislator composition was obtained from the National Conference for State Legislatures. Data on Sierra Club membership was directly obtained from the Sierra Club. The Sierra Club is the most influential grassroots environmental organization in the U.S. with chapters in each state. Thus, membership size, as captured in the variable, is consistent with its use as a proxy for the influence of environmental lobbyists in extant research [73]–[75].

This article has been accepted for inclusion in a future issue of this journal. Content is final as presented, with the exception of pagination.

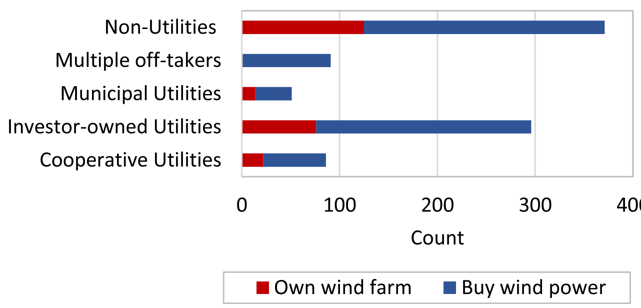

Fig. 5. Distribution of sample data by firm type.

The windfarm transaction is the unit of analysis for the offtaker decisions of 801 windfarms that came online during the 14-years spanning 2004–2017. The sample includes 459 windfarm transactions by utilities and 342 windfarm transactions by nonutilities. There are 328 individual windfarm developers in the sample. Fig. 5 shows the distribution by type of firm and whether they own or contract for wind power, and Fig. 6 shows the growth in the number of firms that buy wind power or own windfarms.

V. Methodology

A. Description of Variables

1) Dependent Variable: We determine the dependent variable using the AWEA Database of online (operational) windfarms. The dependent variable, $MakeOrBuy$, is a binary variable, $(1, 0)$, determined by the power offtake type of the windfarm—the transition pathway, $offtake$. The $offtake$ informs a utility's or nonutility's decision on "owning" (1) or "contracting" (0) the produced power of a particular windfarm. The power offtake type is the agreement to "sell" the power from the project and it is equivalent to whether the project owner is the same as the power offtaker ("Ownership of windfarm") or project owner is different from the power purchaser ("Contract for wind power"). This variable is created as follows:

$$MakeOrBuy_{i,s,t} = \begin{cases} 1, \text{ if } offtake_{i,s,t} \text{ is } \text{"Ownership of windfarm"} \\ 0, \text{ if } offtake_{i,s,t} \text{ is } \text{"Contract for windpower"} \end{cases} \quad (1)$$

where firm index i, state index s, time index in years t. It is important to note here that though there are different contractual mechanisms, such as Feed-in-Tariffs (FiT), hedge contracts, PPA and qualifying facility, the underlying premise of contracting is still valid. We check that the windfarm owner is different from the power offtaker for contractual arrangements while it is the same for the ownership structure. It is important to note here that some of the windfarms have multiple offtakers. This is similar to a market setting where a given seller (windfarm) ends up selling to multiple buyers (offtakers).

2) Independent Variables: For states with RPS mandates, the presence of that policy is captured by

$$\text{Presence of RP S}_{i,s,t} = \begin{cases} 1, \text{ if RPS}_{i,s,t} \text{ exists} \\ 0, \text{ if RPS}_{i,s,t} \text{ does not exist} \end{cases} \quad (2)$$

i.e., RPS presence is binary $(0, 1)$, i.e., 1 if the state has an RPS mandate, 0 otherwise. As of 2017, a total of 29 U.S. states had RPS mandates. Based on the states with RPS presence, we determine the stability or persistence of the RPS mandate using age, RPSAge, of the policy in a given state at the time of a respective windfarm transaction. This variable is calculated as follows:

$$\text{RPS}Ag\,e_{i,s,t} = \text{Year of the wind farm transaction} - \text{year RPS}estab_s \quad (3)$$

where yearRPS$estab_{s,t}$ is the year t, the RPS was established in state s and the year of the windfarm transaction is the year the windfarm went online to produce power. If the windfarm goes online in a year prior to the RPS mandate being established in a state, the value of this variable is zero. The value is also zero for states that do not have RPS mandates.

The share of total fossil in a firm's portfolio is calculated as the ratio of that firm's total fossil (MW) to the total capacity across all technologies by that firm by state by year, $\text{PurchaserPercentFossil}_{i,s,t}$. The variable is calculated as follows:

$$\text{PurchaserPercentFossi l}_{i,s,t} = \frac{\text{PurchaserTotalFossil}_{i,s,t}}{\text{PurchaserTotalCapacity}_{i,s,t}} \quad (4)$$

where $\text{PurchaserTotalFossil}_{i,s,t}$ includes the capacity of all fossil-based conventional technologies in the firm's plants in MW and $\text{PurchaserTotalCapacity}_{i,s,t}$ is the firm's total power capacity in MW.

The distance of the nearest conventional power plant to the windfarm, $DistToConv_{i,s,t}$, was calculated in two steps. Step 1 involved using the latitude and longitude information of every windfarm in our data set to determine the distance of that windfarm from every conventional plant in its vicinity using the *Haversine equation* on latitude and longitude as follows:

$$\text{Distance}_{i,j} = \text{ARCCOS } [(90 - Lat_1)^c (90 - Lat_2)^c + (90 - Lat_1)^c (90 - Lat_2)^c (\text{Long}_1 - \text{Long}_2)^c] \times 6,371$$

where $(\cdot)^c$= RADIANS$(\cdot)$. The latitude and longitude information for all plants was collected from EIA's database of power plants. Step 2 involved using a minimum function to identify the nearest conventional plant to a given windfarm as follows:

$$DistToCon\,v_{i,t} = Min\,\{\text{Distance}_{i^w,j}\} \quad (5)$$

where i^w is a given windfarm and $j \in \{\text{all conventional plants}\}$.

