Nilanjana Dutt

Organizational Search and Decision-Making

in the Renewable Electricity Industry

Egea

Nilanjana Dutt

Organizational Search and Decision-Making

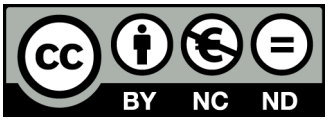
in the Renewable Electricity Industry

Egea

Via Salasco, 5 – 20136 Milano
Tel. 02/58365751 – Fax 02/58365753
egea.edizioni@unibocconi.it – www.egeaeditore.it

First Edition: April 2023

ISBN 978-88-238-8621-6



Contents

Preface

This book examines how organizations, when solving a specific problem, identify a set of potential solutions that we call a "search space." Drawing from evolutionary theory and related literatures on strategic change, scholars have demonstrated differences in search mechanisms that explain how organizations choose solutions. However, there is much we still don't know about how organizations decide where to search, including how they identify a set of potential solutions or search space. This book defines the concept of search space and identifies three factors—uncertainty, prior top managerial attention, and prior experience—that drive differences in search space. Additionally, it begins to disentangle why some firms' top managers are predisposed to paying more attention to new strategic areas by investigating the relationship between uncertainty and top managerial attention.

Hypotheses about the effect of uncertainty, prior top managerial attention, and prior experience on size of search space, and second examining the effect of uncertainty on changes in top managerial attention, are tested using data describing the U.S. renewable electricity sector from 2000 to 2010. We conduct both a cross-sectional analysis using data collected though a multiple respondent survey and a panel data analysis by tracking firms' memberships in renewable electricity trade groups. These data reveal that uncertainty and prior top managerial attention increase the size of a firm's search space, while related prior experience reduces it. Additionally, uncertainty positively changes the attention of top managers at headquarter units, but not the attention of those at subsidiary units, towards renewable electricity.

Interviews conducted with managers at five firms in the sample provide context in helping us understand the role mangers play in defining search space for different types of firms with different perspectives on the problem, in our case a mandated transition to renewables. These results contribute to our understanding of how organizations start solving problems by deciding where to search; how the boundaries of top managerial attention direct search space; and how different types of top managers interpret uncertainty. Empirically, these results have important implications for how renewable policies should be structured and how firms develop new projects in the U.S. renewable electricity sector.

1 An Introduction to Search Space

Organizations solve problems by identifying solutions through a process of search (Berchicci et al., 2019; Cyert and March, 1963; Dutt and Mitchell, 2020; Felin and Zenger, 2014; Jeppesen and Lakhani, 2010; Nelson and Winter, 1982). Existing research on organizational search has highlighted many search mechanisms, including local and distant search (Helfat, 1994; Helfat and Lieberman, 2002; Katila and Ahuja, 2002; Rosenkopf and Nerkar, 2001; Siggelkow and Rivkin, 2006), the impact of managerial cognition on forward-looking search (Dutt and Joseph, 2019; Gavetti and Levinthal, 2000; Gavetti and Tripsas, 2000; Greve and Taylor, 2000; Ocasio, 1997; Zhu et al., 2020), and the relationship between search outcomes and organizational performance (Dahlander et al., 2016; Fleming, 2001; Ganco and Agarwal, 2009; Katila and Ahuja, 2002). It has also raised unanswered questions about the origins of search. What triggers search, and what environmental and organizational characteristics aid organizations in identifying potential solutions (Gavetti and Levinthal, 2000; Jacobides and Winter, 2005a)? By investigating how organizations identify a set of potential solutions that we call "search space," the following chapters seek to further our understanding of a key aspect of the origin of search.

Identifying a problem or, alternatively, an opportunity is typically what initiates search. Search space is the set of potential solutions that organizations identify when addressing a specific problem. In the presence of uncertainty, organizations will often identify multiple potential solutions before choosing the one they will implement. For instance, in a case study of Walmart's expansion into China, Gupta, Govindarajan, and Wang (2008) identify three points in Walmart's journey—(1) deciding where to expand, (2) deciding how to expand, and (3) deciding which suppliers to purchase from—where the company identified multiple potential solutions before ultimately choosing a course of action. (Cyert and March, 1963)) also discuss a scenario where a firm identifies multiple potential consultants before deciding whom to hire. Because firms repeatedly identify potential solutions when problem solving (MacDuffie, 1997; Siggelkow and Levinthal, 2005; Siggelkow and Rivkin, 2006), search space may have important impacts on firms' strategic trajectory.

This book contributes to research on the antecedents of search by defining search space and by understanding how firms identify it. Search space has important implications for firms because solutions must be considered before they can be chosen, and thus, the solutions that firms identify in their search space will likely have an impact on how the firm allocates resources and develops a long-term strategy. Similarly, policy makers often face the onerous task of pushing firms to consider solutions that can benefit the whole industry; by understanding how firms identify search space, we can provide insights about how uncertainty and organizational factors push firms to consider a bigger set of potential solutions.[1]

Drawing on evolutionary theory and relevant behavioral perspectives (Cyert and March, 1963; Dutt, 2022; Gavetti, 2011; Koçak et al., 2022; Nelson and Winter, 1982; Ocasio, 2011; Posen et al., 2018; Snihur and Wiklund, 2019; Tripsas and Gavetti, 2000), the following chapters develop a framework for the conceptualization of organization-level search space. In this framework, boundedly rational organizations solve problems by searching for solutions under uncertainty. In doing so, they are guided by their interpretations of the environment, internal stocks of knowledge, and routines (Cyert and March, 1963; Nelson and Winter, 1982). Organization-level evolutionary and behavioral perspectives reveal that three factors are frequent drivers of a wide range of search mechanisms: (1) uncertainty about the problem, (2) prior top managerial attention towards the context of the problem, and (3) organizations' prior experience in activities related to the problem. The theory section discusses why these three factors are most relevant for understanding search space and how they impact the size of search space.

1.1 Setting: Renewable Portfolio Standards in the U.S. Electricity Industry

To understand the concept of search space, this book will focus on how U.S. electric utilities identify a set of renewable electricity projects and technologies. The U.S. electricity industry predominantly comprises large, publicly listed firms (e.g., Duke Energy) that generate and distribute electricity but do not develop the underlying technology infrastructure themselves. The competitive side of this industry—for instance, retail prices—is largely regulated by state governments (except for 16 states that are deregulated), while research and development (R&D) activities are regulated by the federal government

[1] Research at the individual level has also shown the impact of considering set characteristics such as size on consumer decision-making outcomes (McFadden, 1973; Payne et al., 1988; Roberts and Lattin, 1991).

(Costello, 2016). Such regulation means detailed accounts of firms' generation activities, prices, and internal activities are publicly available.

Important for understanding search space, state governments use policy mandates to push electric utility firms to adopt new technologies. One such set of policies is Renewable Portfolio Standards, or RPSs, which require increases in renewable electricity output. Renewable electricity was, until recently, a relatively underdeveloped niche in the electricity industry (EIA, 2013), making the rollout of RPSs ideal to study search space. Because publicly owned utilities would have been searching for new technologies for investment as RPSs were first rolled out, we examine search activities in this initial period from 2000 to 2010 (Bird et al., 2005; Carley, 2009; Dutt and Cunningham, 2020; Fabrizio, 2012; Fremeth and Shaver, 2014; Lyon and Yin, 2010; Wiser et al., 2007).

Although RPSs are broadly similar across states—requiring that some share (5% to 40%) of the total electricity provided by firms comes from solar, geothermal, biomass, wind, and/or hydro sources by a date five to 30 years in the future—the exact mandated share and date of the regulation varies by state and across years (Carley et al., 2018). For instance, Michigan adopted RPSs in 2008 and required firms operating in the state to provide 15% renewable electricity by 2015. Comparatively, Hawaii adopted RPSs in 2001, setting a target of 10% renewables by 2010, increasing to 30% by 2020 and 100% by 2045.

Renewable electricity capacity was generally low in 2000, when RPSs were first rolled out. While about half the firms in our sample had some renewable electricity capacity, they did not prioritize renewable electricity. This heterogeneity in renewable electricity capacity was largely a function of firms' locations and management preferences. In interviews, some renewable-generating firms mentioned the value of renewable electricity as representing a new market niche. Most, however, clarified that their choice to invest in renewables pre-RPSs was driven by cost effectiveness. For instance, firms in locations proximate to a major river tended to generate hydroelectricity. This pattern suggests that firms facing RPSs may have accumulated natural endowments. Still, the effects of individual firm preferences are likely to intermingle with these natural endowments such that two firms in similar locations may select different search spaces to address RPSs.

Because RPSs have encouraged firms to change their behavior, they can help us identify a specific time range within which to examine U.S. electric utilities' search space. As renewable electricity was a generally underdeveloped strategic area in the early 2000s, and most firms in the sample are located in multiple states (60% supply electricity to multiple states, increasing their likelihood of facing renewable requirements), we can expect firms across most states to have some incentive to identify a search space of renewable projects. Research suggests that in this context firms tend to look across states and consider the wholistic impact of regulations. Overall, the U.S. electric utilities industry provides an exciting context in which to study search space by allowing

us to explore an industry with relatively homogeneous firms searching for renewable electricity projects at an emergent point in time and undergoing technological evolution with vital strategic and public policy implications.

1.2 What We Gain from Studying Search Space

Studying search space can help us understand both evolutionary theory and related literatures on strategic change. The results of this research suggest that uncertainty, prior top managerial attention, and related prior experience have meaningful, independent effects on the size of search space. This suggests that features of state RPS regulation, which is external to the firm, and both top managers' preferences and firm experience, which are internal to the firm, are all important in predicting the number of possible solutions the firm considers. The size of this search space is particularly important to the breadth of ideas considered by a firm to be relevant to its future performance (Dahlander et al., 2016; Dutt and Lawrence, 2021; Lampert and Semadeni, 2010; Laursen, 2012; Leiponen, 2005; Leiponen and Helfat, 2010). In this context, much innovation and R&D occur outside the firm (Costello, 2016; Dutt and Cunningham, 2020), meaning that a broader search space may also have implications for technological development in the industry as a whole and in the development of markets for technology.

Regulations, more generally, are a central feature of this context. Recent research has shown how regulation at the state and federal level affects the search space of firms in the utilities industry (Dutt and Mitchell, 2020). Both federal and state regulations affect search space, but firms' responsiveness depends on their capabilities and regulatory uncertainty (Dutt and Cunningham, 2020; Rockart and Dutt, 2015). While capable firms are more responsive to state-level regulations, less capable firms are more responsive to federal events. All firms are less responsive to regulations that they deem to be unstable. Overall, the findings in this book and other work on this context provide support for the idea that search space varies across firms and is determined by uncertainty, prior top managerial attention, and related prior experience.

