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# Configuration of Value Chain Activities: The Effect of Pre-Entry Capabilities, Transaction Hazards, and Industry Evolution on Decisions to Internalize

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We integrate insights from organizational capabilities, organizational economics, and industry evolution to examine industry entrants' boundary choices about value chain activities and test hypotheses in 1978–2009 data from a sample of U.S. bioethanol producers. We find support for our predictions that transaction hazards, decomposed as either enduring or transient over the stages of industry evolution, are positively associated with the choice to internalize value chain activities. Pre-entry experience in an activity increases the likelihood of its internalization and reduces the effect of enduring transaction hazards on the internalization choice. Importantly, we also distinguish between firm- and founder-level pre-entry capabilities (that is, the capabilities of firms versus those of founders). Diversifying entrants with firm-level integrative capabilities are more likely to internalize value chain activities than start-ups, and this effect persists over the industry's life cycle. The relationship between pre-entry experience with an activity and the likelihood of internalizing it is also stronger for diversifying entrants. Findings improve understanding of the relationships among capability development, boundary choice, and industry evolution.

*Key words*: pre-entry experience; value chain activity; governance choice; industry evolution
*History*: Published online in *Articles in Advance*.

## Introduction

Whether entry into an industry is undertaken by a diversifying entrant or a start-up,[1] a critical strategic question is the configuration of value chain activities, which include procurement, production, marketing and distribution, and technology development (Porter 1985). Firms vary in the extent to which they choose to conduct these activities within organizational boundaries. Given trade-offs between incurring resource commitments for internalization and transaction hazards for external sourcing, organizational choices about value chain activities are of strategic importance to entrants that may lack experiential knowledge, either within or outside the focal industry context.

Balancing the trade-offs involved in optimal organizational choices about value chain activities at the time of entry is critical for several reasons. First, to ensure efficient production, a firm needs to design a system of activities that accounts for both complementarities and substitution effects (Milgrom and Roberts 1995, Porter 1991). Second, the firm's development of industry-specific bundles of resources and capabilities after entry is path dependent (Dierickx and Cool 1989), with the initial design setting the trajectory for long-term capability development (Helfat and Peteraf 2003). Decisions made at entry are likely to create differences in competitive advantages not just then but also over time. Given the strategic importance of initial design of value chain activities, we examine the following research question: What factors determine how a firm configures value chain activities when entering a new industry? Specifically, what are the main and moderating effects of transaction hazards and pre-entry organizational capabilities on the choice between internalization and external development of a value chain activity?

We draw on the organizational economics, organizational capabilities, and industry evolution literatures to address the above question. In doing so, we build on an insightful set of studies that have started to integrate the three bodies of research. In organizational economics, a dynamic view of transaction costs enables examining a firm's boundary decisions while incorporating both firm

evolution (Argyres and Liebeskind 1999) and industry evolution (Argyres and Bigelow 2007, 2010; Bigelow and Argyres 2008; Jacobides and Winter 2005). Similarly, in the organizational capabilities literature, scholars have begun to examine how relational capabilities (Hoetker 2005) or productive capabilities (Jacobides and Hitt 2005, Leiblein and Miller 2003, Walker and Weber 1984) explain boundary choices. Empirical evidence from these two research streams shows that firm and industry evolution both matter and that a firm's capabilities also play an important role in its boundary choices. No study has, however, to the best of our knowledge, examined all three sets of factors together.

The strategic importance of value chain organization for industry entrants and the potentially fruitful theoretical integration of organizational economics, organizational capabilities, and industry evolution literature motivate the current study. The make-or-buy logic from transaction costs theory (Coase 1937; Williamson 1975, 1985) is clearly applicable; substantial transaction costs cause firms to internalize an activity, other things being equal. Transaction hazards, however, may be either transient or enduring. Stigler (1951) argued that as industries mature, markets become increasingly efficient. Thus, as industries evolve, reductions in technological and demand uncertainty and in asset specificity can lower market frictions. Furthermore, to the extent that capabilities and resources affect the above ceteris paribus assumption regarding the effect of transaction costs on internalization, insights from the resource-based approach (Barney 1991, Penrose 1959, Wernerfelt 1984) and the dynamic capabilities view (Helfat et al. 2007, Teece et al. 1997) are relevant. Indeed, acknowledging that firms' capabilities and transaction costs tend to intertwine and that the perspectives focusing on these phenomena can be complementary, Langlois and Foss (1999) called for more integrative efforts. Similarly, Williamson (1999, p. 1103) rephrased the original make-or-buy question as, "How should firm A—which has preexisting strengths and weaknesses (core competence and disabilities)—organize *X*?" An unresolved question here is, what types of firm capabilities may intertwine with transaction characteristics, and in what way?

Although the evolution of firm capabilities from inception and resulting firm have been the foci of the dynamic resource-based framework (Helfat and Peteraf 2003), not all firms entering an industry are start-ups. Helfat and Lieberman (2002), drawing from the industry evolution literature (Agarwal et al. 2002, Carroll et al. 1996, Klepper and Simons 2000), recommended that scholars use entry into a focal industry as a clear demarcation point to examine how pre-entry experience may affect subsequent choices, capability development, and firm performance. This research, however, has largely measured pre-entry experience as a dichotomous, firm-level variable (i.e., diversifying entrants versus start-ups), even though start-ups may benefit from their founders' pre-entry experience (Agarwal et al. 2004, Helfat and Lieberman 2002, Klepper 2002). A dichotomous variable may not capture the rich heterogeneity in the types of experience an entrant brings into the new industry. Both diversifying and start-up entrants (through founder(s)) may have had experience in one or more value chain activities. Diversifying entrants may also be heterogeneous regarding specific experience in and capability for an activity. Furthermore, diversifying entrants may possess integrative firm-level capabilities that start-ups lack (Chen et al. 2011, Helfat and Campo-Rembado 2010). To the best of our knowledge, no study has systematically compared differences in pre-entry experience in an activity and in where that experience resides—whether in an individual founder (i.e., at the "founder level") or in firm routines (i.e., at the "firm level"). Our study addresses this gap.