The experience of the windfarm developer is calculated as the count of the number of installations by a developer in a given year as follows:

$$\text{DeveloperExperience}_{i,t} = \sum_s \sum_t \text{Installations}_{i,s,t}. \quad (6)$$

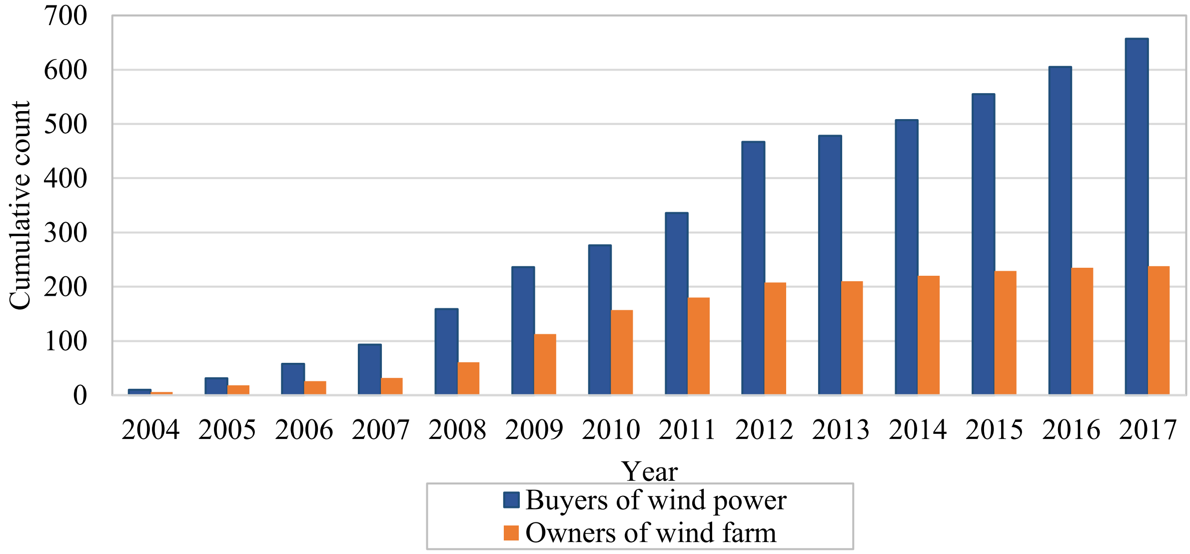

Fig. 6. Cumulative count of buyers of wind power and owners of windfarms.

We find that capturing experience as a function of the MW capacity is equivalent to when captured as represented previously. There is a significant correlation between the cumulative count of installations and the cumulative MW capacity of the installations. We note, however, that the fulcrum of experience as a count of installations is more consistent with the learning-by-doing theories [76].

The installation data are collected from AWEA's database. The MW contracted, a proxy for windfarm size, is a variable that was also collected from AWEA's database. We measure windfarm size with the log of total MW of wind energy contracted or owned from the windfarm [77].

3) Control Variables: We include several control variables at the levels of the offtaker incumbent firm, the windfarm, and the state. We control for whether the offtaker incumbent is a utility or nonutility with a binary (1,0) variable. Utilities include inventor-owned utilities, cooperative utilities, and municipal utilities. Nonutilities include commercial and industrial firms, power marketers, schools, military, and government agency. This control is valid in the examination of H5a and H5b, where the main incumbents are utilities with significant endowments in fossil technologies.

We control for the project age—this variable measures the year in which the windfarm came online and, therefore, controls for the year effect that varies across firms [78]. We control for the difference between the state that the windfarm is located in and that of the incumbent (offtaker) since policies and regulations may differ across states. This variable, different state, is coded as 1 if the windfarm and incumbent (offtaker) are located in different states and 0 otherwise.

We control for influencing factors, such as electricity price, as the annual average retail price of electricity at the state of the offtaker. We control for Sierra Club membership by dividing the number of the club's members in a state by the population of the state. This variable allows us to control for the significance or effects of a social movement for renewable or clean electricity. The variable reflects the influence of the environmental lobbyists on a firm's decision to invest in renewable energy [73]. The literature illustrates how activities of environmental groups result in a positive impact on renewable energy adoption [35], [79]. The activities of environmental groups create normative pressures for incumbents [80] to enhance their corporate social responsibility, promote consumer awareness of renewable technologies and their environmental benefits, and render support to firms embracing these technologies to accelerate investments in renewables.

While social and environmental groups are influential, the disposition of the political composition of a state is an indicator for policies to enhance adoption. We control for the political leaning of a state's population [73] with the proportion of Democrats in the state legislature with data from the U.S. Census Bureau. We calculate the percentage of Democrats in the legislature. Our emphasis on the democratic leaning is based on the predisposition of Democrats being more in favor of legislation for renewable energy than Republicans [79].

Wind electricity generation depends on the availability of wind resources. For windfarms, the availability of wind and its intensity underscore why we control for a state's wind energy resource, wind index, because wind availability is geography specific [74]. Wind resources in a state, wind per state are collected from the EIA database and captures wind generation of utilities and independent power producers as a percentage of total generation at the state level. The variable controls for the extent to which wind power is used at the state level. The more wind power is used at the state level, the more familiar are incumbents with wind power [35], [79].

To control for financial incentives, such as corporate and sales tax incentives, rebates, and property tax incentives, we count the number of such renewable energy incentives available in a state on an annual basis. The data for financial incentives was

TABLE I
MEASURE CHARACTERISTICS AND CORRELATIONS

		Mean	**SD**	**Min**	**Max**	**1**	**2**	**3**	**4**	**5**	**6**	**7**
1	DV: Make or buy	0.29	0.45	0.00	1.00	1.00						
2	Age of RPS policy	8.34	7.73	0.00	33.00	0.01	1.00					
3	Developer experience	2.21	1.92	0.00	10.00	-0.20	0.00	1.00				
4	Log of MW contracted	2.81	2.33	-2.30	6.10	-0.46	0.00	0.18	1.00			
5	Log of distance	2.34	0.90	-2.31	4.48	-0.04	-0.06	0.02	0.28	1.00		
6	Percent of offtaker's fossil	0.83	0.33	0.00	1.00	0.03	0.13	-0.01	-0.16	0.03	1.00	
7	Utility offtaker	0.57	0.49	0.00	1.00	-0.10	-0.02	0.01	0.33	0.19	-0.36	1.00
8	Project age	8.62	2.98	3.00	15.00	0.13	-0.35	-0.05	-0.15	-0.04	-0.07	0.09
9	Different state	0.12	0.33	0.00	1.00	-0.07	-0.20	0.00	0.16	0.13	-0.61	0.33
10	Financial incentives	3.48	3.44	0.00	20.00	-0.14	0.14	0.09	0.12	-0.11	-0.33	0.03
11	Wind incentives	1.04	1.03	0.00	5.00	-0.11	0.21	-0.05	0.02	-0.14	0.10	-0.20
12	Production tax credits	0.50	0.50	0.00	1.00	0.07	-0.14	0.05	0.05	0.08	0.06	-0.04
13	Democrats in legislature	0.51	0.16	0.19	0.91	0.13	0.13	0.00	-0.30	-0.36	-0.04	-0.12
14	Electricity price	10.09	3.16	4.92	34.04	0.02	0.03	-0.01	-0.18	-0.23	-0.06	-0.19
15	Log of wind index	11.88	1.70	6.85	14.11	-0.03	0.14	0.03	0.02	0.01	0.32	-0.09
16	State wind energy	0.08	0.13	0.00	1.00	-0.07	0.31	-0.02	0.14	0.14	0.01	0.14
17	Sierra Club membership	2.19	1.16	0.63	6.43	0.06	-0.11	-0.02	-0.12	-0.19	-0.25	0.18
18	Natural gas price	5.19	2.04	0.00	11.81	0.09	-0.22	-0.02	-0.04	-0.03	-0.08	0.04
		8	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
8	Project age	1.00										
9	Different state	0.05	1.00									
10	Financial incentives	0.25	0.24	1.00								
11	Wind incentives	0.01	0.04	-0.10	1.00							
12	Production tax credits	0.35	0.01	-0.11	0.02	1.00						
13	Democrats in legislature	0.21	0.00	0.22	0.21	0.02	1.00					
14	Electricity price	-0.14	0.00	0.34	0.09	-0.08	0.58	1.00				
15	Log of wind index	0.10	0.26	-0.10	0.02	0.02	0.00	-0.06	1.00			
16	State wind energy	0.43	-0.03	-0.01	-0.08	0.03	-0.33	-0.16	0.06	1.00		
17	Sierra Club membership	0.27	0.13	0.41	-0.19	0.07	0.56	0.33	-0.08	-0.19	1.00	
18	Natural gas price	0.67	0.08	-0.23	-0.01	0.42	0.12	-0.20	-0.08	-0.19	0.13	1.00