Understanding search space also contextualizes our current understanding of how organizations evaluate and select solutions. Early approaches to studying search often implicitly assumed that the choice of local or distant search was independent of search space. That is, all possible alternatives are laid out for an organization, and the main challenge is selection. Often, we assumed a common search space for all firms that reflected shared knowledge of an industry's competitive landscape (Levinthal and Warglien, 1999; Rivkin and Siggelkow, 2002). Yet recent research has revealed that different problem conceptualizations and reference groups may emerge for firms in a similar context (Baer et al., 2013; Fiegenbaum and Thomas, 1995;

Foss et al., 2016; Massini et al., 2005; von Hippel and von Krogh, 2015). In turn, this suggests differences in search spaces across firms facing similar challenges in similar contexts. Internal factors such as prior experience and external factors such as regulatory uncertainty play a critical role in explaining the variation in search space. By integrating organization-level search space into the search process, we can now bridge a key gap between search's antecedents and its consequences.

The study of the U.S. renewable electricity sector that constitutes Chapter 4 of this book demonstrates that the ways in which firms search can have far-reaching implications. Because renewable policy changes are relatively new, and most companies have limited prior experience using renewable electricity, it is difficult to predict which renewable electricity technologies will be adopted in different settings and which will become dominant over time. By understanding how organizations make search choices, we can shed some light on why certain renewable electricity technologies are identified and included in firms' search space, and possibly why they are adopted more extensively and quickly than others; we can also determine the roles that uncertainty, prior top managerial attention, and related prior experience play in directing technology search. Finally, we can use this research to assess the degree to which past policy changes have affected firm behavior and developed the renewable electricity sector across different types of firms.

2 Theory

2.1 Conceptual Mechanisms

This book develops the concept of search space by examining how organizations evaluate alternatives and choose solutions, and the contingent relationships between search outcomes and organizational performance. It draws upon seminal research on adaptation and search choices to understand how the set of available alternatives is created (Cyert and March, 1963; Dutt, 2022; Gavetti, 2011; Jacobides and Winter, 2005b; Koçak et al., 2022; Nelson and Winter, 1982; Ocasio, 2011; Posen et al., 2018; Snihur and Wiklund, 2019; Tripsas and Gavetti, 2000).

An important direction for new research on this topic is developing frameworks to understand the antecedents to search. Ongoing work has started to clarify this topic. By delving into the role of analogies, for instance, Gavetti and Levinthal (2000) have started to explore processes by which managers interpret the world around them to initiate new endeavors and solve new problems. Jacobides and Winter (2005:396), meanwhile, discuss the importance of "which of the possible choices on the menu of available alternatives will be chosen by an individual firm at a given time," and of understanding how the "menu" itself is created (Jacobides and Winter, 2012, 2005a). Other scholars using different theoretical lenses have also discussed the notion of an organization-level search space and its impact on important decision outcomes (Kulchina, 2012).

These efforts are important starting points if we want to understand the origins of search. However, more strategy research must examine antecedent mechanisms before we have a framework to explain the origins of search. Existing research suggests that some combination of competitive and environmental forces, organizational routines, and managerial characteristics affects how organizations initiate search. This established literature also suggests potential roles for uncertainty and experience. Meanwhile, work examining a variety of managerial characteristics such as cognition (Gavetti, 2005; Gavetti and Tripsas, 2000; Kaplan and Tripsas, 2008) and attention (Eggers and Kaplan, 2008; Ocasio, 1997; Ocasio and Joseph, 2005) highlights

the importance of cognitive drivers to search's antecedents. As we shall see, both uncertainty and important organizational factors help shape search space.

The concept of search space is particularly relevant to the U.S. renewable electricity sector because utility companies have important incentives to consider new renewable technologies. Because of the prevalence of regulatory compliance in the industry, U.S. electric utility companies are typically aware of renewable electricity regulations and their options for meeting requirements. All firms seem to have access to the same publicly available information from state and federal governments, suggesting no information advantage based on external sources. This suggests that public firms in this industry are reasonably similar in terms of their access to information about the future of the industry, access to lobbyists, and incentives to search for renewable projects. While the study later looks specifically at regulatory changes between 2000 and 2010 as an important driver of the search for renewables, firms in the study period were also searching for renewables in anticipation of future regulatory changes and to satisfy demand from a small niche of customers willing to pay for renewable electricity.

Despite the apparent similarities across publicly held utility companies, interviews with two large investor-owned utilities located in the same state, facing the same regulatory hurdles, and with the same access to renewable electricity resources show that the two firms identified different search spaces. One firm said it would like to capitalize on its "existing hydros" and described investing in wind and looking at solar "just in case things change." The second firm said it was "only interested in proven technologies and would only consider biomass." Here and elsewhere, search space differs across seemingly similar firms in the same setting facing the same problem.

Companies view the identification of search space as an important activity; therefore, their top managers are involved in making important strategic decisions. Those we examine in this book allocated, at minimum, hundreds of thousands of dollars to identify search space, with expenditures focusing on allocating employees to identify search space, purchasing reports and industry analyses, paying membership fees to join trade groups, and hiring external consultants. The cost of hiring consultants alone ranged from the low thousands to hundreds of thousands of dollars for companies that bought complex analytical tools. Initial investments such as these have significant long-term impacts; after top managers identified their firm's search space and chose a specific renewable electricity project for investment, they expected to spend billions of dollars on infrastructure and to exercise multi-year power purchase agreements with state governments. For top managers and their firms, identifying search space is serious business.

Search typically begins with a triggering event, such as a technological or a regulatory shift that is likely to have significant consequences for an industry, or even a particular firm. While search can also arise because of internal

differences in firms, we focus on cases where there is some general event that is applicable to a broad range of firms in an industry. For U.S. electric utilities, RPS policy changes were an important trigger: They provided an explicit problem and goal that applied to most firms in the industry, identified a time range within which firms had to comply with new regulations, and were independent of firms' characteristics. We assume the trigger to search is independent of prior firm activities, top managers' interpretations of the external environment, and internal firm capabilities. In the U.S. renewable electricity setting, this is a reasonable assumption. Future work will seek to include potentially endogenous triggers to search as part of the analysis, answering what remains an open empirical question. The three independent variables included here still likely have a significant impact on the size of search space.

2.2 Determining the Size of Search Space

A firm's "search space" is the number of potential solutions to a problem that the firm can think of. The size of a firm's search space is determined by the firm's prior experience with similar problems and the amount of attention that top managers have given to the problem. More experience does not necessarily translate to a larger search space: Experienced firms whose top managers devote significant attention to a problem will have moderately sized search spaces, while those whose top managers devote little attention to the problem will have small search spaces. Less experienced firms will have large search spaces if their top managers devote significant attention to the problem, and they will have moderately sized search spaces if their top managers devote little attention to the problem. No firm will identify all the possible solutions to the problem it is facing, but a firm stands to benefit from searching just widely enough to find a good solution without expending too many resources.

2.2.1 Effect of Related Prior Experience on Search Space

Highly experienced firms are likely to be more familiar with more alternatives, while less experienced firms will know about fewer. Highly experienced firms also know more about which potential solutions have been successful in the past. Because firms have a natural tendency to exploit a particular area of competence (Agarwal and Helfat, 2009; Helfat, 1994), they are also more likely to be aware of which types of alternatives are a good fit for their business. In addition, because experienced firms have already considered several alternatives in detail in the past, they need to conduct in-depth research on fewer alternatives when they receive an external trigger to search. This means they will include fewer potential solutions in their search space—their search space will be smaller.

Less experienced firms, meanwhile, will not know which solutions are a good fit for their business. They will not have explored any possible solutions in the past and will not have in-depth research they can rely on to help them solve their problem. Thus, when facing an explicit trigger to search, less experienced firms should include all the potential solutions they are aware of in their search space—only then will they be able to determine which solution, or solutions, to pursue.

2.2.2 Effect of Prior Top Managerial Attention on Search Space

Firms with top managers who have been paying attention to the context of the problem are likely to have already heard of some of the potential solutions. This means that when the firm faces the problem, it will be easier for them to find a solution. At the same time, top managers who pay little or no attention to the context of the problem are unlikely to have heard of potential solutions and will have a harder time finding a solution. Search space for firms with varying prior experience and prior top managerial attention is illustrated in **Figure 2.1**.

Figure 2.1 Decision model results: effect of related prior experience and prior top managerial attention on size of search space

	High attention	**Low attention**
High experience	Moderate = X (h/2) + Yh	Small = X(h/2) + Yl
Low experience	Big = Xl + Yh	Moderate = Xl + Yl

When firms are trying to identify a solution, they will first identify a search space of all the potential options. They will then evaluate these options and choose the best one. The size of the firm's search space will predict whether the chosen solution will be local or distant. If the firm has a small search space, it is likely that it will only have local options and will choose a local solution, since firms generally start by searching locally (Martin and Mitchell, 1998; Rosenkopf and Nerkar, 2001; Stuart and Podolny, 1996). If the firm has a large search space, it is likely that it will have more distant options and will choose a distant solution. If the firm has a moderate search space, the solution will be determined by the firm's prior top managerial attention. If the firm has high prior top managerial attention, it is likely to be aware of more distant options and will choose a distant solution. If the firm has low prior top managerial attention, it will have fewer distant options and will choose a local solution. A simple two-by-two matrix summarizing this logic is shown in **Figure 2.2**.

Figure 2.2 Decision model results: effect of related prior experience and prior top managerial attention on proximity and distance of search space

	High attention	Low attention
High experience	Distant	Local
Low experience	Distant	Local

This framework to predict search space can be used to understand the effect of prior top managerial attention on both the size of search space and the nature of the chosen solution. Its logic is largely consistent with the conventional wisdom on search, but by illustrating the independent (and not just contingent) effect of prior top managerial attention on both the size of search space and the nature of the chosen solution, it extends our understanding of search. We can see this playing out in the studies we discuss later, where results show that, on average, firms will identify a larger search space if their top managers have been paying attention to the problem area prior to facing the problem and a smaller search space if they have a lot of experience with potential solutions. Similarly, firms with top managers that have been paying attention to the context of the problem will, on average, choose distant or new (for them) solutions; low prior-top-managerial-attention firms, meanwhile, will choose a local solution simply because they are unaware of potential solutions they have not already implemented. Although both prior experience and prior top managerial attention determine the size of search space, prior top managerial attention alone can determine the nature of the chosen solution.

3 Empirical Setting

3.1 The U.S. Electric Utilities Industry

The renewable sector in the United States provides a good example of how search space works because many companies have to make decisions about new investments in renewable electricity. This includes companies that provide electricity to homes and businesses—such as Consolidated Edison Inc., which is large and publicly owned—as well as smaller, privately owned companies such as Atlanta Power Co. of Idaho. We are only focusing on investor-owned utilities (IOUs) that are run for profit, rather than non-profit or government-owned companies, because our theory assumes that companies are trying to make money during the process of identifying search space.