Building on these theoretical perspectives, we derive the main and moderating effects of transaction hazards and pre-entry experience on a firm's decisions about configuring value chain activities. We hypothesize that transaction hazards, both transient and enduring, are positively related to internalization of an activity, as are pre-entry experiences at the activity and firm levels. Importantly, we predict that the influences of organizational capabilities on boundary choices vary over time, given the transience of some transaction hazards. We further predict that pre-entry activity experience at the firm level rather than founder level will result in a higher likelihood of internalization and that pre-entry activity experience positively moderates the relationship between enduring transaction hazards and decisions to internalize. We tested our hypotheses in the evolving U.S. bioethanol industry from 1978 to 2009 and found support for most of them.

Our study makes contributions to each theoretical perspective it draws upon. First, it extends the transaction cost literature beyond the few studies that have examined governance choice in start-ups and small firms (Bigelow and Argyres 2008) by answering the (rephrased) call by Williamson (1999): Given their particular resources and capabilities at founding, how should a firm organize value chain activity *X*? Second, this study contributes to efforts to join the organizational capability and the transaction cost theories (Argyres 1996, Hoetker 2005, Jacobides and Winter 2005, Leiblein and Miller 2003, Madhok 2002, Walker and Weber 1984) to reveal how a firm's initial bundle of resources and capabilities may be the foundation for capability development and governance choice strategies after entry into an industry. Third, our study decomposes this initial bundle into activity- and firm-level capabilities to show their differential effects. Thus it enriches the construct of pre-entry experience developed in the industry evolution literature, further enabling inquiries into the effect of pre-entry experience on postentry strategies, complementing the

often-studied relationships between pre-entry experience and firm performance or survival.

It is our hope that, taken together, these contributions position our study as the first of further inquiries about the coevolving relationships among governance choice, capability development, and industry evolution. Our framework highlights the need for an integrative approach to theory development, emphasizing that organizational economics, organizational capability, and industry evolution explanations work in tandem rather than in isolation. Just as industry evolution reshapes boundary choices by reshaping governance costs, so do pre-entry experience and capabilities. Furthermore, although transaction cost economics focuses on a firm's ability to "manage across activities" (to transact exchanges), and organizational capabilities theory focuses on managing a particular activity, they both seem to yield similar predictions about boundary choices. This parallel leads to an intriguing speculation that the capability for managing an activity and that for governing it are less distinct theoretically and empirically than they are commonly considered to be.

## Hypothesis Development

Because we integrate several theoretical perspectives, we begin with an overview of the constructs derived from each theory and their potential interrelationships. Similar to Porter (1985), we describe a firm as engaging in various value chain activities that complement its core production activity and in particular differentiate four activities: raw material procurement, marketing and distribution for primary products, marketing and distribution for coproducts, and technology development. Each activity requires different sets of resources and capabilities and thus can be regarded as a sub-bundle of resources and capabilities. An underlying assumption is that differences in needed resources and capabilities are much larger between than within activities, thus permitting "activity-level" decomposition of capabilities.

Among various organizational capabilities, pre-entry experience is experience in related industries gained before entry into a focal industry. The term is comprehensive, including both functional and dynamic capabilities and both general and specialized resources (Helfat and Lieberman 2002). Researchers have often bundled these together, largely assuming that start-ups lack pre-entry experience and have fewer resources and capabilities than diversifying entrants (Helfat and Lieberman 2002, Teece 1986). For example, as Teece (1986) pointed out, a lack of complementary assets (e.g., a marketing capability) puts start-ups at a disadvantage, even though they may have superior technological capabilities. However, other researchers have noted that start-ups can have pre-entry experience in the form of founder knowledge (see Agarwal et al. 2004, Helfat and Lieberman 2002, Klepper 2002), because founders convey resources (e.g., human capital, networks, status) and capabilities (e.g., marketing know-how, technological know-how). Here, we decompose a firm's pre-entry experience into activity-level pre-entry experience (for both diversifying entrants and start-ups) and firm-level integrative capabilities (for diversifying entrants only).

We define a *firm's pre-entry activity-level experience* as experience accrued by the firm, or the founder(s) of a start-up, that is related to a particular value chain activity and gained prior to entry in the focal industry. Pre-entry activity-level experience is thus the possession of resources and capabilities related to that value chain activity. For example, in our empirical setting, the bioethanol industry, a pipeline company would have relevant pre-entry experience in fuel distribution but not in feedstock procurement. In contrast, a farmer who is engaged in bioethanol production would likely have experience in feedstock procurement but not in marketing and distribution of bioethanol. We note that the construct of activity-level pre-entry experience places diversifiers and start-ups on common ground, given both founders' and firms' prior capabilities.