collected from the database of state incentives for renewables and efficiency [70]. Since financial incentives are quite diverse in their nature and vary greatly across states, we used a count variable as a proxy to compare magnitude of financial incentives across states. We also control for incentives directly aimed at supporting wind electricity, wind incentives is a count of total incentives targeted to support wind activities. We control for production tax credits (PTC) associated with windfarms, and capture whether or not the federal production tax credit was up for renewal during the year that a respective windfarm went online. We control for natural gas price as a competing alternative to wind electricity. Natural gas prices are measured as averages of their respective years.

B. Estimation Strategy

We estimate a Logistic model using data on 801 windfarm transactions, i.e., incumbents' offtaker decisions, from 2004 to 2017. A Logistic regression estimates a linear regression defined as

$$\text{logit}\left(\pi_i\right) = x_i^{'}\boldsymbol{\beta} \tag{7}$$

where logit of probability π_i is a linear function of the predictors, x_i is a vector of covariates, $\boldsymbol{\beta}$ is a vector of coefficients, such that

$$\frac{\pi_i}{1-\pi_i} = \exp\left\{x_i^{'}\boldsymbol{\beta}\right\} \tag{8}$$

$$\pi_i = \frac{\exp\left\{x_i^{'}\boldsymbol{\beta}\right\}}{1+\exp\left\{x_i^{'}\boldsymbol{\beta}\right\}}. \tag{9}$$

$MakeOrBuy$ is a variable that takes the values one or zero with probabilities π_i and $1-\pi_i$, respectively [81]. We estimate the Logit using STATA to control for unobserved firm and time period effects, as there is not sufficient statistic to condition fixed-effects out of the likelihood in a Logit function.

C. Results

1) Descriptive Statistics: We present the means, standard deviations, minimum, maximum, and correlations for the variables in Table I. An offtaker's (incumbent's) decision to own a windfarm negatively correlates with the windfarm's capacity.

TABLE II
RANDOM-EFFECTS LOGISTIC: DV = INCUMBENT'S MAKE (1) OR BUY (0) DECISION FOR WIND ENERGY

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Utility offtaker	-0.633***	-0.731***	-0.710***	0.117	0.0899	-0.00614	0.0770
	(0.191)	(0.201)	(0.202)	(0.206)	(0.207)	(0.218)	(0.227)
Project age	0.0432	0.0593	0.0282	-0.0372	-0.0399	-0.0426	-0.00992
	(0.0455)	(0.0463)	(0.0460)	(0.0500)	(0.0497)	(0.0506)	(0.0537)
Different state	0.0301	0.239	0.296	0.353	0.280	-0.151	0.364
	(0.293)	(0.312)	(0.319)	(0.357)	(0.356)	(0.422)	(0.424)
Financial incentives	-0.156***	-0.180***	-0.172***	-0.110**	-0.104**	-0.117**	-0.117**
	(0.0304)	(0.0326)	(0.0334)	(0.0348)	(0.0347)	(0.0370)	(0.0394)
Wind incentives	-0.457***	-0.508***	-0.576***	-0.456***	-0.432***	-0.420***	-0.330**
	(0.0978)	(0.105)	(0.110)	(0.114)	(0.114)	(0.116)	(0.122)
Production tax credits	0.178	0.224	0.323	0.584**	0.560**	0.599**	0.628**
	(0.192)	(0.194)	(0.196)	(0.215)	(0.216)	(0.217)	(0.224)
Democrats in	3.380***	2.663**	3.117***	1.537	1.813	1.908	1.099
legislature	(0.867)	(0.897)	(0.940)	(0.984)	(0.985)	(1.015)	(1.099)
Electricity	-0.0342	-0.0176	-0.0231	-0.0305	-0.0340	-0.0388	-0.0407
price	(0.0322)	(0.0329)	(0.0333)	(0.0336)	(0.0336)	(0.0342)	(0.0376)
Log of wind index	-0.0804	-0.0876	-0.0898	-0.0618	-0.0622	-0.0499	-0.0380
	(0.0480)	(0.0491)	(0.0504)	(0.0511)	(0.0509)	(0.0520)	(0.0557)
State wind energy	0.496	-0.0972	-0.408	-0.938	-0.961	-0.928	-1.382
	(0.777)	(0.850)	(0.822)	(0.897)	(0.877)	(0.865)	(0.901)
Sierra Club	0.0464	0.106	0.0441	0.0180	0.0209	0.00662	0.00840
membership	(0.102)	(0.107)	(0.112)	(0.128)	(0.128)	(0.129)	(0.140)
Natural gas price	-0.0492	-0.0520	-0.0285	0.0302	0.0341	0.0248	0.0252
	(0.0558)	(0.0561)	(0.0577)	(0.0614)	(0.0613)	(0.0626)	(0.0633)
Age of RPS		0.0337*	0.0342*	0.0288	0.0281	0.0296	.261***
Policy (H1)		(0.0133)	(0.0140)	(0.0166)	(0.0166)	(0.0165)	(0.0748)
Developer			-0.311***	-0.229***	-0.228***	-0.230***	-0.267***
Experience (H2)			(0.0601)	(0.0540)	(0.0541)	(0.0552)	(0.0596)
Log of MW				-0.436***	-0.449***	-0.458***	-0.505***
Contracted (H3)				(0.0431)	(0.0446)	(0.0440)	(0.0464)
Log of distance (H4)					0.188	0.225*	0.186
					(0.101)	(0.105)	(0.109)
Percent of Offtaker's						-0.849*	0.975
Fossil (H5a)						(0.410)	(0.608)
% Offtaker's							-0.262***
fossil X RPS (H5b)							(0.0763)
pseudo R-sq	0.086	0.093	0.130	0.232	0.235	0.241	0.272
AIC	903.8	899.2	865.5	769.2	768.4	765.1	736.9
BIC	964.7	964.8	935.8	844.2	848.0	849.4	825.9
N	801	801	801	801	801	801	801