Although U.S. electric utilities generate most of their electricity (about 87%) from cheaply available non-renewable sources such as coal and natural gas,[2] most (70%) large IOUs also have some renewable assets. This might seem puzzling: Why would profit-maximizing firms provide any electricity from more expensive renewable sources when cheaper sources are available? There are two reasons why they do. First, historically, some electric utilities have had access to natural renewable resources such as rivers (on which hydroelectric plants are built) that made renewable electricity financially sustainable. Second, some electric utilities have invested in renewables to diversify their portfolios in preparation for possible regulatory changes (deregulation of the electricity industry in the 1990s) and changes in customer preferences (emergence of green-power programs that allowed customers to voluntarily pay a premium for renewable electricity). Given the low volume of renewable electricity produced by U.S. electric utilities, the focal study included here looks at how electric utilities identified search space for different renewable electricity projects and technologies from 2000 to 2010. The studies focus on understanding the impact of uncertainty, prior top managerial attention, and related prior experience on each company's search space.

[2] http://www.eia.gov/totalenergy/data/annual/showtext.cfm?t=ptb0201f.

U.S. electric utilities may identify search space for a number of reasons, but state policy is an especially important one. As of 2010, 29 states, Washington, D.C., Guam, and Puerto Rico had passed legislation, and eight more had initiated renewable policies including voluntary goals for electric utilities to provide a percentage of their total electricity from renewable sources. By 2020 (Barbose, 2021), 38 states, plus Washington, D.C., had passed legislation or had initiated renewable policies including voluntary goals for electric utilities to provide a percentage of their total electricity from renewable sources. RPSs include the following requirements: (1) the percentage or amount of renewable electricity required, (2) all of the possible renewable electricity technologies that the utility may use to meet the requirement, (3) annual goals (if any), (4) whether or not the renewables must come from new construction, (5) whether or not the construction must be in state, and (6) the year by which companies must meet the full requirements of the policy. Exact percentages, amounts, and dates vary by state—some states include geothermal energy as a potential renewable source, while others have a required solar energy quota—but the overall structure of the law is similar across states. The most recent policy changes have mandated U.S. electric utilities to provide between 5% and 40% of their total electricity from some combination of five renewable technologies (solar, nuclear, biomass, wind, and hydro) by 2015 to 2030. The goal of RPSs is to push utility companies to build renewable capacity in an economically sustainable manner (Fremeth and Marcus, 2011; Lyon and Yin, 2010).

More recent trends in this industry suggest a big uptick in investments by investor-owned firms and a reduction in the cost of renewable electricity. Thus, it is worth clarifying that the patterns and models discussed in this book are most relevant for explaining search in a nascent industry context with limited competitive pressures, rather than in settings that are in a steady state.

The dataset for the focal study includes information on all U.S. investor-owned electric utilities, including firms not facing the policy change, from 2000 to 2010. These data allow us to study firms' search spaces across states with different policy requirements—and, in most cases, before and after the policy change was enacted. This study was among the first to explore the concept of search space, and it relies on two measures to better assess the validity of the constructs. In early studies such as this, it is ideal if both measures yield consistent results. However, if the results are contradictory, they are still useful for identifying a boundary condition to a new theory. In either case, multiple measures, as well as several qualitative case studies, allow for better development of the core concept of search space.

3.2 Qualitative Data

The following five exploratory interviews can help us understand the underlying structure of decision-making in the U.S. renewable electricity sector and firms' responses to the renewable electricity policy change. Each of the featured companies was approaching the renewable electricity industry differently at the time of the interview. Some companies were already active in renewables, some were not; some viewed RPSs and renewables positively, and others negatively. While these differences do not always translate to differences in search space, they do show how companies approach search differently.

In addition to identifying the main decision-makers, these interviews highlighted the processes these companies used to make decisions about investing in renewables and the timeline of those decisions. Conducted along with the survey that provides key data for the study in Chapter 4, early interviews provided information about their reliability while later interviews focused solely on gaining background information to understand how and why these companies entered the renewable electricity sector.

Information from the interviews provides us with the following five case studies, which help us understand how firms think about search space. The chosen firms vary in size, performance, diversification, geographic location, organizational structure, and size and contents of their search space. As Eisenhardt and Graebner (2007) have pointed out, in a multiple case study approach, it is often valuable to choose cases based on how much they can contribute to extending the boundaries of the project, even if they are not prototypical examples. We can generalize the collective findings of the case studies to create a portrait of search space within the renewable sector of the U.S. energy utility industry.

3.2.1 Company A

The first company we interviewed, Company A, was a large, publicly owned, diversified utility company located in the Southeast. Because this company was a pioneer in the renewable electricity industry, its perspective on the industry was particularly useful for the project. The first interview took place on April 22, 2010, with a follow-up several months later to confirm the data.

Company A was both geographically and business diversified, which was useful because both performance and diversification are key variables along which companies are differentiated. To mitigate this interview's retrospective bias, questions focused on the company's past as well as present practices and multiple people were interviewed. The responses of a company veteran in the renewable division were corroborated by the employee hired to replace that veteran, who retired between the first interview and the follow-up.

Company A's respondents asserted that their company was a pioneer in the renewable electricity field, one that started investigating renewable

electricity in early 2000. The RPS requirements in the states where the company operated were only passed in 2007, and Company A was a staunch supporter of the legislation at that time. The legislation allowed Company A to include renewable electricity in its rate base, the most sustainable strategy for long-term profits. The main impetus to invest in renewables came from Company A's forward-looking CEO. According to the director of renewable energy, the CEO "had grandchildren and wanted to leave them in a better world." The company started looking into renewable sources of electricity well before the rest of the industry or the push from the government. The strategic direction of the firm was chosen based on the CEO's preferences, and because the company was successful, the board and employees trusted the CEO's discretion.

Once this decision was made, the company researched the actions of other U.S. and international firms. Unfortunately, useful examples were hard to find: There were few other American firms investing in renewables and, while there were many renewable electricity companies in Spain and Germany, the regulatory environment was too different to make analogous comparisons. In the end, Company A examined a few firms in Florida before deciding what types of technologies to include in its search space.

Because Company A was a pioneer, it was compelled to create an internal consulting group that did most of its pre-entry research. External consultants and the government were not much help, although the company had a good relationship with the latter. Similarly, because there was no industry for renewable electricity when it started, Company A searched for all types of information before finalizing its investment strategy.

The interview confirmed that companies do in fact *do* research prior to entering a new industry, and one aspect of this research is focused on identifying search space. It also confirmed that although for some types of projects (and probably some types of firms) there is a search protocol in place—such as a predefined group of employees to do the research—in many cases firms search ad hoc by employing both internal and external consultants. At the very least, this interview suggested that in the case of an emergent market, search protocol was equally uncertain and likely to differ across firms.

The interview confirmed that the questions in the survey were relevant to understanding how companies search for information prior to making investment decisions. However, perhaps more usefully, Company A asserted that competitive pressures are largely absent in this monopolistic and highly regulated industry. Our interview subjects identified a complete lack of incentives for aggressively imitating or monitoring competitors in other states. They were the pioneers, so there were few potential competitors to monitor, and differences in regulatory regimes implied a lack of similarity across contexts. Because of this, later interviews did not include questions focused on

understanding how much time was spent evaluating the behavior of competitors in other states or other countries.

Overall, the interviews suggested that the biggest push to move to renewables comes from the top. Although they did not reveal *why* CEOs may harbor specific preferences, they did suggest that those preferences matter. Furthermore, they validated the presence of search space and identified the search practices of an industry pioneer. Intuition may have suggested that, because it was a first mover and lacked information about the industry, Company A wouldn't search. But it did, very broadly, because it could not rely on anyone else's information and was attempting something new and risky.

3.2.2 Company B

The interview with Company B took place on July 9, 2010. Although similar to Company A in many ways, it had a few key differences.

Like Company A, Company B was big, well performing, publicly owned, and geographically diversified. However, unlike Company A, Company B was not a pioneer in the renewable electricity industry. In fact, it only started investing in renewables to meet the RPS requirements after legislation had been passed. Interviews with the strategic planning division of Company B revealed that the main reason for its lukewarm response to renewables was the lack of financial viability of renewable electricity: The top management team did not view renewable electricity as a profitable opportunity to be pursued at the time. Because the company operated mostly in the southern United States, management believed that their most viable renewable option was "wind energy; however, given the current state of technology and electricity pricing, wind energy is still expensive compared to fossil fuels." In addition, wind energy loads (calculated by studying wind maps) "move in the same direction as fossil fuels and thus do not provide a benefit to their electricity portfolio." Finally, because of its location, Company B sold to a relatively poor customer base; the interviewees believed that their customers would not be willing to pay any sort of premium for clean electricity, making "renewables financially impossible." Company B did say that there was some pressure from shareholders to go green, but until the top management team found a strategy to make renewables profitable, it was unlikely to happen. One alternative the company considered was nuclear energy; the interviewees stated that Company B had nuclear assets that could be refurbished in order to meet the RPS requirements.

Company B's top management preferences were strongly reflected in its search behavior. For instance, while it chose to search for multiple types of information, its biggest search was for business information, for a way to make renewables profitable. Next, it searched with equal intensity for regulatory and

technological information. More interestingly, it relied quite heavily on external consultants to learn about the state of the industry before making any renewable investments. This may have been because the company lacked internal expertise about renewables, or because external consultants have more legitimacy when making decisions with uncertain outcomes. Company B utilized other external sources of information more extensively than Company A. These outside sources of information were both available and reliable because Company B started its search for information much later than Company A.

3.2.3 Company C

Company C was also interviewed in early July 2010. Unlike the first two companies, Company C was very small, non-diversified, and privately owned. Because of the state in which it was located and its small size, Company C was not required to meet any RPS requirements. However, because it was physically located close to a river, it had always been 100% green and provided hydroelectricity. In addition, the company management was local to the town where it was based and felt that being green was important to the town's well-being. Because Company C's electricity was not part of a grid, it focused on reliability. As hydroelectricity met this need, it felt no need to find an alternate source of electricity, with interviewees stating that it was unlikely that the company would expand into other renewables even if local demand were to increase. Company C seemed to be a company that had found a successful strategy for providing electricity and felt little need to devise new strategies for the future. In that respect it was markedly different from large, diversified, publicly owned companies that were constantly hedging for the future.

Company C's search behavior reflected the above preferences. For instance, while it did not engage in any search related to new market entry, a member of the company management did attend seminars and conferences and kept tabs on what competitors were doing. This focus on competitor actions was in sharp contrast to the majority of the industry, which claimed not to spend much time evaluating competitors. In addition, Company C also claimed to follow a "role-model" policy, mirroring the actions of model companies whose success it hoped to emulate. Finally, because of its small size and stable business conditions, Company C hired external consultants to learn more about the industry but did not do any research in-house; indeed, it felt that the cost of the latter was too high. Since Company C was not required to meet the RPS requirements, the main finding in the case—that Company C did very limited research, and no in-house research—is not surprising. However, it is surprising that it monitored its competitors, especially since this practice is not symptomatic of the industry.