Nonetheless, the distinction between diversifying entrants and start-ups is germane, because there may be systematic differences in how activity-level capabilities affect boundary choices if these capabilities reside in founders (for start-ups) rather than in firms (for diversifiers). Theoretically, this relates to the presence of established firm-level routines or *integrative capabilities*, which Helfat and Raubitschek (2000) defined as knowledge of how to integrate activities, capabilities, and products in one or more vertical chains. Helfat and Campo-Rembado (2010) highlighted the role of such integrative capabilities in enabling communication and coordination across stages of value chain activities. By virtue of having existed in another industry prior to entry into a new one, diversifying entrants possess integrative capabilities relatively lacking in start-ups (Chen et al. 2011). We define firm-level or integrative pre-entry capabilities as present in diversifying entrants.

Following Capron and Mitchell (2009), we define the boundary choice for a value chain activity as the decision to undertake it either through internal development (within firm boundaries) or external development (partnering with another firm through joint venture, licensing or strategic alliances, or outsourcing). External sourcing of a value chain activity exposes a firm to transaction hazards, defined as the costs incurred if an activity is carried out externally. Furthermore, transaction hazards can be of two types: enduring and transient.

### Transaction Costs and Economies of Scale: Organizational Economics Hypotheses

When it comes to vertical integration in an industry evolution context, Williamson (1975) and Stigler (1951)

differ about the relative impact of production costs and transaction costs. Stigler (1951) regarded scale economies to be an independent source of production cost differentials and developed an industry life-cycle theory of vertical integration. In this theory, firms in young industries tend to be vertically integrated, but as industries grow, specialized suppliers can be sustained by a larger scale of industry output. Williamson (1975) argued, however, that production cost differentials derived from scale economies are not sufficient for vertical integration, as buyers can also achieve economies of scale by producing in-house and selling extras to customers, absent transaction costs. Put differently, it is high transaction cost, rather than low production cost, that leads to vertical integration (Riordan and Williamson 1985).

These two views about vertical integration over an industry's life cycle can be synthesized via a decomposed view of transaction costs, however. Asset specificity, uncertainty, and transaction frequency are the primary drivers of transaction costs (Williamson 1975). Some of these sources may be more enduring than others. The Stiglerian view highlights transient transaction hazards, which studies of industry evolution have associated with asset specificity and technological uncertainty (Agarwal et al. 2002, Argyres and Bigelow 2010, Gort and Klepper 1982). Knowledge accumulation and spillovers in an industry promote standardization of technology specifications (Abernathy and Utterback 1978, Gort and Klepper 1982), thus reducing the technological uncertainty, asset specificity, and potential economic hold-ups that drive high transaction costs (Argyres and Bigelow 2010, Hoetker 2004, Williamson 1975). Although asset specificity never vanishes completely, and aspects of asset specificity such as physical colocation and the learning costs engaged in switching partners remain significant even for higher standardized products (Klein 1988), its relative importance declines over time. For instance, both technological uncertainty and asset specificity of the feedstock procurement activity have decreased as the bioethanol industry has evolved. Along with standardization of various value chain activities, specialized suppliers have emerged. Stigler's (1951) view is therefore conceptually aligned with the idea of transient transaction costs, in that a decrease in uncertainties and asset specificity facilitates economies of scale.

However, other sources of costs, particularly as they relate to other types of uncertainty (e.g., demand and environmental, systemic technology shocks) and transaction frequency may endure throughout an industry's life. Some industries and some activities may exhibit consistently higher transaction hazards than others, regardless of life-cycle stage. Helfat and Campo-Rembado (2010) discussed how some industries (characterized by multiple overlapping markets) require more coordination and communication than other industries even as they mature, resulting in higher transaction costs. Furthermore, variations in the transaction hazards related to value chain activities may persist. For instance, a bioethanol firm needs to transact to procure feedstock as often as production requires, and the transactions are subject to price fluctuations in the commodity market. Neither the frequency of transactions nor the price uncertainty is correlated with industry life stage. We note that this type of environmental uncertainty contrasts with technological uncertainty, which is likely to decrease as an industry evolves.

In all, as an industry evolves, transaction costs resulting from transient factors may decrease, but transaction costs resulting from enduring factors remain. Put differently, although the influence of transient transaction costs (e.g., asset specificity changes) on boundary choice for a given activity may vary as industry ages, the influence of enduring transaction costs (e.g., uncertainty and transaction frequency) is independent of industry evolution. Given this temporal dimension of transaction costs, the timing of entry into the industry is an important determinant of the magnitude of transaction hazards an entrant experiences. Therefore, we maintain that both the Williamsonian transaction costs view and the Stiglerian view can be valid in the context of industry evolution, and we put forward two baseline hypotheses.

HYPOTHESIS 1A (H1A). *An entrant is more likely to internalize a value chain activity if the enduring transaction hazards of carrying out that value chain activity are high.*

HYPOTHESIS 1B (H1B). *A late entrant is less likely to internalize a value chain activity because transient transaction hazards are lower later in the industry life cycle.*

### Pre-Entry Experience: Organizational Capability Hypotheses

The resource-based theory argues that firms pursue growth based on extant resources and capabilities (Wernerfelt 1984, Chang 1995). Extended use of resources and capabilities provides economies of scope (Teece 1980)[2] and, thus, production cost advantages for entrants in the focal industry who possess the relevant resources and capabilities. In general, scholars have documented that pre-entry experience provides relevant resources and complementary assets, resulting in a performance and survival advantage, and such pre-entry experience can exist at both the firm level (Carroll et al. 1996, Helfat and Lieberman 2002, Klepper 2004, Klepper and Simons 2000, Mitchell 1991) and the individual founder level (Agarwal et al. 2004, Phillips 2002). Complementing the literature on diversification in corporate strategy regarding what industries or markets a firm should enter (Chatterjee and Wernerfelt 1991, Montgomery and Hariharan 1991, Montgomery and Wernerfelt 1988, Silverman 1999), industry evolution

scholars have compared entrants' pre-entry experience (Bayus and Agarwal 2007, Carroll et al. 1996, Klepper and Simons 2000). These two theoretical perspectives convey one common message: the relatedness of a potential entrant's resources and capabilities to those required by an industry is a driver of industry entry (Helfat and Lieberman 2002).