Standard errors in parentheses; $^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p < 0.001$

The decision to own a windfarm and the persistence of RPS mandates correlates positively. We find that the windfarm developer experience positively correlates with contracting. The variance inflation factors (VIFs) for the variables range from 1 to 3 indicating the absence of multicollinearity. VIFs greater than 10 indicate model weakness due to multicollinearity [81]. Table II shows the Logit model where the dependent variable is make (1) when the offtaker owns the windfarm and buy (0) when the offtaker buys wind power.

We note here that the discontinuous and nonlinear properties of the Logistic regression imply that the magnitude of the effects may not be inferred from the coefficients, but only the sign and statistical significance of the variables [82], [83]. Thus, we focus on the sign and the significance in the following discussion of the results.

2) Hypotheses Tests: Hypothesis 1 states that the more established the RPS, the more likely the incumbent is to own windfarms rather than contract for wind power. The main outcome of Model 2 is the validation of Hypothesis 1. The coefficient for age of RPS is positive and significant ($\beta = 0.0337; p < 0.05$). This result shows the importance of sustaining RPS mandates in promoting incumbent windfarm ownership. The strength of this outcome reverberates through the five models testing the hypotheses. This is consistent with our expectation because as the policy becomes more entrenched, without repeal, the likelihood of ownership increases to expand the capability set of the imcumbent firm.

Hypothesis 2 states that incumbents are more likely to contract for wind power than own the windfarm, the more experienced the windfarm developer. Table II, Model 3 shows a significant negative coefficient for windfarm developer experience ($\beta = -0.311; p < 0.001$) supporting Hypothesis 2. This outcome is consistent with prior literature that observes that past and emerging capabilities affect firm boundaries [84]–[86].

The premise of Hypothesis 3 is that incumbents are more likely to contract for wind power than own the windfarm, the greater the wind power capacitity they acquire. The coefficient for the MW output of the windfarm is negative, significant ($\beta = -0.436; p < 0.001$), supporting Hypothesis 3.

Hypothesis 4 states that incumbents are more likely to own a windfarm than contract for its wind power, the greater the windfarm's physical distance to existing conventional power plants. We find a positive, significant coefficient in Model 5 ($\beta = 0.188; p < 0.10$) that gains significance further in Model 6 considering fossil technologies. Hypothesis 4 is supported. As windfarms are more geographically distant from conventional power plants, transactional hazards increase, and incumbents are more likely to own a windfarm. In lieu of generalizing this observation, we note similar contexts where colocation may offer insights into innovation and sustainability. An example is the adoption of electric cars with the proximity of the adopter to charging station locations. Another instance is the location of sustainable manufacturing in close location to the path to market, e.g., owning sustainable coffee plantations versus contracting for such sustainably grown coffee.

Table II, Model 6 confirms Hypothesis 5a that the higher the proportion of fossil output in the incumbent's electricity generation, the more likely the incumbent is to contract for wind power than own a windfarm. The percent of fossil coefficient is negative and significant ($\beta = -0.893; \mathrm{p} < 0.05$). This outcome is consistent with our expectations that firms internalize activities along the value chain where they possess superior capabilities and outsource activities where the market has a comparative capability advantage [42], [45], [53]. This finding affirms that an incumbent's experience with existing technologies may result in local search to further exploit its expertise than engage in distant search [55].

Hypothesis 5b predicts that the longer RPS mandates persist, utilities with greater existing endowment in fossil technologies are more likely to own windfarms. We turn to Model 7 in Table II. The coefficient for the interaction is negative and significant. Completing our hypotheses tests for the effects of endowment in fossil technologies hypothesized in H5a and H5b, we conduct two more steps.

First, utilities have traditionally been most reliant on fossil technologies in their generation segments. We, therefore, split the sample in Table II into a subsample of utility incumbents (offtakers) and nonutility incumbents (offtakers). We expect H5a and H5b to hold for the subsample of utility offtakers. Models

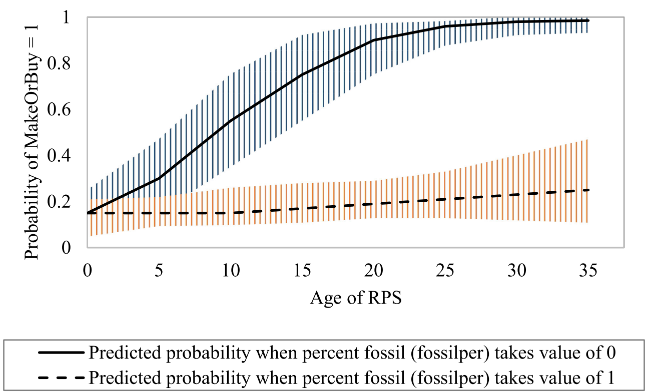

Fig. 7. Interaction effect between RPS policy persistence and offtakers' (regime incumbents') proportion of fossil capacity.

1–3 in Table III present the results for the subsample of utility offtakers while Models 4–6 in Table III present the results for the subsample of nonutility offtakers. In Model 2, the direct effect of percent of fossil endowment is negative and significant for utility offtakers ($\beta = -1.164$) supporting H5a that utilities with a greater fossil endowment are more likely to contract for wind power than own windfarms. In contrast the fossil endowment effect is not significant in the nonutility subsample. In Model 3, the interaction effect of age (persistence) of RPS and fossil endowment is negative and significant ($\beta = -0.207$), consistent with the full sample findings. In contrast, the interaction is not significant in the non-utility sample. A reason, therefore, may be that the policy we study tries to promote renewable adoption by utilities.

Second, since logit models are nonlinear, we need to graph the marginal effect of the interaction between fossil endowment and age of RPS. We used simulation-based approach [87] and the graphic approach [88] to simulate and graph the interaction effect in Stata using function *intgph*. We graphed the interaction effect, as shown in Fig. 7, at high and low levels of fossil along the data range of age of RPS for the subsample of utility offtakers.