3.2.4 Company D

Company D was interviewed in early November 2010. Like Company C, Company D was located in a state that had no RPS regulations; however, unlike Company C, Company D was owned by the state government. Its responses therefore help us extend the boundaries of the analysis and understand exactly how companies approach renewable electricity investments in the absence of regulatory pressure.

Like Company A, Company D was a pioneer in renewable electricity, both in its home state and across the country. This is surprising, given that Company D's home state still does not have an RPS requirement; in fact, at the time that it went green, in 2001, Company D had no idea RPS requirements would proliferate so rapidly across the United States. Since 2001, however, Company D has continued to include renewable projects in its activities. Interviewees offered two reasons for this. First, the board, which was somewhat independent from the state government, viewed sustainability as central to the company's mission. Second, because the company was state-owned, there was a sense of responsibility for the local environment: Company D felt strongly about keeping its state clean and green.

While Company D was in many ways similar to Company A, its search processes were quite different. Both companies searched for all types of information, but Company D hired external consultants who worked with its internal groups to gather information. Interviewees justified this approach by noting that they knew nothing about renewable electricity in the beginning and preferred to have "experts" tell them about their options before deciding. However, like the interviewees at Company A, they admitted to getting little useful information from looking at utility companies in other states and countries because the context was too dissimilar. Another difference was that Company D focused on finding the best technology for its renewable projects. Given that it did not face a regulatory hurdle and that being government-owned meant that it was less affected by competitive forces such as price changes or organizational pressure from board members who want big dividends, it makes sense that technology would outrank business and regulatory preferences for Company D.

Although this case is atypical for many reasons—it is a government-owned, pioneering company that does not need to be green—a quick comparison with the case of Company A highlights important potential similarities and differences among pioneering companies. In both cases, top managers' impetus to push the company in a particular direction led to a strategic change. What is truly surprising is that this seems to hold across different locations and ownership regimes.

3.2.5 Company E

Company E was interviewed in late November 2010 and again in March 2011. Company E was quite different from the other cases: It was a medium-sized, non-diversified, publicly owned company with below average performance. It was also located in a different part of the country than any of the other companies.

While Company E was not a pioneer in the industry, it did start investing in renewable electricity before legislation was passed. Its first renewable project was executed in conjunction with a local wind farm in 2003–2004, three years before RPS requirements in its state were passed. Its renewable projects have continued, but the company has become more focused on meeting RPS requirements. Interestingly, interviewees told us that designing projects to meet RPS standards was somewhat bureaucratic and less useful with regard to the company's overall mission to go green than the strategies it had previously employed.

Company E's original decision to go green was in line with its goals and mission. Since then, both shareholders and management have stayed true to this decision and continued pursuing renewable projects. However, in determining the company's strategic direction, company management is much more important, and the initial decision to invest in renewable energy came from them—they saw renewables as a growth opportunity and brought shareholders on board.

Company E's search process was very similar to Company D's: It was interested in finding the right technologies and using information from external consultants, feeling that it was safer to draw on expert knowledge rather than rely only on an internal group. A lack of internal knowledge would also explain the company's frustration with the bureaucratic and regulatory requirements of the RPS legislation: Managers and employees might have been especially unfamiliar with the legal code. Surprisingly, Company E did find information from the government to be somewhat useful. But in all other aspects, it generally designed an entry strategy with help from external consultants alone.

The five companies in these case studies vary in size, performance, diversification, geographic location, organizational structure, and the contents of their search space. Some companies were already active in renewables when they were interviewed, while others were not; some viewed RPSs and renewables positively and others negatively. These differences along with the three determinants of search highlight how companies approach search differently.

Table 2.1 Summary of organizational characteristics of cases

Case	Size	Geographic Diversification	Business Diversification	Performance	Pioneer
A	Big	Yes	Yes	Good	Yes, 2000s
B	Big	Yes	No	Good	No
C	V. Small	No	No	Good	Yes, but by default
D	Big	No	No	Medium	Yes, 2001
E	Medium	No	No	Bad	2004

Table 2.2 Summary of regulatory characteristics of cases

Case	Perception of RPS	Regulatory Knowledge	Relations w/ Government	Unregulated Assets	Search Amount	Facing RPS
A	Positive	Yes	Yes	Yes	Medium	Yes
B	Negative	Yes	Unknown	No	High	Yes
C	Neutral	No	No	No	V. Low	No
D	Positive	Yes	Yes	No	Low	No
E	Positive	Medium	No	No	Medium	Yes

4 What Determines the Size of Search Space?

Identifying search space is an important part of the search process with significant implications for understanding why firms choose local or distant solutions and the impact of those solutions on future performance. One important aspect of search space is its size: how broadly or narrowly firms search. The size of search space tells us how many of all possible solutions to a problem a firm is likely to consider, and it has implications for the firm's long-term trajectory, including R&D investments, new product development strategies, and long-term performance (Katila, 2002; Laursen, 2012; Leiponen and Helfat, 2010). Thus, we start by testing the conceptual model developed in the theory chapter to see whether and how much experience, uncertainty, and attention predict the size of search space.

Existing research on search suggests that some combination of competitive and environmental forces, organizational routines, and managerial characteristics affects how organizations search. Uncertainty and experience play central roles in driving local search across a variety of individual and organizational settings. Search also has cognitive drivers, which have been highlighted in work linking behavioral and evolutionary perspectives to examine the related effects of cognition (Eggers and Kaplan, 2008; Gavetti, 2005; Gavetti and Tripsas, 2000) and attention (Dutt and Joseph, 2019; Eggers and Kaplan, 2008; Ocasio, 1997; Ocasio and Joseph, 2005). We therefore focus on the impact of uncertainty, prior experience, and prior top managerial attention on the size of search space.

We use a basic conceptual framework to understand how top managers in U.S. electric utility firms solve problems. In the presence of uncertainty, organizations will identify multiple potential solutions (Fleming, 2001) to a maximum of N, where N is the universe of all possible solutions as defined by the problem. Boundedly rational organizations will identify search space by using routines to calculate the cost–benefit trade-off for each potential solution that they are aware of and believe can solve the problem at hand; only potential solutions that have the highest cost–benefit trade-off will be included in their search space. Because we are primarily interested in defining and understanding search space, we assume that all firms will solve problems according to this

framework. The main concepts, their definitions, and operationalizations can be found in **Table 4.1**.

Table 4.1 Concepts table

No.	Concept	Definition	Operationalization
1	Search space	Set of potential solutions identified when addressing a specific problem or opportunity	Set of potential renewable electricity projects considered; set of renewable trade groups joined
2	Uncertainty	A setting in which multiple aspects of that setting have the potential to change, but the likelihood of change is not known	Number of years until the RPS policy change deadline
3	Prior Top Managerial Attention	Top managers' focus on a new area, technology, or product	Count of words related to renewable electricity in the annual report from the prior year
4	Related Prior Experience	Prior knowledge, routines, and skills in a technological or product area that is closely linked in terms of routines to the specific problem being addressed	Total megawatts of renewable electricity that each firm has generated in the prior year

4.1 Research Questions

4.1.1 Uncertainty and Size of Search Space

Uncertainty about the future of the industry is likely to be the most critical factor leading firms to identify several alternatives in their search space rather than one, seemingly optimal, solution (Argote, 1982; Eggers, 2012; Fabrizio, 2012; Fleming, 2001; Hitsch, 2006; Levinthal and March, 1981; Tushman and Nelson, 1990). For our purposes, the nature of the uncertainty is such that multiple attributes of the focal problem may change, but the likelihood of change is not known (Knight, 1921).

There are two possible sources of uncertainty that may be relevant to search space: uncertainty about the costs and benefits of potential solutions (Fleming, 2001; Toh and Kim, 2012), and uncertainty about the problem (Dutt and Joseph, 2019; Eggers, 2012; Fabrizio, 2012; Knight, 1921).

First, because the costs and benefits of potential solutions depend on firms' prior experience with different solutions, we can assume that this type of uncertainty will differ across firms based on their prior experiences. This means that uncertainty about the costs and benefits of potential solutions is not a property of the problem being solved but a property of the firm solving the problem. To some extent, this source of uncertainty should be linked with prior experience and subsumed by the experience measure.

The second type of uncertainty, uncertainty in the problem, is best characterized as Knightian uncertainty (Knight, 1921). Organizations may know which aspects of the problem can change over time, but they do not know how the problem will change (the amount of renewable electricity may increase or decrease; the number of renewable electricity sources may increase or decrease) or when the problem will change (the law may change before the deadline). Because organizations do not know how and when the problem will change, they cannot assign probabilities to the likelihood of change. Thus, this is fundamentally a type of uncertainty, not risk.

Research on Knightian uncertainty suggests that an inability to assign probability distributions to factors that may change over time will limit decision-makers' ability to assign risk profiles. This may in turn reduce firms' reliance on quantitative analysis while increasing their reliance on qualitative analysis (Cyert and March, 1963). Furthermore, as Knightian uncertainty increases, the number of potential solutions considered should also increase to allow organizations to hedge for the future; instead of knowing which solution is optimal, organizations will consider multiple scenarios matching multiple solutions. Unlike pure uncertainty (where the decision-makers do not know what might change) and risk (which allows the probability distribution to be quantified), Knightian uncertainty allows firms to consider multiple different scenarios that are best addressed by different solutions, thereby increasing the total number of potential solutions considered.

The interviews discussed in the previous chapter confirm this trend anecdotally: U.S. electric utility executives acknowledged considering some renewable electricity sources solely to hedge for the future, as "anything could happen." Because identification of search space is a mechanism by which organizations solve problems, uncertainty in the problem (the third type) is most relevant for our argument. This logic leads to our first empirical expectation: Higher levels of Knightian uncertainty about the problem should be associated with an increase in the size of search space.

4.1.2 Prior Top Managerial Attention and Size of Search Space

Recent research exploring the cognitive underpinnings of behavioral mechanisms in organizations highlights the important role that top managers play in deciding where and how their organizations search (Gavetti and

Levinthal, 2000; Ocasio, 1997; Ocasio and Joseph, 2005; Zhu et al., 2020). There is a growing belief that organizations make key strategic choices based on the attention of their top managers (Dutton and Ashford, 1993; Ocasio, 2011). Top managerial attention, as defined by the attention-based view of the firm, combines both structural and cognitive elements that affect organizations' strategic actions (Eggers and Kaplan, 2008; Ocasio and Joseph, 2005). At a structural level, what Ocasio (1997:2) describes as "situated attention" depends on organizational characteristics such as rules, distribution of activities and resources, and the context in which top managers make decisions; at a cognitive level, what Ocasio (1997:2) calls "focus of attention" identifies discretionary choices top managers make when deciding what to focus on when making decisions (Barnett, 2008; Cho and Hambrick, 2006; Dutt and Joseph, 2019). We can therefore define top managerial attention as *top managers' focus on a new area, technology, or product*.