In addition, Helfat and Eisenhardt (2003) extended the concept of economies of scope to include a temporal dimension: a firm achieves intertemporal economies of scope by transferring resources and capabilities from existing uses that may become obsolete to emerging and profitable new opportunities. Thus, whether firms with pre-entry experience pursue existing or intertemporal economies of scope, production costs are likely to be lower for them than for entrants who lack such experience.

Although governance choice is not a central topic of either the resource-based or the industry evolution literature, the formula for economies of scope suggests an integration strategy. To achieve economies of scope, a firm may choose to integrate two businesses within its boundaries. The same line of reasoning can be applied to value chain activities. If an entrant has experience in operations (either at the firm level or founder level) that use resources and capabilities similar to those required by a value chain activity in the new industry, then this entrant is likely to have a cost advantage over entrants without such experience and is likely to carry out that activity itself. Therefore, we predict the following.

HYPOTHESIS 2A (H2A). *An entrant is more likely to internalize a value chain activity if it possesses pre-entry experience related to that activity.*

A second important class of capabilities relates to integration of activities via communication and coordination across the components of a system or across value chain activities at different stages of production (Chen et al. 2011, Helfat and Campo-Rembado 2010, Helfat and Raubitschek 2000, Henderson 1994, Parmigiani and Mitchell 2009). Such integrative capabilities, which exist at the firm level, are important for product innovation (Helfat and Raubitschek 2000), for firm growth (Chen et al. 2011), and for reducing the communication and coordination costs of conducting a transaction in-house (Poppo and Zenger 1998).

Diversifying industry entrants have more integrative capabilities than start-ups. Development of these capabilities, however, is costly (Helfat and Campo-Rembado 2010). Firms may choose to vertically integrate or deintegrate as an industry evolves but bear significant costs for such flexibility. The cost of setting up a vertically integrated governance structure can be particularly high for specialized firms and start-ups (Leiblein and Miller 2003). As a result, there is likely to be a tendency to maintain the initial boundary choice for both vertically integrated and specialized firms. Helfat and Campo-Rembado (2010) found that firms may choose to remain vertically integrated in anticipation of new systemic changes in either their own or other industries, and Chen et al. (2011) found that diversifying entrants navigate systemic change better than start-ups. Like systemic innovation (Helfat and Campo-Rembado 2010), entry into a different industry represents systemic change for a firm and calls for integrative capabilities (Chen et al. 2011). Yet relative to diversifying entrants, start-ups may experience higher costs for integration of value chain activities, particularly in the absence of founder pre-entry capability in the activities. Given the greater levels of pre-entry integrative capabilities of diversifying entrants, we predict the following.

HYPOTHESIS 2B (H2B). *A diversifying entrant is more likely to internalize a value chain activity than a start-up.*

We now turn to an important distinction that relates to where pre-entry activity experience resides. Hypothesis 2A concerns the relatedness of pre-entry activity experience and not whether such experience is equally transferable to a new industry for both start-ups and diversifying entrants. Similarly, Hypothesis 2B focuses on the existence of an entrant's firm-level integrative capabilities but not potential interactions with pre-entry activity-level capabilities. We now argue that a firm's integrative capabilities positively moderate the relationship between pre-entry experience in an activity and the decision to internalize that activity.

A diversifying entrant's integrative capabilities should help it transfer activity experience. Start-up founders with experience in an activity may possess the relevant knowledge, but firm-level routines that combine resources and capabilities for the ability to conduct the activity in-house are still needed. In contrast, even if activity experience acquired in related industries needs to be reconfigured to meet the new industry's requirements, diversifying entrants have already incurred much of the necessary cost (Helfat and Campo-Rembado 2010), whereas start-ups have to incur these costs anew. A diversifying entrant's integrative capabilities should also enable it to leverage such experience better than a start-up can, because firm-level routines are more holistic and encompassing than knowledge residing in the mind of a founder that needs to be translated to the firm level. This idea is consistent with the finding by Chen et al. (2011) that diversifying firms can deal with "growing pains" better than start-ups. Thus, we predict the following.

HYPOTHESIS 2C (H2C). *The positive relationship between a firm's likelihood of internalizing a value chain activity and the possession of pre-entry experience in that activity is stronger for diversifying entrants than for start-ups.*

### Organizational Economics and Organizational Capabilities: An Integration Exercise

*Transient Transaction Hazards (Entry Year) and Pre-Entry Experience.* As industries evolve, entrants can rely on an increased stock of industry-specific knowledge (Gort and Klepper 1982), which has important implications not only for changes in the relevance of pre-entry experience (Bayus and Agarwal 2007, Klepper 2002) but also for the availability of specialized external partners or suppliers (Jacobides and Winter 2005). As discussed above, entry timing also relates to changes in asset specificity and uncertainty, and thus it should also have an important contingency effect on the relationship between pre-entry experience and boundary choices.