The simulated line is almost horizontal for utility offtakers with high fossil endowments indicating a clear preference for contracting for wind power regardless of the age of the RPS. In contrast, the simulated line for utilities with low fossil endowment increases as the age of the RPS increases, indicating that as the RPS mandate's persistence increases, utilities with less fossil endowment are more likely to own windfarms. This finding is interesting, yet counter to that proposed in H5b and, therefore, H5b is not supported. The finding shows the persistence of existing endowment and skills holding utilities back in terms of new generation technology ownership. The finding also highlights that RPS mandates that are agnostic as to how utilities add renewable energy to their generation portfolio are more likely associated with contracting for wind power than utilities owning windfarms.

Regarding the two subsamples in Table III, a few interesting observations are in place. Policy tools appear to be strong drivers of utility offtaker ownership or contracting decisions with age of RPS positively impacting wind ownership. The

TABLE III
RANDOM-EFFECTS LOGISTIC: DV = INCUMBENT'S MAKE (1) OR BUY (0) DECISION FOR WIND ENERGY

	Utility Offtakers			**Non-utility Offtakers**		
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**
Age of RPS policy	0.0500**	0.0501**	0.229*	-0.00208	-0.00236	0.224
	(0.0160)	(0.0161)	(0.0908)	(0.0606)	(0.0604)	(0.188)
Developer experience	-0.271***	-0.265***	-0.314***	-0.230	-0.229	-0.227
	(0.0713)	(0.0706)	(0.0813)	(0.120)	(0.121)	(0.120)
Log of MW contracted	-0.0488	-0.0644	-0.125	-1.216***	-1.213***	-1.217***
	(0.0744)	(0.0748)	(0.0740)	(0.129)	(0.130)	(0.132)
Log of distance	0.187	0.235	0.172	0.174	0.172	0.175
	(0.151)	(0.155)	(0.156)	(0.212)	(0.213)	(0.215)
Project age	-0.0548	-0.0699	-0.0428	0.0331	0.0317	0.0266
	(0.0631)	(0.0659)	(0.0669)	(0.103)	(0.104)	(0.104)
Different state	0.141	-0.353	0.0436			
	(0.332)	(0.401)	(0.407)			
Financial incentives	-0.152***	-0.191***	-0.209***	-0.00999	-0.0117	-0.0188
	(0.0421)	(0.0494)	(0.0574)	(0.0833)	(0.0844)	(0.0843)
Wind incentives	-0.446**	-0.436**	-0.400*	0.191	0.193	0.216
	(0.154)	(0.162)	(0.163)	(0.237)	(0.235)	(0.230)
Production tax credits	0.827**	0.906**	0.909**	0.0394	0.0296	0.0376
	(0.282)	(0.286)	(0.292)	(0.463)	(0.466)	(0.474)
Democrats in legislature	2.083	2.650	2.124	-1.926	-1.894	-2.076
	(1.333)	(1.478)	(1.529)	(2.785)	(2.804)	(2.814)
Electricity price	0.0402	0.0342	0.0335	-0.0495	-0.0501	-0.0596
	(0.0412)	(0.0420)	(0.0405)	(0.125)	(0.125)	(0.128)
Log of wind index	-0.0789	-0.0503	-0.0232	-0.130	-0.129	-0.132
	(0.0658)	(0.0693)	(0.0749)	(0.126)	(0.127)	(0.128)
State wind energy	-0.366	-0.412	-0.935	-1.739	-1.728	-1.767
	(0.978)	(0.960)	(1.060)	(1.929)	(1.928)	(1.921)
Sierra Club membership	0.116	0.0797	0.0575	-0.333	-0.326	-0.268
	(0.149)	(0.152)	(0.158)	(0.377)	(0.376)	(0.362)
Natural gas price	0.117	0.0987	0.102	0.0877	0.0881	0.0974
	(0.0753)	(0.0787)	(0.0768)	(0.148)	(0.148)	(0.149)
Percent of Offtaker's		-1.164*	0.0776		0.236	2.903
Fossil (H5a)		(0.470)	(0.578)		(1.169)	(1.970)
Percent of Offtaker's			-0.207*			-0.232
fossil X RPS (H5b)			(0.0952)			(0.182)
pseudo R-sq	0.125	0.140	0.167	0.598	0.598	0.600
AIC	480.5	474.8	462.7	206.8	208.8	210.0
BIC	546.5	545.0	537.0	264.3	270.1	275.2
N	459	459	459	342	342	342

Standard errors in parentheses; $^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p < 0.001$

policy control variables of financial incentives, wind incentives, and PTC are significant in the subsample of utility offtakers. A reason, therefore, may be that these government policies tend to be specifically targeted toward utilities' renewable energy adoption. While developer experience influences utilities' decision toward contracting for wind power, the size of the windfarm transaction greatly influences nonutilities' ownership versus contracting decision. The different state variable is not included in the nonutilities' sample because all nonutilities in the sample were in the same state as the windfarm for their transaction.

3) *Discussion of Control Variables:* Table II, Model 1 shows the control variables. We discuss several of the significant control variables. In this model, the utility offtaker is negative and significant ($\beta = -0.633; p < 0.001$), indicating that there is a difference in make-or-buy decisions by offtaker type with utilities less likely than nonutilities to own windfarms. The rationale for this behavior is not far-fetched for three reasons as follows.

1) Utilities tend to have significant knowledge in established generation technologies implying that they have inertia within the space of their expertise [89]. Thus, we surmise that utilities are already entrenched in their ways of generating electricity unlike nonutilities.
2) Closely related is the fact that electric utilities are in the business of generating and selling electricity while nonutilities only consider electricity as a by-product.
3) Nonutilities are significantly diverse, including players such as schools and community centers. They adopt windfarms to cover their own electricity consumption with

small capacities of windfarm adoptions on their own property.

The financial incentives ($\boldsymbol{\beta} = -0.156$) and wind incentives ($\boldsymbol{\beta} = -0.457$) are negative for the full sample indicating a higher likelihood for contracting. Financial incentives encourage more contracting than owning because 1) the duration of the incentives have been known to be uncertain; 2) the incentives tend to vary from location to location. When these two factors are combined with the fact that investments may be long term, incumbents tend to favor contracting to hedge against policy uncertainty [90], [91]. In addition, to a large extent, incentives may be agnostic to the option of owning or contracting, which implies that they may be equally realized independent of the offtake option. The exception is with production tax credits that benefit making. However, the proportion of Democrats in the legislature is positive and significant ($\boldsymbol{\beta} = 3.38; p < 0.001$). Since Democrats are generally receptive to policies for renewable energy, it is perhaps a confirmation of their ideological approval (than Republicans) for wind energy that supports the ownership decision rather than the contractual alternative [79]. The significant and not significant results are fairly consistent across the six sets of models except for Democrats in legislature losing significance while production tax credits renewal becomes significant in Models 3–6.