Top managers will attend to things that the firm has already done as well as new endeavors that the firm has not yet done. Empirically, we focus on new activities because we are trying to understand how firms discover new potential solutions to include in their search space. The experience construct should account for firms' prior knowledge, routines, and skills, especially regarding activities that have been completed. The example of Lou Gerstner and IBM illustrates how prior top managerial attention is distinct from things that the firm has already done.

After suffering big losses in 1993, IBM's board hired Gerstner as their new CEO. Gerstner's legacy at IBM was to refocus and transition IBM from hardware to a service-based firm. Gerstner's attention towards a service-based strategy led him to envision IBM as a services company, even though this strategy did not match the firm's existing experience as embodied by its organizational routines. We may never know why Gerstner was focused on a more service-oriented strategy. Yet we do know that his attention to this potential solution was a key input to IBM's strategy. Moreover, Gerstner's attention to a service-based strategy was, at least partly, independent from IBM's experience and routines—and instrumental in changing the course of IBM's strategic trajectory.

Existing work integrating evolutionary processes with behavioral mechanisms attributes strategic outcomes to cognitive drivers such as top managerial cognition and attention (Eggers and Kaplan, 2008; Gavetti and Levinthal, 2000; Ocasio, 2011). We focus on top managerial attention for two reasons. First, top managerial cognition often explains differences in interpretation of the problem (Barr et al., 1992; Porac and Thomas, 1990); our focus is on a context in which organizations are solving *the same problem* and thus we do not expect different interpretations of the problem to drive differences in search space. Although this is an assumption in our analysis, close examination of the renewable policy change suggests that firms have a vast

amount of experience with regulatory changes and understand policy changes clearly. Second, of the various cognitive elements at play, top managerial attention is responsible for decision-making that affects the identification of potential solutions (D Hambrick and Finkelstein, 1987; Hambrick and Mason, 1984). Top managerial attention is especially pertinent to this setting because firms are developing a new strategic area in their core industry where top managers' prior attention is crucial to guiding the firm's strategic direction (Cho and Hambrick, 2006; Eggers and Kaplan, 2008).

Existing research linking strategy with top managerial attention has demonstrated top managerial attention's impact on a variety of strategic outcomes, including strategic orientation (Bouquet and Birkinshaw, 2008), strategic change (Cho and Hambrick, 2006), and speed of entry into new markets (Eggers and Kaplan, 2008). These findings suggest that firm strategy is an outcome of things that top managers have been attending to, which typically are things that they consider important.

By applying the above mechanisms to renewable electricity, one expects firms' search spaces to reflect things that top managers consider important and, consequently, have been attending to. Top managers who consider renewable electricity to be an important future direction for the industry are likely to be more attentive to developments in the renewable electricity sector, such as knowing about more new technologies, compared with top managers who do not consider renewables important. Thus, when more attentive top managers face a problem related to renewable electricity, they will identify a greater number of potential solutions that their firm may not have used in the past simply because they have already been attending to new developments in the industry. Because these managers believe the new industry is important, they know more about renewable solutions and are not constrained by their firms' prior experience when identifying new potential solutions. They are therefore likely to identify a larger search space compared with less attentive managers. Conversely, top managers who have not been paying attention to renewable electricity will not know about potential solutions that their firm has not already used and are likely to identify a smaller search space.

Attention may also be considered a resource that top managers are using while maximizing the cost–benefit differential with respect to identifying potential solutions. Top managers who have been more attentive to the renewable electricity sector should incur a lower marginal cost for identifying each new potential solution in their search space, simply because they have already paid attention to and are aware of potential solutions. Conversely, top managers who have not been attentive to the renewable electricity sector are likely to incur a higher cost for identifying each new potential solution and are likely to identify a smaller search space.

4.1.3 Experience and Size of Search Space

Evolutionary research has focused on understanding how experience drives search choices (Agarwal et al., 2004; Agarwal and Helfat, 2009; Karim and Mitchell, 2000; Katila and Ahuja, 2002; Martin and Mitchell, 1998; Rosenkopf and Nerkar, 2001). By starting with the idea that organizations are likely to repeat routines from the past, especially when past routines have yielded successful outcomes, evolutionary scholars have put forth the idea of local search. Identified by Nelson and Winter (1982), local search is "a central assumption in evolutionary theory" (Rosenkopf and Nerkar, 2001:1), namely that an organization's current activities are closely related to its previous activities. Empirical studies across a range of industries, including the semiconductor industry, the optical disk industry, the magnetic resonance imaging industry, and the industrial robotics industry, have demonstrated the predominance of local search in directing search choices (Holbrook et al., 2000; Katila and Ahuja, 2002; Martin and Mitchell, 1998; Rosenkopf and Nerkar, 2001). In our setting, we define "related prior experience" as prior knowledge, routines, and skills in a technological or product area that is closely linked in terms of routines to potential solutions in the universe of solutions (Eisenhardt and Martin, 2000).

The idea of local search and prior experience driving search closely parallels March's notion of exploitation (March, 1991). Because organizations use already utilized routines, implementation costs of exploitation and local search are lower than those for new routines. Lower costs, when the benefits are expected to be the same for all potential solutions, make local search an attractive search strategy. For instance, when first developing a new product, firms may want to start by building on an existing product until they understand consumers' needs and willingness to pay for new products or new features in existing products. Under such conditions, entering a new market niche with an existing product—even if that product leads to an early exit—is a good strategy if it can result in gains of valuable product and consumer demand knowledge (Hitsch, 2006). Along these lines, we can understand why firms might favor potential solutions that they have already implemented over new potential solutions.

Based on the extensive body of research on local search, we expect prior experience with related activities to condition organizations to be prone to local search when they are identifying search space. Additionally, the amount of related prior experience should push organizations to identify search space even more locally; because highly experienced organizations tend to consider themselves experts on potential solutions they have used successfully, they will be reluctant to consider new or unsuccessful potential solutions. We can therefore expect a reduction in search space as firms gain more related prior

experience. Thus, the greater the related prior experience, the smaller the size of search space.

To summarize, in situations where firms face uncertainty about the features of the problem they are solving, they will draw upon top managerial attention and related prior experience to decide on their search space. Uncertainty about the problem and prior top managerial attention to the renewable sector *increases* the size of search space, while related prior experience *reduces* the size of search space. The mechanisms are slightly different for each factor. While uncertainty leads firms to employ a hedging strategy, prior top managerial attention increases managers' awareness of new potential solutions. Both increase the number of potential solutions considered by the firm.

More related prior experience, similar to local search, leads firms to capitalize on what they have used successfully in the past, decreasing the number of potential solutions considered. The review of existing evolutionary theory and related literatures on strategic change is included in Chapter 2. Thereafter, the theoretical framework informs the expectation that these three factors highlight the most important mechanisms that determine the size of search space.

4.1.4 Measures, Models, and Results[3]

The key focus of this study is search space. Thus, the analysis measures search space in two ways: first, via a survey administered to the majority of the firms in the U.S. utilities industry, and second, by tracking memberships of all the firms in the industry in technology trade groups. While the first measure is more precise—it gets answers from multiple members of each firm about specific projects the firm is considering starting—it is a single measure at one point in time. A project is the combination of a renewable electricity technology and generation method, that is, using solar, nuclear, hydro, wind, or biomass electricity and either self-generating the electricity, buying it from a third party, or doing both (this combination gives rise to ten potential solutions). The second measure of search space captures the time and money firms invest in learning about different technologies and its evolution over time. Together, these measures give us a comprehensive overview of the search spaces of firms in this industry.

To capture *uncertainty*, we need to account for the deadline by which firms must be compliant with the law. When the deadline is further in the future, there is a longer period of time during which the law may be amended (which frequently occurs in this setting), and hence a greater amount of uncertainty about when the policy may change. Measuring the number of words related to

[3] A more detailed description of the measures can be found in Appendix I.

renewable electricity technologies, that is, proper nouns in the annual report for the prior year for each electric utility for each year, captured *prior top managerial attention*. Finally, *related prior experience* measured the total megawatts of renewable electricity that each company generated in the prior year. Overall, these measures are consistent with the main concepts and are robust to sensitivity analyses (Dutt, 2013).

Firms might identify a larger or smaller search space for a number of reasons independent of uncertainty, prior top managerial attention, and related prior experience. The panel data analysis controlled for firm and year fixed effects and important time variant factors such as firm performance (net income), firm size (number of employees), the renewable electricity goal in each state in each year, whether the firm was in a state with a history of regulatory instability (Fabrizio, 2012), share of Democrats in the Senate, green sentiment in each state, and the price of electricity in the state in each year. Overall, the analysis accounted for several factors that could influence search space but kept the focus on uncertainty, prior top managerial attention, and related prior experience.

4.1.5 Results

Two sets of analyses tested the hypotheses predicting the size of search space. The first analysis was conducted on the cross-sectional survey data to test the impact of uncertainty, prior top managerial attention, and related prior experience on the size of search space. These can be found in **Table 4.2**. Next, the panel data analyses used both OLS regression for panel data and a count data model using panel-specific Poisson regression with robust standard errors clustered by firm, time dummies, and appropriate control variables. While the Poisson results were a better fit to the count data, the results were consistent with the OLS models and both supported the hypotheses. These can be found in Appendix III.

The results of the cross-sectional survey are most simply and clearly represented by the cross tabs in Table 4.2. The number of potential solutions in search space varies based on uncertainty, prior top managerial attention, and related prior experience. All three sets of cross tabs show significant (based on t-tests) differences between the high and low values of each variable, which are estimated by splitting the sample along the median. The magnitudes of the differences between high and low values of each explanatory variable are meaningful. Firms facing high uncertainty identified an average of 4.8 renewable electricity projects while those in states with low uncertainty on average only identified 3.1 projects. Firms with high prior top managerial attention identified 4.5 projects compared with 3.2 projects identified by firms with low prior top managerial attention. Firms with high related prior experience identified only 2.2 potential solutions while those with low related

prior experience identified 4.4 projects. These results provide support for our theory of how firms identify search space.

Table 4.2 Survey data cross tabulation results

	Search Space				
	Mean	Std. Dev	No. Obs.	Diff. in Means	T-Stat
Low Uncertainty	3.1	3.5	75	1.4*	2.17
High Uncertainty	4.5	4	20		

	Search Space				
	Mean	Std. Dev	No. Obs.	Diff. in Means	T-Stat
Low Attention	3.2	3.8	67	1.6**	5.06
High Attention	4.8	3.5	23		

	Search Space				
	Mean	Std. Dev	No. Obs.	Diff. in Means	T-Stat
Low Experience	4.4	3.7	52	2.2***	37.26
High Experience	2.2	2.95	27		

The results of the panel data similarly show consistent results when looking at how a firm's search space changes as uncertainty, prior top managerial attention, and related prior experience change. Based on the measures, the greater the number of years until the RPS deadline, the greater the number of trade group memberships held by a firm; more specifically, a one-year increase in the time until the deadline increases the size of search space by 1.53 memberships or 53%. Next, a one unit increase in prior top managerial attention for a specific firm over time increases the size of search space by 1.27 trade group memberships or 27%. Finally, a one unit increase in related prior experience for a firm over time reduces its likelihood of joining a trade group by 0.1 or roughly 10%. Comparing across the coefficients, uncertainty and prior top managerial

attention have bigger impacts on the size of search space for changes in a specific firm over time. In sum, these results indicate that firms with more time until the deadline are likely to have the most trade group memberships; firms with top managers that pay more attention to renewables are likely to be members of more trade groups; and firms with more prior experience providing renewable electricity to their customers are less likely to be members of renewable trade groups.