The industry evolution literature documents temporal changes in the technological and demand conditions in industries (Abernathy and Utterback 1978, Agarwal and Bayus 2004, Gort and Klepper 1982). At the early stages, characterized by uncertainties in technology, demand, and government policy, resources and capabilities compete for value creation potential. Few, if any, supplier firms offer standard or easily customized applications for incumbent firms. Therefore, firms with transferable pre-entry activity experience are likely to be able to create competitive advantage. Given a small pool of suppliers, even imperfectly transferable pre-entry experience may make a firm the "least incapable" of the available suppliers (Hoetker 2004). However, as the industry evolves, industry-specific knowledge develops (Gort and Klepper 1982). Particularly after a dominant design is set, product features become largely predictable, and innovations are mainly add-ons to existing well-known production technologies (Abernathy and Utterback 1978). Pre-entry resources and capabilities from other industries, even if they are related, are less likely to fit the norms of the focal industry; hence, the value creation potential and relevance of pre-entry experience decrease over time (Bayus and Agarwal 2007, Ganco and Agarwal 2009). The increasing availability of capable suppliers means pre-entry experience loses value over time, and overall, pre-entry experience in an activity becomes less of a differentiator as an industry develops.

Similarly, interfaces between value chain activities simplify over time because product features are gradually standardized. The organization of each value chain activity becomes more modular than it was early in industry evolution, which increases the pool of potential external partners specializing in various value chain aspects (Jacobides and Winter 2005). Early in an industry's life, integrative capabilities allow diversifying entrants to gain competitive advantage by organizing transactions within their boundaries more efficiently than is possible in the nascent market. However, the standardization and modularization of the value chain over time increase the efficiency of organizing via the market and reduce the advantage of leveraging integrative experience to conduct activities in-house.[3] The above logic suggests a moderating effect of entry time on the relationships predicted in H2A and H2B.

HYPOTHESIS 3A (H3A). *The positive relationship between pre-entry experience in an activity and the decision to internalize that activity is weaker for later entrants.*

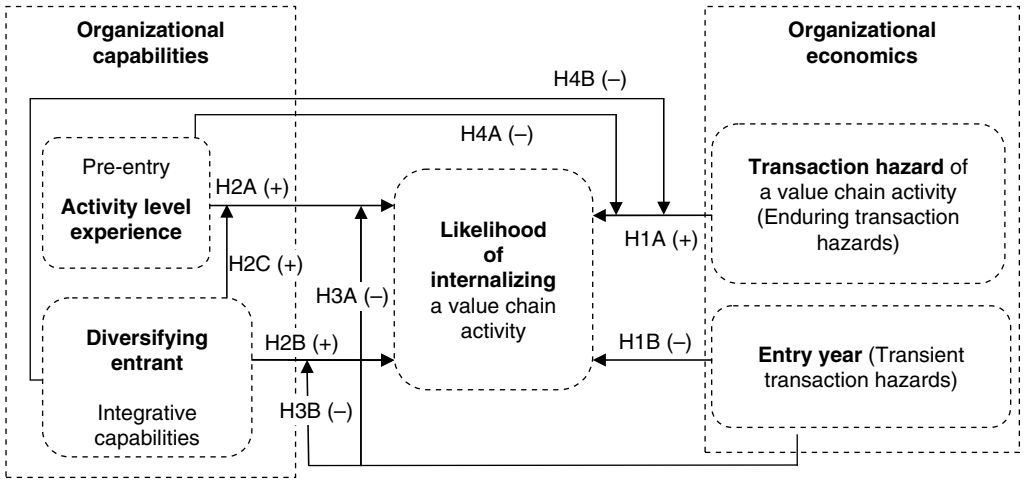
HYPOTHESIS 3B (H3B). *The positive relationship between being a diversifying entrant and the decision to internalize a value chain activity is weaker for later entrants.*

*Enduring Transaction Hazards and Pre-Entry Experience.* Our organizational capabilities hypotheses also imply that firms may differ in their ability to manage enduring transaction hazards. We now examine the impact of both a firm's experience with a given activity and its overall experience on its ability to manage transactions related to that activity in a new setting.

The nascent literature on dual governance—that is, the combination of making and buying similar inputs—suggests that organizations with internal capabilities deal with market transactions and manage external supplier relationships better (Mayer and Salomon 2006). Firsthand experience with an activity helps a firm assess the performance of an outside supplier, reducing the risk of opportunism and hold-ups (Mayer and Salomon 2006, Parmigiani 2007). Knowledge about the activity also allows the firm to credibly threaten to internalize it, reducing the firm's vulnerability to external suppliers (Grant 1996, Kogut and Zander 1992).

Work on dual governance has generally examined simultaneous or near-simultaneous production of components in the same industry value chain. However, to the degree that value chain activities are similar in an entrant's prior and new industries, a firm that internalized that stage in its prior industry or the founder of a start-up with similar prior experience should be able to apply lessons learned to management of external suppliers in the new industry. Accordingly, prior internal experience in a stage of the value chain will lower the cost of managing a given level of transaction hazards. In H2A, we argue pre-entry activity experience makes a firm more likely to integrate. Suppose two firms face a transaction hazard, and one has experience but the other does not. If transaction hazard goes up by some degree of change, or "delta," the inexperienced firm is subject to that entire delta in additional hazard. The experienced firm, however, because it has knowledge and capabilities relevant to the situation, is only subject to a fraction of the delta. The *marginal effect* of transaction hazards is therefore less for experienced firms. Given the lower marginal cost of dealing with an increase in transaction

**Figure 1 Theoretical Framework of Hypotheses**




hazards, we predict that prior activity-level experience will mitigate the transaction hazards posed by external sourcing of the activity and thus negatively moderate the transaction hazard–internalization relationship.