D. Post-Hoc Analyses

We conduct two post-hoc analyses regarding the roles that 1) the distance of a windfarm to conventional generation and 2) windfarm size have on the windfarm ownership versus contracting for wind power decision. To do so, we first created a dichotomous variable by splitting the distance variable at its mean of 14.7 into windfarms located in close proximity and windfarms more distant from existing conventional generation. We re-estimated results for these two subsamples, as shown in Table IV Models 1 and 2.

Comparing the findings in Models 1 to those in Models 2, we see that the effects of windfarm developer experience and windfarm size do not vary across the subsamples and are consistent with those predicted in the full sample. However, we find that the age of RPS increases the likelihood of owning windfarms only for those windfarms in greater distance to conventional plants, whereas age of RPS promotes contracting for windfarms closer to conventional power plants. A possibility for this finding may be that the economic influence of contractual hazards is greater than the policy influence. The windfarm size measure is negative, significant for windfarms in closer proximity to conventional power plants, a finding consistent with the full sample, while windfarm size did not influence the offtaker decision for distant located windfarms. The continuous windfarm distance measure is positive, significant in Model 1 for windfarms in close proximity, indicating that as windfarms become more distant to conventional generation, they are more likely to be owned by the power offtaker, a finding consistent with Table II. Among the controls, policy measures seem to play a particular role in distant windfarm transactions.

Second, we created a dichotomous variable by splitting the variable MW contracted for windfarm size at its mean of 68 MW into a subsample of smaller windfarms and larger windfarms. We re-estimated the results for these two subsamples, as shown in Table IV Models 3 and 4. While many variable coefficients are the same across both subsamples in terms of significance and direction, we also find notable differences.

The coefficient sign for distance varies between the two subsamples. For smaller windfarms, a greater distance is more likely to lead to an ownership decision whereas for larger windfarms, the distance variable is not significant. We further find a mixed impact of financial and wind incentives on the windfarm ownership or contracting decision.

E. Robustness Tests

We estimated several robustness tests as presented in Table V Models 1–5. First, we re-estimated the full model using only the subsample of offtakers in states with RPS mandates.

The results are presented in Model 1 and are largely consistent with those in the main model, except for age of RPS and distance, two predictors that maintain their coefficient direction but lose their significance in Model 1. Second, since many studies use the dichotomous RPS mandate measure for states of the offtaker, we re-estimated the full model using the dichotomous RPS measure in Model 2. The results are consistent with those in the main model. The coefficient for presence of RPS mandate is positive, significant, indicating that offtakers in states with RPS mandates are more likely to own a windfarm than buy wind power.

Since some windfarms have multiple power offtakers, a situation that tends to be associated with windfarms selling their wind power in PPAs rather than being owned by one of the offtakers, we re-estimate our model excluding the 91 windfarms in the sample that have multiple offtakers. The results are presented in Model 3 and consistent with those of the full model presented in Table II Model 6. We further restricted the sample excluding the 91 windfarms to only utility offtakers in Model 4. Model 4 shows results consistent with those in Table III Model 2 for RPS age, developer experience, and offtaker fossil experience. However, windfarm size and distance are not significant, once the model is restricted to only utility-buyers and the 91 windfarms with multiple offtakers are excluded, similar to Table III Model 2. A reason therefore may be that the presence of multiple offtakers reduces the MW capacity that each offtaker procures from a respective windfarm. We examined the robustness of the result with respect to experience as a function of capacity rather than count of installations, and we found no statistical difference in the results.

Finally, we checked for whether the type of utility (Coop, investor-owned utility, or municipal utility) matters in the windfarm ownership or wind power buy decision in Model 5. We re-estimated the analysis using the utility subsample and introduced a dummy variable that is 1 if the offtaker is an investor-owned utility (IOU) or zero otherwise. The dummy variable for IOU is not significant indicating that utility-type does not seem to influence the wind power ownership or buy decision in our

TABLE IV
RANDOM-EFFECTS LOGISTIC: DV = INCUMBENT'S MAKE (1) OR BUY (0) DECISION FOR WIND ENERGY BY DISTANCE TO A CONVENTIONAL PLANT (MODELS 1 AND 2); BY SIZE OF THE WINDFARM (MODELS 3 AND 4)

	Model 1 Conventional plant is close	Model 2 Conventional plant is far	Model 3 Small size	Model 4 Large size
Age of RPS policy	0.0278	0.0343	-0.0536**	0.199***
	(0.0194)	(0.0377)	(0.0197)	(0.0347)
Developer experience	-0.217***	-0.241*	-0.233**	-0.651***
	(0.0607)	(0.117)	(0.0742)	(0.169)
Log of MW contracted	-0.443***	-0.421***	-0.693***	0.431
	(0.0542)	(0.0859)	(0.0780)	(0.597)
Log of distance	0.424**	0.447	0.328*	-0.666
	(0.163)	(0.455)	(0.133)	(0.385)
Percent of Offtaker's fossil	-0.937	-0.964	0.776	-4.292***
	(0.499)	(0.766)	(0.701)	(0.926)
Utility offtaker	-0.00905	0.0157	0.135	
	(0.285)	(0.407)	(0.297)	
Project age	-0.00341	-0.0212	-0.0760	0.0782
	(0.0676)	(0.0881)	(0.0658)	(0.117)
Different state	-0.701	-0.00681	-1.118	1.610
	(0.679)	(0.731)	(0.945)	(0.885)
Financial incentives	-0.112*	-0.0954	-0.0574	-0.349**
	(0.0446)	(0.0868)	(0.0493)	(0.110)
Wind incentives	-0.219	-1.120***	-0.160	-1.545**
	(0.121)	(0.290)	(0.145)	(0.499)
Production tax credits	0.496	0.788	0.573*	1.284*
	(0.266)	(0.405)	(0.287)	(0.544)
Democrats in legislature	2.407*	-0.369	2.486	-2.948
	(1.213)	(2.095)	(1.475)	(3.325)
Electricity price	-0.0972*	0.0516	-0.0458	-0.0836
	(0.0477)	(0.0575)	(0.0518)	(0.134)
Log of wind index	-0.0184	-0.154	-0.0904	0.0436
	(0.0681)	(0.104)	(0.0802)	(0.143)
State wind energy	-1.109	-0.524	-2.106	-1.762
	(1.339)	(1.128)	(1.170)	(1.804)
Sierra Club membership	-0.0990	0.130	-0.270	0.149
	(0.185)	(0.199)	(0.189)	(0.385)
Natural gas price	-0.0332	0.0227	0.0283	0.0460
	(0.0827)	(0.118)	(0.0879)	(0.149)
pseudo R-sq	0.257	0.294	0.339	0.486
AIC	516.3	253.4	446.0	186.8
BIC	592.8	319.1	520.7	251.4
N	517	284	470	330

Standard errors in parentheses; $^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p < 0.001$

sample. The remaining coefficient results are consistent with those presented in the utility-buyer only subsample in Table III.