4.1.6 Robustness

Four robustness tests confirmed that when collecting the survey data, the concepts being measured aligned with the questions being asked. First, the survey was conducted in a heavily regulated industry using language that survey respondents were familiar with; this was done by enlisting the help of the Electric Power Research Institute (EPRI), which conducts regular surveys with utilities companies, in designing the survey. Second, the survey was rolled out incrementally to ensure that any problems in the pilot testing phase did not linger. Third, the one-on-one interviews that became the case studies in Chapter 3 were conducted in tandem with the survey to confirm that the concept of search space was being measured accurately; these interviews confirmed the validity of the setting and the clarity of the questions in the survey. Fourth, survey responses were tested for construct and response validity. As a result of these four robustness tests, the survey received a large number of responses (44% response rate), with multiple respondents from each firm with over ten employees (79% of the total sample).

4.1.7 Supplementary Results

Beyond uncertainty, experience, and top managerial attention, the RPS policy change is likely to be a big factor in pushing firms to consider fewer or greater numbers of renewable technologies in their search space. In additional analyses, in Appendix IV, the main independent variables were interacted with the RPS dummy and regressed on the total number of memberships in renewable trade groups to reveal whether the RPS policy change had a differential impact on how the three independent factors influenced the size of search space.

While uncertainty measures a feature of the RPS change that is external to the firm, attention and experience are internal. Here, the results are consistent with our expectations: Managerial attention towards renewables increased by one unit in the year prior to a firm facing the policy change and increased a

firm's likelihood of joining a trade group by 0.207 units or roughly 21%.[4] Although there does not seem to be a significant difference in the effect of attention before and after firms faced the policy change, and between firms facing the policy change and those that never faced the policy change, prior top managerial attention continued to have a positive impact on the size of search space.

At the same time, we see something different in how experience influences search space when we account for the presence of the RPS policy change. A one unit increase in experience affected their likelihood of joining a trade group by 0.207 units, that is, it reduced their likelihood of joining a new trade group by 21%. However, when we interact experience with the policy change, we see a positive association with joining a trade group. We decompose this by seeing how the likelihood of new memberships changed over the time period of the sample. In the years before the firm faced the policy change, a one unit increase in related prior experience had a negative association with a firm joining a trade group. If a firm never faced the policy change, the increasing experience had an even larger negative association with total memberships.[5] Meanwhile, for firms actively facing the regulation, there is a 22% increase in joining a trade group.

This suggests that the negative impact of experience on the size of search space is the smallest for firms facing the policy change. Rather, firms facing the policy are *more likely* to seek new knowledge even when they already possess some experience. This initially surprising result is important because it suggests a strategy by which experienced firms can search for new knowledge and mitigate the inherent path dependence that occurs as a result of gaining expertise (Arora and Ceccagnoli, 2006; Dutt and Mitchell, 2020; Gambardella et al., 2014; Karim and Mitchell, 2000; King and Tucci, 2002; Sydow et al., 2009). Upon reflection, this result seems intuitive: If firms are facing a shift outside their technology of comfort, and they have time before they must reach a certain level of competence, it seems plausible that they would take the time to learn more about new technologies before making expensive, long-term investments.

[4] Interestingly, when we test the attention model using a random effects model, the coefficients are bigger and more significant, suggesting that when it comes to understanding the policy change, differences across firms' attention are significant.

[5] All three studies also ran combined models with all three independent variables and interactions; while the results held for the OLS models, there were too many interactions for the Poisson model to hold, hence they were not included in the final results.

5 Discussion and Conclusions

Evolutionary scholars have long been interested in understanding how firms' search choices can generate long-term performance improvements (Helfat and Lieberman, 2002; King and Tucci, 2002). By implicitly assuming a homogeneous search space, scholars have focused on identifying differences in search processes, such as local and distant search, as drivers of firm performance (Helfat, 1994; Katila and Ahuja, 2002; Stuart and Podolny, 1996). These findings about the differential impact of search choices on firm performance have inspired a body of research aimed at understanding the conditions under which local and distant search are beneficial for firm performance. Yet, despite the importance of organizational search, and the volume of research on search choices, few studies have explicitly articulated or empirically tested variations in how firms identify different search spaces.

This book makes two important contributions. First, by explicitly defining search space and demonstrating differences in search spaces across firms in the same setting facing the same problem, it shows that search space does indeed vary even within a narrow context. Combined with research showing the initial choices of search affect performance outcomes (Dutt, 2022; Katila, 2002; Koçak et al., 2022; Lampert and Semadeni, 2010; Laursen, 2012; Levinthal and March, 1981), it clarifies the emergence of an important starting condition of search. The results of the study in Chapter 4 suggest that firms start searching by considering different sets of potential solutions that are likely to affect later search activities. For instance, based on the potential solutions in their search space, firms may decide to choose a local or distant solution. Second, this research also operationalizes important concepts including search space, uncertainty, and related prior experience, which follow directly from Nelson and Winter (1982) and can be applied in empirical settings to test evolutionary theories at the organizational level.

For policy makers, the results highlight many relevant findings. First, variation in the time until firms must meet the RPS deadline has a significant association with a larger search space. This is consistent with existing research on parallel search processes and research on regulatory uncertainty, which

would suggest that under uncertainty, firms are likely to employ a hedging strategy (Fabrizio, 2012). If policy makers want to push firms to explore multiple technologies, some uncertainty in the policy may allow even experienced firms to develop new solutions that would be good for innovation within the industry. Similarly, finding ways to push top managers to pay attention to new technologies has a positive impact on the size of search space. This finding further extends existing research by showing that attention has an independent effect from experience on the size of search space. More research is needed to understand the exact mechanisms by which managerial attention affects firms' search spaces. In general, the link between cognitive and evolutionary mechanisms, such as top managerial attention and search processes, has not been sufficiently explored. This book takes a step towards understanding how these two important aspects of firm behavior affect search or problem solving by presenting a conceptual framework and baseline results to inform future research.

The supplementary results support proposals by scholars linking local search with search outcomes and add to this body of research. First, we see that even when identifying search space in a new area, firms have an overwhelming tendency towards local search. When firms possess related prior experience in the form of related routines, they are less likely to seek new knowledge, for example by joining new renewable trade groups. Second, this tendency towards local search is constrained when firms are solving a cogent problem that is outside their realm of expertise (Dutt and Mitchell, 2020). Existing research on RPS policy suggests that policy changes are determined by policy makers in conjunction with the needs of local utilities; perhaps we should perceive RPS change not as a problem, but instead as an opportunity for firms to build renewable assets (Fremeth and Marcus, 2011; Lyon and Yin, 2010). This may mean that one way in which firms can add to their knowledge base is by searching for solutions to address a new opportunity, even if they have no immediate need to identify new opportunities. For policy makers, these results suggest one strategy by which firms can be pushed to innovate outside their areas of expertise: negotiate with firms and design a policy that provides them with opportunities so that they want to push innovation and the development of new technology. Future work can test the impact of different types of problems and opportunities, including different types of policy changes, on search space.

References

Agarwal, R., Echambadi, R., Franco, A.M., Sarkar, M.B., 2004. Knowledge transfer through inheritance: spin-out generation, development, and survival. Academy of Management Journal 47, 501–522.

Agarwal, R., Helfat, C.E., 2009. Strategic renewal of organizations. Organization Science 20, 281–293.

Argote, L., 1982. Input uncertainty and organizational coordination in hospital emergency units. Administrative Science Quarterly 27, 420–434.

Arora, A., Ceccagnoli, M., 2006. Patent protection, complementary assets, and firms' incentives for technology licensing. Management Science 52, 293–308.

Baer, M., Dirks, K.T., Nickerson, J.A., 2013. Microfoundations of strategic problem formulation. Strategic Management Journal 34, 197–214.

Barbose, G., 2021. U.S. renewables portfolio standards 2021 status update: early release. NREL (National Renewable Energy Laboratory (NREL), Golden, CO (United States)).

Barnett, M.L., 2008. An attention-based view of real options reasoning. Academy of Management Review 33, 606–628.

Barr, P.S., Stimpert, J.L., Huff, A.S., 1992. Cognitive change, strategic action, and organizational renewal. Strategic Management Journal 13, 15–36.

Berchicci, L., Dutt, N., Mitchell, W., 2019. Knowledge sources and operational problems: less now, more later. Organization Science 30, 1030–1053.

Bird, L., Bolinger, M., Gagliano, T., Wiser, R., Brown, M., Parsons, B., 2005. Policies and market factors driving wind power development in the United States. Energy Policy 33, 1397–1407.

Bouquet, C., Birkinshaw, J., 2008. Weight versus voice: how foreign subsidiaries gain attention from corporate headquarters. Academy of Management Journal 51, 577–601.

Carley, S., 2009. Distributed generation: an empirical analysis of primary motivators. Energy Policy 37, 1648–1659.

Carley, S., Davies, L.L., Spence, D.B., Zirogiannis, N., 2018. Empirical evaluation of the stringency and design of renewable portfolio standards. Nature Energy 3, 754–763.

Cho, T.S. and Hambrick, D.C., 2006. Attention as the mediator between top management team characteristics and strategic change: the case of airline deregulation. Organization science, 17(4), 453–469.

Costello, K., 2016. A primer on R&D in the energy utility sector (No. 16/05). National Regulatory Research Institute, Silver Spring, MD.

Cyert, R.M. and March, J.G., 1963. A behavioral theory of the firm. Prentice-Hall.

Dahlander, L., O'Mahony, S., Gann, D.M., 2016. One foot in, one foot out: how does individuals' external search breadth affect innovation outcomes? Strategic Management Journal 37, 280–302.

Dutt, N., 2022. Knowledge search and learning in sustainability practices: array. Sinergie Italian Journal of Management 40, 35–50.

Dutt, N., 2013. Identifying search space (Doctoral dissertation, Duke University).

Dutt, N., Cunningham, C.M., 2015. Regulatory uncertainty and firm response in the US electricity industry. In Academy of Management Proceedings (Vol. 2015, No. 1, p. 13490). Briarcliff Manor, NY 10510: Academy of Management.

Dutt, N., Joseph, J., 2019. Regulatory uncertainty, corporate structure, and strategic agendas: evidence from the U.S. renewable electricity industry. Academy of Management Journal 62, 800–827.