Under the same logic, diversifying entrants' integrative experience provides knowledge about reducing communication and coordination costs that can be leveraged to manage the transaction costs of external sourcing. Firm-level experience in monitoring, identifying internal milestones, and creating routines to coordinate activities can also be leveraged to draw up contracts that safeguard against transaction hazards. Collectively, these factors make a diversified entrant's decisions about internalization of an activity less sensitive to the transaction hazards associated with that activity than the decisions of a start-up. Accordingly, we posit two moderating hypotheses.

HYPOTHESIS 4A (H4A). *The positive relationship between the enduring transaction hazards posed by an activity and the decision to internalize that activity is less for firms that have pre-entry experience in it.*

HYPOTHESIS 4B (H4B). *The positive relationship between the enduring transaction hazards posed by an activity and the decision to internalize that activity is less for diversifying entrants than for start-ups.*

To summarize, Figure 1 presents our theoretical framework. Our first set of hypotheses examines the effects of enduring (H1A) and transient (H1B) transaction hazards on the decision to internalize a value chain activity, and the second set of Hypotheses (H2A, H2B, and H2C) focuses on the role of organizational capabilities in this decision. The third (H3A and H3B) and fourth (H4A and H4B) sets integrate consideration of transaction hazards and organizational capabilities to predict contingent effects on boundary choices.

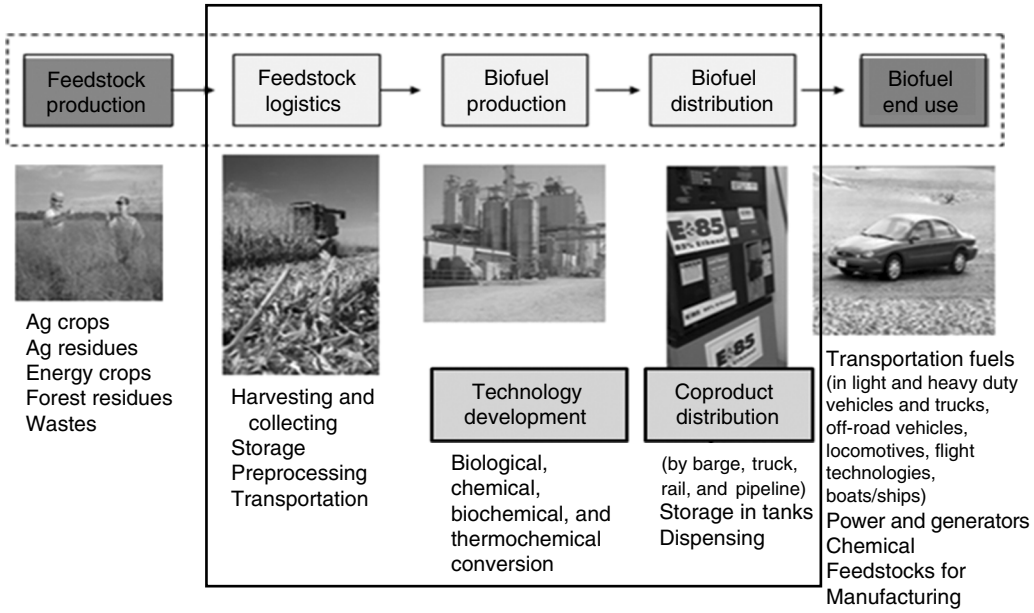
## Data and Methodology

### Empirical Context: The U.S. Bioethanol Industry

We tested our hypotheses with data from extant bioethanol producers that entered this evolving industry over 1978–2009. The industry dates back to the "oil shock" in the 1970s, which sparked interest in renewable energy sources. In 1978, President Jimmy Carter asked ADM (Archer Daniels Midland) to develop an alternative to OPEC (Organization of the Petroleum Exporting Countries) oil. Subsequently, research funding, subsidies, and tax incentives from federal and state governments fueled the growth of the bioethanol industry. Additional support stemmed from various agencies related to environment protection, agricultural development, and economic development. Recently, societal attention to environmental and economic issues related to fossil fuels has provided an additional boost to the use of alternative energies (e.g., renewable fuels, solar energy, and wind). In the United States, bioethanol is one of the two most important biofuels (bioethanol and biodiesel) and is made primarily from amylaceous grain plants (e.g., wheat, corn). The bioethanol industry is an ideal context for our study, given its clear demarcation of value chain activities, recent evolution, and entrants' heterogeneous pre-entry experience.

Figure 2 reproduces the value chain activities related to ethanol production as depicted by the U.S. Environmental Protection Agency, originating with feedstock production and ending with consumption. Entry into the industry requires incurring the capital costs of building a plant using one of two dominant technologies: dry or wet mill processing.[4] As Figure 2 shows, four key value chain activities complement ethanol production: (1) feedstock procurement, (2) technology development, (3) bioethanol marketing and distribution, and (4) coproduct marketing and distribution. Accordingly, we could identify whether producers chose to internalize any of these complementary activities.