VI. DISCUSSION AND CONCLUSION

We contribute to the literature on sustainability transitions by taking a closer look at how niche characteristics, policy, and incumbents' established resource endowment impact incumbents' transition pathway strategies. This article presents a comprehensive examination of the factors related to incumbents make-or-buy decisions to diversify into wind energy. Our article highlights factors that relate to incumbents pursuing different transition pathways when adopting new technologies. Although policymakers often focus on innovation diffusion overall rather than the pathways toward adoption, we suggest that policymakers should care about whether firms are more likely to contract or own when adopting new technologies. While an increase in policy persistence encourages windfarm ownership among incumbents, greater developer experience and greater MW acquisition of wind point toward contracting as the preferred incumbent firm choice to diversify into wind energy. In this regard, we find that developer's experience underlines how specialization and

TABLE V
RANDOM-EFFECTS LOGISTIC: DV = INCUMBENT'S MAKE (1) OR BUY (0) DECISION FOR WIND ENERGY

	Model 1 RPS persistence for RPS states	**Model 2 Full Model by presence of RPS**	**Model 3 Full model, single Offtakers**	**Model 4 Utility buyers only, single offtakers**	**Model 5 Utility buyers only**
Utility offtaker	0.147	0.173	-0.354		
	(0.249)	(0.207)	(0.242)		
Project age	-0.0538	-0.0341	-0.0294	-0.0785	-0.0715
	(0.0552)	(0.0496)	(0.0532)	(0.0682)	(0.0665)
Different state	0.0758	-0.286	-0.374	-0.518	-0.415
	(0.462)	(0.425)	(0.426)	(0.405)	(0.403)
Financial incentives	-0.122**	-0.111**	-0.133***	-0.209***	-0.188***
	(0.0409)	(0.0348)	(0.0388)	(0.0515)	(0.0499)
Wind incentives	-0.318*	-0.380***	-0.402***	-0.424*	-0.424**
	(0.132)	(0.110)	(0.119)	(0.168)	(0.163)
Production tax credits	0.643**	0.639**	0.643**	0.893**	0.920**
	(0.235)	(0.219)	(0.221)	(0.292)	(0.287)
Democrats in legislature	1.589	1.909	1.404	2.740	2.752
	(1.267)	(1.020)	(1.043)	(1.520)	(1.487)
Electricity price	-0.0687	-0.0582	-0.0375	0.0429	0.0315
	(0.0424)	(0.0345)	(0.0349)	(0.0435)	(0.0428)
Log of wind index	-0.106	-0.0460	-0.0686	-0.0562	-0.0427
	(0.0546)	(0.0512)	(0.0543)	(0.0725)	(0.0718)
State wind energy	-1.134	-0.805	-0.711	-0.254	-0.415
	(0.958)	(0.912)	(0.912)	(1.007)	(0.966)
Sierra Club membership	-0.0842	-0.0264	0.0781	0.0829	0.0698
	(0.169)	(0.129)	(0.140)	(0.157)	(0.154)
Natural gas price	0.103	0.0196	0.0405	0.145	0.0996
	(0.0679)	(0.0617)	(0.0674)	(0.0825)	(0.0786)
Age of RPS policy	0.0200		0.0326	0.0525**	0.0485**
	(0.0182)		(0.0168)	(0.0161)	(0.0161)
Developer experience	-0.229***	-0.229***	-0.213***	-0.235**	-0.264***
	(0.0584)	(0.0534)	(0.0573)	(0.0715)	(0.0700)
Log of MW contracted	-0.505***	-0.479***	-0.406***	-0.0294	-0.0792
	(0.0517)	(0.0453)	(0.0448)	(0.0761)	(0.0754)
Log of distance	0.164	0.217*	0.240*	0.242	0.238
	(0.116)	(0.104)	(0.109)	(0.159)	(0.156)
Percent of Offtaker's fossil	-1.205**	-0.931*	-1.001*	-1.230**	-1.101*
	(0.463)	(0.410)	(0.418)	(0.465)	(0.479)
Presence of RPS		0.806*			
		(0.326)			
Investor-owned utility					0.226
					(0.270)
pseudo R-sq	0.262	0.243	0.233	0.147	0.141
AIC	649.1	762.9	725.7	454.3	476.2
BIC	730.7	847.3	808.1	523.3	550.5
N	690	801	719	429	459

Standard errors in parentheses; $^{*}p < 0.05$ $^{**}p < 0.01$ $^{***}p < 0.001$

competence in the technology segment influence incumbents' decision to contract.

In contrast, a greater windfarm distance to conventional generation points to a greater likelihood of windfarm ownership among incumbents due to increasing transactional hazards. The challenges inherent in finding developers willing to contract for wind power from more distant windfarms is further exacerbated by the requirement for transmission access. Different niche characteristics and niche-regime conditions, thus, relate to incumbents pursuing different transition pathway strategies.

Furthermore, we find that incumbents with a greater foothold in the existing technology are more likely to contract. This finding shows that incumbents greatly embedded in existing technologies are less likely to hands-on deploy the innovation, but rather they delegate that effort to niche actors in partnerships. Although we expected the persistence of policy to cause incumbents with greater fossil endowment to own windfarms, we find that the tendency to contract for wind power was robust for incumbents with greater fossil endowments. This finding implies that persistence in policy may not be sufficient to prompt

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incumbents to internally learn about the new technology and incorporate it into their operations.

A. Contributions to the Sustainability Transition Literature

We contribute to sustainability transitions research, e.g., [2]–[4], [13], [46]. We contribute to prior work that has tried to unpack the "black box" regarding the role of incumbents in sustainability transitions [1], [5], [10], [11]. First, we go beyond [1] by considering not only the supplier, but also innovation characteristics, such as the size and physical location of the innovation and niche actor experience in influencing incumbents' transition strategies. We suggest that the distinction of suppliers as innovation developers and incumbents as the deployers of the innovation maynot be sufficient. Incumbents may also delegate deployment of the innovation through partnerships with niche actors. The implications of this distinction matter for the extent to which the incumbent embraces and learns about the innovation in its internal operations, which may be a prerequisite for incumbent adaptation. Incumbents may supplement their core activities by diversifying into the niche innovation [1], [5], but incumbents may also partner with niche actors thereby shielding their core activities.