Dutt, N., Lawrence, M., 2022. Learning to manage breadth: experience as repetition and adaptation. Organization Science, 33(4), 1300–1318.

Dutt, N., Mitchell, W., 2020. Searching for knowledge in response to proximate and remote problem sources: evidence from the U.S. renewable electricity industry. Strategic Management Journal 41, 1412–1449.

Dutton, J.E., Ashford, S.J., 1993. Selling issues to top management. Academy of Management Review 18, 397–428.

Eggers, J.P., 2012. Falling flat: failed technologies and investment under uncertainty. Administrative Science Quarterly 57, 47–80.

Eggers, J.P., Kaplan, S., 2009. Cognition and renewal: comparing CEO and organizational effects on incumbent adaptation to technical change. Organization Science 20(2), 461–477.

EIA (Energy Information Administration), 2013. Electric power annual 2012. U.S. Department of Energy, Washington D.C.

Eisenhardt, K.M., Graebner, M.E., 2007. Theory building from cases: opportunities and challenges. Academy of Management Journal 50, 25–32.

Eisenhardt, K.M., Martin, J.A., 2000. Dynamic capabilities: what are they? Strategic Management Journal 21, 1105–1121.

Fabrizio, K.R., 2012. The effect of regulatory uncertainty on investment: evidence from renewable energy generation. Journal of Law, Economics, and Organization 29, 765–798.

Felin, T., Zenger, T.R., 2014. Closed or open innovation? Problem solving and the governance choice. Research Policy, Open Innovation: New Insights and Evidence 43, 914–925.

Fiegenbaum, A., Thomas, H., 1995. Strategic groups as reference groups: theory, modeling and empirical examination of industry and competitive strategy. Strategic Management Journal 16, 461–476.

Fleming, L., 2001. Recombinant uncertainty in technological search. Management Science 47, 117–132.

Foss, N., Frederiksen, L., Rullani, F., 2016. Problem-formulation and problem-solving in self-organized communities: how modes of communication shape project behaviors in the free open-source software community. Strategic Management Journal 37, 2589–2610.

Fremeth, A.R., Marcus, A.A., 2011. Institutional void and stakeholder leadership: Implementing renewable energy standards in Minnesota. Stakeholders and Scientists: Achieving Implementable Solutions to Energy and Environmental Issues, 367–392.

Fremeth, A.R., Shaver, J.M., 2014. Strategic rationale for responding to extra-jurisdictional regulation: evidence from firm adoption of renewable power in the US. Strategic Management Journal 35, 629–651.

Gambardella, A., Ganco, M., Honoré, F., 2014. Using what you know: patented knowledge in incumbent firms and employee entrepreneurship. Organization Science 26, 456–474.

Ganco, M., Agarwal, R., 2009. Performance differentials between diversifying entrants and entrepreneurial start-ups: a complexity approach. Academy of Management Review 34, 228–252. https://doi.org/10.5465/amr.2009.36982618

Gavetti, G., 2011. Perspective: toward a behavioral theory of strategy. Organization Science 23, 267–285.

Gavetti, G., 2005. Cognition and hierarchy: rethinking the microfoundations of capabilities' development. Organization Science 16, 599–617.

Gavetti, G., Levinthal, D., 2000. Looking forward and looking backward: cognitive and experiential search. Administrative Science Quarterly 45, 113–137.

Greve, H.R., Taylor, A., 2000. Innovations as catalysts for organizational change: shifts in organizational cognition and search. Administrative Science Quarterly 45, 54–80.

Gupta, A.K., Govindarajan, V., Wang, H., 2008. The quest for global dominance: transforming global presence into global competitive advantage. John Wiley & Sons.

Hambrick, D.C., Finkelstein, S., 1987. Managerial discretion: a bridge between polar views of organizational outcomes. Research in organizational behavior.

Hambrick, D.C., Mason, P.A., 1984. Upper echelons: the organization as a reflection of its top managers. Academy of Management Review 9, 193–206.

Helfat, C.E., 1994. Evolutionary trajectories in petroleum firm R&D. Management Science 40, 1720–1747.

Helfat, C.E., Lieberman, M.B., 2002. The birth of capabilities: market entry and the importance of pre-history. Industrial and Corporate Change 11, 725–760.

Hitsch, G.J., 2006. An empirical model of optimal dynamic product launch and exit under demand uncertainty. Marketing Science 25, 25–50.

Holbrook, D., Cohen, W.M., Hounshell, D.A., Klepper, S., 2000. The nature, sources, and consequences of firm differences in the early history of the semiconductor industry. Strategic Management Journal 21, 1017–1041.

Jacobides, M.G., Winter, S.G., 2012. Capabilities: structure, agency, and evolution. Organization Science 23, 1365–1381.

Jacobides, M.G., Winter, S.G., 2005. The co-evolution of capabilities and transaction costs: explaining the institutional structure of production. Strategic Management Journal 26, 395–413.

Jeppesen, L.B., Lakhani, K.R., 2010. Marginality and problem-solving effectiveness in broadcast search. Organization Science 21, 1016–1033.

Kaplan, S., Tripsas, M., 2008. Thinking about technology: Applying a cognitive lens to technical change. Research Policy 37, 790–805.

Karim, S., Mitchell, W., 2000. Path-dependent and path-breaking change: reconfiguring business resources following acquisitions in the U.S. medical sector, 1978–1995. Strategic Management Journal 21, 1061–1081.

Katila, R., 2002. New product search over time: past ideas in their prime? Academy of Management Journal 45, 995–1010.

Katila, R., Ahuja, G., 2002. Something old, something new: a longitudinal study of search behavior and new product introduction. Academy of Management Journal 45, 1183–1194.

King, A.A., Tucci, C.L., 2002. Incumbent entry into new market niches: the role of experience and managerial choice in the creation of dynamic capabilities. Management Science 48, 171–186.

Knight, F., 1921. Risk, uncertainty and profit, 1st ed. Boston, MA: Hart, Schaffner & Marx; Houghton Mifflin Co.

Koçak, Ö., Levinthal, D.A. and Puranam, P., 2022. The dual challenge of search and coordination for organizational adaptation: how structures of influence matter. Organization Science.

Kulchina, E., 2014. Media coverage and location choice. Strategic Management Journal 35(4), 596-605.

Lampert, C.M. and Semadeni, M., 2010, August. Search breadth and the cost of search. In Academy of Management Proceedings (Vol. 2010, No. 1, 1-6). Briarcliff Manor, NY 10510: Academy of Management.

Laursen, K., 2012. Keep searching and you'll find: what do we know about variety creation through firms' search activities for innovation? Industrial and Corporate Change 21, 1181–1220.

Leiponen, A., 2005. Organization of knowledge and innovation: the case of Finnish business services. Industry and Innovation 12, 185–203.

Leiponen, A., Helfat, C.E., 2010. Innovation objectives, knowledge sources, and the benefits of breadth. Strategic Management Journal 31, 224–236.

Levinthal, D., March, J.G., 1981. A model of adaptive organizational search. Journal of Economic Behavior & Organization 2, 307–333. https://doi.org/10.1016/0167-2681(81)90012-3

Levinthal, D.A., Warglien, M., 1999. Landscape design: designing for local action in complex worlds. Organization Science 10, 342–357.

Lyon, T.P., Yin, H., 2010. Why do states adopt renewable portfolio standards? An Empirical Investigation. Energy Journal 31, 133–157.

MacDuffie, J.P., 1997. The road to "root cause": shop-floor problem-solving at three auto assembly plants. Management Science 43, 479–502.

March, J.G., 1991. Exploration and exploitation in organizational learning. Organization Science 2, 71–87.

Martin, X., Mitchell, W., 1998. The influence of local search and performance heuristics on new design introduction in a new product market. Research Policy 26, 753–771. https://doi.org/10.1016/s0048-7333(97)00037-1

Massini, S., Lewin, A.Y., Greve, H.R., 2005. Innovators and imitators: organizational reference groups and adoption of organizational routines. Research Policy 34, 1550–1569.

McFadden, D., 1973. Conditional logit analysis of qualitative choice behavior. Frontiers in Econometrics 105–142.

Nelson, R.R., Winter, S.G., 1982. An evolutionary theory of economic change. Cambridge, MA: Harvard University Press.

Ocasio, W., 2011. Attention to attention. Organization Science 22, 1286–1296.

Ocasio, W., 1997. Towards an attention-based view of the firm. Strategic Management Journal 18, 187–206.

Ocasio, W., Joseph, J., 2005. An attention-based theory of strategy formulation: linking micro- and macroperspectives in strategy processes. London: Emerald Group Publishing.

Payne, J.W., Bettman, J.R., Johnson, E.J., 1988. Adaptive strategy selection in decision making. Journal of Experimental Psychology: Learning, Memory, and Cognition 14, 534–552.

Porac, J.F., Thomas, H., 1990. Taxonomic mental models in competitor definition. Academy of Management Review 15, 224–240.

Posen, H.E., Keil, T., Kim, S. and Meissner, F.D., 2018. Renewing research on problemistic search—A review and research agenda. Academy of Management Annals, 12(1), 208–251.

Rivkin, J.W., Siggelkow, N., 2002. Organizational sticking points on NK Landscapes. Complexity 7, 31–43.

Roberts, J.H., Lattin, J.M., 1991. Development and testing of a model of consideration set composition. Journal of Marketing Research 28, 429–440.

Rockart, S.F., Dutt, N., 2015. The rate and potential of capability development trajectories. Strat. Mgmt. J. 36, 53–75.

Rosenkopf, L., Nerkar, A., 2001. Beyond local search: boundary-spanning, exploration, and impact in the optical disk industry. Strategic Management Journal 22, 287–306.

Siggelkow, N., Levinthal, D.A., 2005. Escaping real (non-benign) competency traps: linking the dynamics of organizational structure to the dynamics of search. Strategic Organization 3, 85–115.

Siggelkow, N., Rivkin, J.W., 2006. When exploration backfires: unintended consequences of multilevel organizational search. Academy of Management Journal 49, 779–795.

Snihur, Y., Wiklund, J., 2019. Searching for innovation: product, process, and business model innovations and search behavior in established firms. Long Range Planning 52, 305–325. https://doi.org/10.1016/j.lrp.2018.05.003

Stuart, T.E., Podolny, J.M., 1996. Local search and the evolution of technological capabilities. Strategic Management Journal 17, 21–38.

Sydow, J., Schreyögg, G., Koch, J., 2009. Organizational path dependence: opening the black box. Academy of Management Review 34, 689–709.

Toh, P.K., Kim, T., 2012. Why put all your eggs in one basket? A competition-based view of how technological uncertainty affects a firm's technological specialization. Organization Science 24, 1214–1236.

Tripsas, M., Gavetti, G., 2000. Capabilities, cognition, and inertia: evidence from digital imaging. Strategic Management Journal 21, 1147–1161.