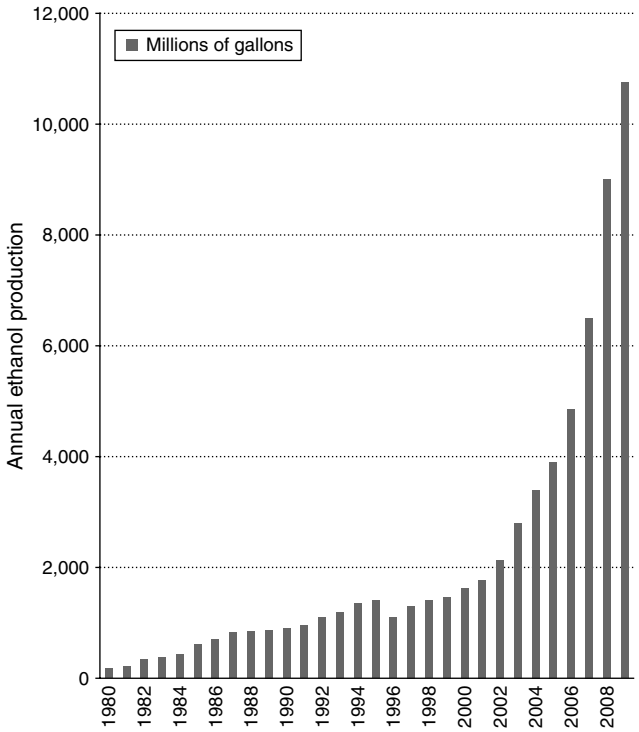
**Figure 2 Value Chain Activities Related To Ethanol Production**




*Source.* Adapted from http://www.epa.gov/Sustainability/images/biofuel_chain.png.

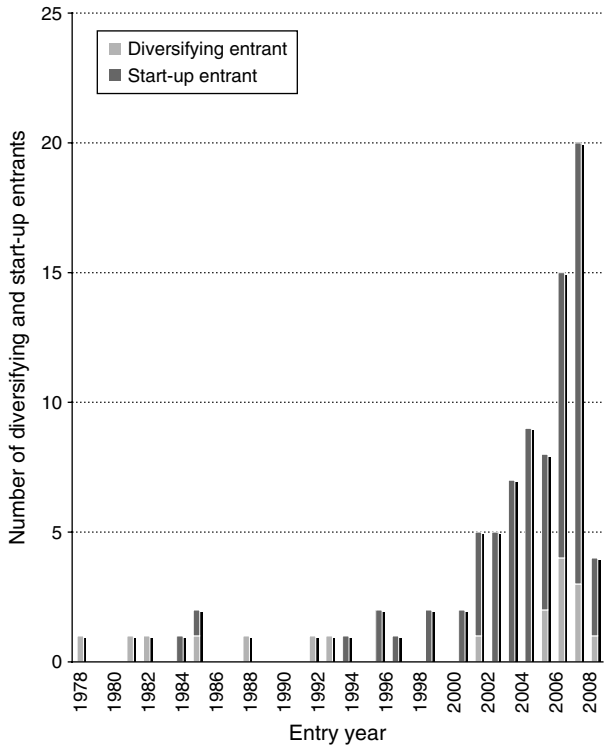
Figures 3–5 depict the evolution of key industry variables. The industry has experienced rapid growth in both sales and the number of firms, and it now ranks as the largest in the world in terms of total production (Renewable Fuels Association 2008). Figure 3 shows a clear growth trend over the last three decades, with an annual rate of about 13.33% for the last 25 years and acceleration since 2000 to about 17.4%. Furthermore, aggressive government incentives and policies have fostered entry by both diversifying entrants and start-ups (Figure 4). As befits the early and growth phases of the industry life cycle (Agarwal and Gort 1996), not many exit events

**Figure 3 Historical U.S. Fuel Ethanol Production**



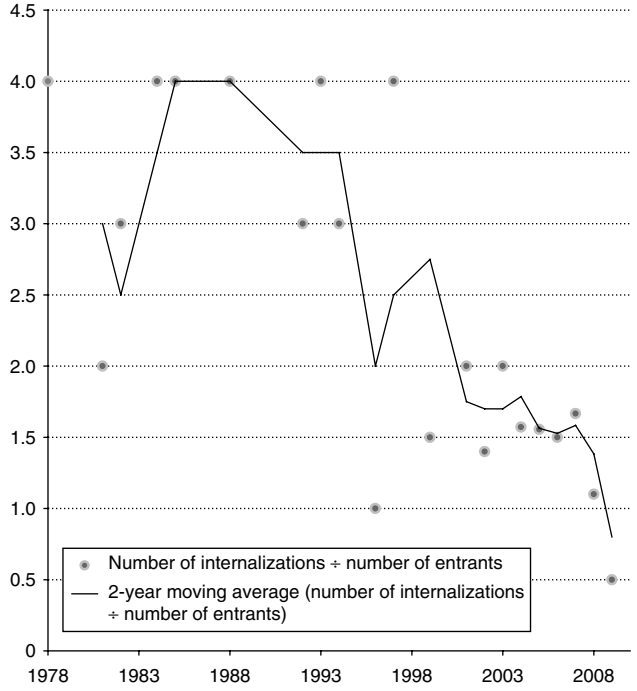

*Source.* http://www.ethanolrfa.org/pages/statistics/.

**Figure 4 Number of Entrants by Year**




*Source.* Calculation and compilation performed by authors.