Building on the thoughts abovementioned, we extend work on sustainability transition pathways, e.g., [4], [13], by taking a granular and more microlevel view by suggesting that incumbents may adopt the same innovation using different transition pathway strategies—ownership or contracting. Transition pathways may, thus, not only exist at the system level and shift over time, but incumbents may demonstrate heterogeneity in the pathways pursued. To reconcile this viewpoint with prior work, we acknowledge that although there exist dominant transition pathways at the system level, at a more microlevel variance may exist within that dominance. We show how incumbents' endowments in the established technology and niche characteristics may relate to make-or-buy strategies. Though transaction cost considerations suggest that firms choose their firm boundaries in order to economize on transaction costs by reducing contractual hazards associated with asset specificity and uncertainty, firms' choices are also influenced by the significance of windfarm heterogeneity and a firm's comparative capabilities relative to the market. We, thus, contribute to work on the agency of incumbents in sustainability transitions.

Finally, our work relates to prior research that has demonstrated the central role of policy in shaping sustainability transitions [3], [16]–[18]. We show that while policy persistence in promoting the niche innovation increases the likelihood of incumbents owning the innovation, this is only the case for incumbents less endowed in the regime technology. Our findings show that incumbents most endowed in the existing technology, tend to contract and keep the innovation more at arms-length.

B. Implications for Policymakers and Practitioners

Policy persistence sends a message to incumbent firms that they are safe to invest internally in the skills and capabilities needed to advance an innovation. The finding in the context of wind energy underscores the reinforcing role of policy not only in helping to increase the adoption of renewable energy, but also in shaping the mode with which incumbents adopt.

While policy incentives often target specific groups of firms in the diffusion of new technology, policy tools are often agnostic to the mode of adoption. Among the few exceptions is the federal production tax credit that bestows benefits on firms that build and own windfarms. This article shows that an increase in persistence surrounding policy mandates (e.g., RPS) increases the likelihood that firms commit to windfarm ownership. We find support for the argument that firms tend to invest more in new assets in states that have greater persistence in policies for renewable energy development. While policymakers have largely focused on accelerating overall adoption of renewables, a closer eye to the transition pathway in which such adoption occurs may be warranted. Incumbents contracting with niche actors for wind power are likely to foster growth among niche actors, and thus greater diffusion of the niche innovation, but they are less likely to acquire skills specific to the niche innovation. Thus, from a skill and capability perspective, incumbents remain experts in regime technologies, but are unlikely to meaningfully expand their own skill set in the innovation. As a result, synergies and syntheses between the old and the new may be harder to detect during the sustainability transition.

In contrast, incumbents that own the innovation foster greater learning inside the regime. This learning may pertain to the deployment of the innovation, or to interfaces between the innovation and existing complementary assets. At the same time, the incumbent may still foster growth among niche actors as it pertains to the innovation's development (i.e., orchestrating the building of windfarms), but less so in terms of its deployment. By assuming greater responsibility for the innovation's deployment, the incumbent owning windfarms may create greater regime-niche overlap, which potentially could accelerate the sustainability transition. Greater regime-niche overlap could also result in an accelerated move away from fossil-burning electricity generation.

Furthermore, the policy effect varies by incumbent attributes. Incumbents that are more endowed in the existing technology are more likely to contract than own, and even increased persistence surrounding policy mandates does not change that incumbent preference. These findings point to the persistence of established resource endowments, and the need for policymakers to be as clear as possible about policy intent. In the context of wind energy, the finding shows that the persistence of policies that are agnostic to how utilities add renewable energy to their generation portfolio are more likely to support contracting for wind power for incumbents with greater existing technology endowments.

What makes this decision more complicated in the wind energy sector is the variety of regulatory mandates that surround the sustainability transition. As the wind energy sector continues to emerge, the influence of existing capabilities, the accumulated developer experience of wind technology, increased regulatory persistence, closeness to complementary assets of transmission lines and the proportion of conventional technology capacity plays interesting and often unanticipated roles in the agency of incumbents in sustainability transitions.

C. Implications for Managers

This article sheds significant light on the management of incumbents' sustainability transitions using the example of the wind energy sector. One transition pathway may lead incumbents to delegate the innovation deployment to niche actors, i.e., new entrants and third parties who are experts in the new technology. Another transition pathway has incumbents, i.e., entities in their established industry, supplement their core activities by diversifying into the innovation through ownership. Managers should keep in mind that adopting an innovation through contracting with niche actors provides them with access to the innovation but builds less internal innovation-related skills in their organization. This article suggests that managers should consider the innovation characteristics, such as the size and physical location of the innovation and the experience of niche actors. First, managers should consider their comparative capability to those in the market for the innovation. When able to tap into highly-experienced innovation experts, contracting may be the preferred choice. Similarly, large initial innovation investments may render innovation skill expertise crucial and, therefore, contracting can be the preferred choice. Transaction hazards might become particularly pronounced for large innovation investments that are distant to the incumbents' existing operations and for which access to complementary assets is limited. Under such condition, ownership may be the preferred choice. Incumbents with strong skills in the existing technology may stay with contracting despite policy persistence. Here, it is important for policymakers to consider that policies promoting an innovation that are simply focused on innovation diffusion and, thus, agnostic to the mode of adoption, may lead to more contracting than ownership of the innovation among incumbents. While such is not a problem *per se*, policymakers may consider that contracting builds less innovation-related skills within incumbent organizations than innovation ownership does. This may have implications for the sustainability transition outcome.

D. Limitations and Future Research Directions

This article has limitations that can be the start for future research. First, although we controlled for several state-level variables, the impact of consumer demand in deregulated markets on sustainability transition pathways should be further investigated. Second, while our study is at the transaction level for windfarms, future research could study incumbents that build their wind portfolio over time, and how ownership decisions may become intertwined with contracting to yield a make-and-buy portfolio of several windfarms. Such a study could build on [13] who suggest that transition pathways can be fluid and systems are not locked into an initially chosen transition path. Third, the influence of nonmarket dynamics in sustainability transitions, particularly in shaping an incumbent's energy technology portfolio of make-or-buy, energy resource planning, and optimization, are yet to be understood and offer opportunities for future research. Fourth, using a large-scale sample of a total of 801 windfarm transactions we miss out on the nuances and detail that more qualitative studies can provide. Future research could use qualitative methods to study the niche-regime interaction between windfarm developer and incumbents to yield further insights in the interplay of policy, niche characteristics, and incumbent attributes in affecting incumbents' transition pathways. Finally, this article focused on one type of renewable energy, namely wind. Future research could look at whether transition path choices vary within the same firm across different types of renewable energy sources such as wind and solar.

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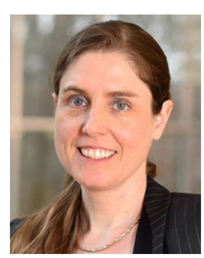

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