Tushman, M.L., Nelson, R.R., 1990. Introduction: technology, organizations, and innovation. Administrative Science Quarterly 35, 1–8.

von Hippel, E., von Krogh, G., 2015. CROSSROADS—Identifying viable "need–solution pairs": problem solving without problem formulation. Organization Science 27, 207–221.

Wiser, R., Namovicz, C., Gielecki, M., Smith, R., 2007. The experience with renewable portfolio standards in the United States. The Electricity Journal 20, 8–20.

Zhu, Q., Hu, S., Shen, W., 2020. Why do some insider CEOs make more strategic changes than others? The impact of prior board experience on new CEO insiderness. Strategic Management Journal 41, 1933–1951.

Appendix I: Measures

Dependent Variable: Size of Search Space

Number of Potential Projects: The first measure of the size of search space is the number of potential renewable electricity projects considered by each firm. In this setting, we define a project as the combination of a renewable electricity technology and generation method, that is, either using solar, nuclear, hydro, wind, or biomass electricity and either self-generating the electricity, buying it from a third party, or doing both (this combination gives rise to ten potential solutions). These data were collected via a multi-respondent survey of all 223 U.S. electric utility firms (99 firms, 44% of the industry, responded), as described in Chapter 4, and are an excellent operationalization of the conceptual definition of search space.

Number of Renewable Trade Groups: The second measure of the size of search space is the number of renewable electricity trade group memberships for each firm from 2000 through 2010. There are five possible trade groups: solar, nuclear, hydro, biomass, and wind. Because trade group memberships cost an annual fee and reflect time and energy on the part of a firm to interact with stakeholders in its community and supply chain, the decision to join and stay in a trade group reflects actions taken by a firm towards understanding potential renewable electricity solutions.

Independent Variables

Uncertainty: This variable is measured as the amount of time in years until the RPS deadline. Although the RPS legislation stipulates which electricity technologies qualify as renewable, how much renewable electricity must be provided, and the deadline by which the renewable electricity goals must be met, there have been amendments to the law in 22 of 29 states. When the deadline is further in the future, there is a longer period of time during which the law may be amended, and hence a greater amount of uncertainty in terms of when and

how the policy may change. Because RPS policy articulates different requirements that electric utilities must meet, there are essentially four potential types of changes: (1) expanding the different possible renewable electricity sources, (2) changing or introducing an annual requirement, (3) extending the deadline, and (4) introducing a quota for solar or some other renewable source. By definition, this variable only exists for electric utilities facing the RPS policy change; electric utilities not facing the regulation are assumed to identify search space in the absence of uncertainty about the problem.

Prior Top Managerial Attention: This variable measures the number of words related to renewable electricity in the annual report for the prior year for each electric utility. This is a commonly used measure of top managerial attention and captures the conceptual definition: attention that top managers focus on the renewable electricity sector. These data were collected by downloading annual reports from the SEC database and conducting text analysis using the program "Atlas.ti." First, annual reports for all years for all firms were downloaded. Next, uploading batches of files to "Atlas.ti" generated word counts for all the words in each annual report. We then counted all the words corresponding to each of five major renewable electricity sources: solar, biomass, nuclear, hydro, and wind. We conducted sensitivity analyses by including other terms related to the policy change, such as renewable, portfolio standards, and legislation, and found consistent results.

Related Prior Experience: This variable measures the total megawatts of renewable electricity that each company generated in the prior year, that is, the cumulative expertise that each electric utility has in providing renewable electricity to its customers. This variable is coded from archival information about each company from Platts.

RPS Dummy: This variable is coded as 1 in the years in which the state had passed the policy change and the years after; it is 0 in the years before the policy change and -1 for all years in states where the policy change was never passed. Because this variable differs for each state-year, it is distinct from a time trend and a state fixed effect and helps tease out the effect of the policy change on firms' search space. We found consistent results when we coded this variable to include states with voluntary RPS goals, and as a 0–1 dummy variable.

Control Variables

Firms might identify a larger search space for a number of reasons independent of uncertainty, prior top managerial attention, and related prior experience. The

panel data analysis controlled for firm and year fixed effects and important time variant factors that may impact the size of search space.

Performance: Better-performing firms might have the means to conduct a bigger search. Conversely, firms that have been successful in the past might put less effort into searching for information regarding new technologies. In either case, controlling for each company's net income in the prior year limited the impact of prior performance on search space.

Size: Since larger firms may need to make larger financial investments to generate the same percentage of renewable electricity as smaller firms, it is reasonable to expect that these firms may gather more information and identify a larger search space. To control for any impact on search space, we controlled for the number of employees in the prior year for each firm.

Renewable Electricity Requirement: It is reasonable to expect that utility firms' search space will differ based on the amount of renewable electricity required by the policy change. Hence, we controlled for the percentage of renewable electricity required by each state in each year.

Repeal Dummy: Similarly, electric utilities located in states with a history of regulatory change are less likely to commit resources to meeting the policy change (Fabrizio, 2012) and are less likely to consider a larger number of potential solutions in their search spaces. Hence, we used a dummy variable to control for the history of regulatory repeal in each state.

Percentage Democrats: One might expect states with a higher percentage of Democrats in the senate to respond differently to the regulation than other states. We controlled for the percentage of Democrats in the state legislature in each year.

Appendix II: Panel Data Descriptive Statistics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Membership in Ren. Groups	1											
Related Prior Experience	0.09	1										
Top Managerial Attention	0.28	0.02	1									
Uncertainty	0.23	0.05	0.36	1								
RPS Dummy	0.04	0.77	0.06	0.03	1							
Performance	0.20	0.10	0.08	0.33	0.07	1						
Size	0.18	0.02	0.04	0.36	0.05	0.53	1					
Renewable Requirement	0.08	0.65	0.09	0.04	0.65	0.06	0.03	1				
Repeal Dummy	0.10	0.08	0.06	0.06	0.06	0.02	0.11	0.10	1			
Percent of Democrats	-0.01	0.31	0.02	0.08	0.29	0.07	0.02	0.46	0.03	1		
No. of Sierra Club Members	0.11	0.25	0.03	0.12	0.26	0.16	0.19	0.19	0.42	0.11	1	
Average Price of Electricity	0.01	0.35	0.05	0.07	0.49	0.08	0.01	0.64	0.01	0.51	0.24	1
Mean	0.9	0	0	0	0.2	301.9	1	0.1	0.1	0.5	18715.7	8.8
S.D.	0.9	0	0	0	0.9	4.7	1.3	0.1	0.3	0.1	27783.8	3.2
Min	0.0	0.8	0.9	0.5	1.0	-0.3	-5	0	0	0.1	470	4.2
Max	4.0	0.3	0.2	0.2	0	6692.8	5	0.5	0	0.9	175000	29.2

Appendix III: Panel Data Main Results

DV: Total Memberships	OLS				POISSON			
	H1	H2	H3	ALL	H1	H2	H3	ALL
Uncertainty	0.447***			0.403***	0.426***			0.382***
	(0.0759)			(0.0641)	(0.120)			(0.109)
Attention		0.201***		0.185***		0.236**		0.197*
		(0.0580)		(0.0523)		(0.111)		(0.105)
Experience			-0.113**	-0.136***			-0.0994***	-0.109***
			(0.0512)	(0.0464)			(0.0382)	(0.0317)
Performance	0.000100*	8.81e-05	8.76e-05*	0.000107**	6.15e-05	5.83e-05	4.15e-05	7.38e-05
	(5.19e-05)	(5.46e-05)	(5.21e-05)	(5.15e-05)	(4.34e-05)	(4.99e-05)	(3.86e-05)	(4.76e-05)
Size	-0.0517	0.0738	-0.129	-0.0845	0.127	0.170	0.0958	-0.00879
	(0.0909)	(0.0820)	(0.108)	(0.106)	(0.202)	(0.187)	(0.207)	(0.194)
Renewable Requirement	-0.339	-0.585	0.376	-0.760	-0.595	-0.708	5.08e-05	-1.044
	(1.076)	(1.270)	(1.281)	(1.154)	(1.251)	(1.404)	(1.415)	(1.237)

DV: Total Memberships	OLS				POISSON			
	H1	H2	H3	ALL	H1	H2	H3	ALL
RPS Dummy	-0.997***	0.119	-0.107	-0.737**	-0.984**	0.0943	-0.0881	-0.731*
	(0.285)	(0.289)	(0.286)	(0.300)	(0.400)	(0.319)	(0.328)	(0.390)
No. Sierra Club Members	-2.10e-05**	-1.62e-05**	-1.97e-05***	-2.76e-05***	-1.02e-05**	-1.68e-06	-2.44e-06	-1.05e-05**
	(9.70e-06)	(8.05e-06)	(6.92e-06)	(6.67e-06)	(4.48e-06)	(5.32e-06)	(5.06e-06)	(4.77e-06)
Price of Electricity	-0.0523**	-0.0461*	-0.0660*	-0.0395*	-0.0618	-0.0246	-0.0448	-0.0376
	(0.0221)	(0.0268)	(0.0334)	(0.0209)	(0.0418)	(0.0396)	(0.0448)	(0.0399)
Year Indicators	YES	YES	YES	YES	YES	YES	YES	YES
Observations	1,118	1,030	1,074	973	899	862	875	818
R-Squared	0.379	0.339	0.336	0.430				
No. Companies	112	112	108	106	87	88	83	82

Robust standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1

Appendix IV: Panel Data Results with Policy Change (RPS Dummy = 0, 1)

DV: Total Memberships	OLS			POISSON		
	H1	H2	H3	H1	H2	H3
Uncertainty	0.402***			0.362***		
	(0.0843)			(0.112)		
Attention		0.0924			0.161	
		(0.0679)			(0.111)	
Experience			-0.207***			-0.163***
			(0.0630)			(0.0333)
Attention*RPS		0.207**			0.149	
		(0.102)			(0.165)	
Experience*RPS			0.220**			0.119
			(0.0845)			(0.0801)
RPS Dummy	-0.952***	-0.0149	-0.0667	-0.935***	-0.0955	-0.123
	(0.222)	(0.108)	(0.109)	(0.302)	(0.130)	(0.106)
Performance	8.43e-05*	7.72e-05	6.74e-05	4.79e-05	4.60e-05	3.19e-05
	(4.98e-05)	(4.89e-05)	(4.14e-05)	(4.08e-05)	(4.64e-05)	(3.13e-05)
Size	-0.0175	0.0733	-0.0444	0.150	0.162	0.134
	(0.0876)	(0.0755)	(0.101)	(0.206)	(0.190)	(0.199)

Year Indicators	YES	YES	YES	YES	YES	YES
Obervations	1,171	1,083	1,127	934	897	910
R-Squared	0.351	0.338	0.333			
No. Companies	117	117	113	90	91	86

Robust standard errors clustered by firm in parentheses; *** p<0.01, ** p<0.05, * p<0.1