**Figure 5 Number of Internalizations Divided by Number of Entrants**




*Source.* Calculation and compilation by authors.

occurred in the industry in studied period. The pre-entry experience of industry entrants varies significantly. The firms and the founders of start-ups that entered the bioethanol industry came from a variety of backgrounds. For example, diversifying entrants included agricultural products companies that had engaged in grain processing and distribution (e.g., ADM, Bunge North America, Cargill), firms who had engaged in electricity or coal related production (e.g., Great River Energy, Headwaters), and firms that had related production technology (e.g., ICM). Among the start-ups, founders' pre-entry experience varied considerably as well. Some were farmers (e.g., the founder of Central Indiana Ethanol Plant was a fourth-generation Hoosier farmer). Other start-ups' founders had been employed in incumbent firms but "spun out" to build new plants (e.g., a cofounder of Pacific Ethanol had managed a smaller-scale plant making bioethanol from beer and soft-drink syrup before he founded Pacific Ethanol, which has much larger scale and uses corn as its primary feedstock).

Importantly, Figure 5 shows a declining trend in the number of internalized activities per firm. Thus, the evolution of the U.S. bioethanol industry is also evident in a decrease in integrated firms over time, a trend that is consistent with Stigler (1951) and our Hypothesis 1B.

## Data Sources

Our data represent all extant bioethanol producers[5] in the United States that entered from 1978 to 2009. We compiled information on the firms by cross-referencing information from the Renewable Fuels Association (RFA) and a consulting firm (BBI International)[6] that specializes in renewable fuels and publishes the leading annual directory of the industry. Additional information regarding timing of entry, pre-entry experience, boundary choices for value chain activities, and production capacity was compiled from various resources, including U.S. Securities and Exchange Commission (SEC) filings, firm websites, shareholder newsletters, press releases, industry magazines (*Ethanol Producer Magazine*),[7] and various regional news reports on agriculture and biofuels.[8] These secondary data sources were complemented by interviews with managerial personnel who provided expert opinions on one of our key variables: enduring transaction hazards. The data contain 90 bioethanol producing companies and 360 firm-activity observations.

## Estimation

The unit of analysis in our study is the internalization decision at the time of industry entry for each of four specific value chain activities. We report the results from probit estimation of the decision to internalize with clustering by firm to account for each firm's generation of four observations, one for each activity. Thus, our estimation technique computes robust standard errors for the coefficients and accounts for inherent heteroskedasticity.

## Variable Definition

The dependent variable, *internalization*, indicates a firm's governance choice for feedstock procurement, technology development, bioethanol marketing and distribution, or coproduct marketing and distribution (1 = internalization; 0 = external development). We collected information on boundary choices at founding from a firm's first filed 10-K (or 10-KSB), which has required sections for each of the four complementary activities. This information, checked against the firms' websites and industry publications, outlined whether these activities were conducted in-house or externally sourced through agreements with specialized suppliers or with other integrated ethanol producers. We also ensured, from information for later years, that these boundary choices remained unchanged, and we observed no switches between internal and external modes within our sample firms. Table 1 shows the internal/external breakdown for each value chain activity in our sample.

**Table 1 Frequency of Internalization (1) and External Development (0) by Activity**

| | Internal | External |
|---|---|---|
| 1. Feedstock procurement | 62 | 28 |
| 2. Technology development | 19 | 71 |
| 3. Ethanol marketing and distribution | 36 | 54 |
| 4. Coproduct marketing and distribution | 44 | 46 |

The variable *enduring transaction hazards* was used to capture transaction hazards for each activity that endures throughout the industry's life and is based on six industry experts' responses to survey questions about perceived frequency and uncertainty (see Appendices A and B).[9] The experts were randomly selected from among top managers in the industry. For each activity, the experts assigned a value from 1 (low) to 5 (high) for a typical bioethanol producer. We averaged these six responses, using the following procedure to ascertain interrater reliability and agreement.

We first checked the interrater reliability by calculating intraclass correlation coefficients (ICCs).[10] For the 24 ratings of activity frequency (four activities and six ratings for each activity), the ICC for average measures was 0.97. For the 24 ratings of activity uncertainty, the ICC for average measures was 0.93. We then computed Fleiss's kappa statistics,[11] obtaining 0.54 for the frequency questions and 0.47 for the uncertainty questions on the four activities. These statistics show moderate agreement among respondents. For all eight questions together, the Fleiss's kappa is 0.61, showing substantial agreement. Thus, the six responses to our questions on the frequency and uncertainty of four value chain activities showed strong interrater reliability and moderate to substantial agreement among raters. Having established the reliability of our measures of frequency and uncertainty, we compiled a single measure of each activity's transaction hazards, averaging the six experts' ratings on both variables. The measure for enduring transaction hazards is the sum of these two averages for each value chain activity.[12] Table 2 presents these four values. Robustness checks revealed no change in results when we used a rank order of the activities rather than the values reported in Table 2.

*Entry year* (*transient transaction hazards*) was defined as the year in which a firm started bioethanol production. For a firm with more than one plant, we used the founding year of its first operating plant, or the earliest available year. We subtracted 1977 from the chronological year of entry so that 1 represents the earliest entry year in our sample. This measure captures the effect of transient transaction hazards, because industry experts agreed asset specificity had reduced over time (see Appendix B).[13] Robustness checks confirmed that the results did not change when a logarithm of entry year was used.

**Table 2 Enduring Transaction Hazards by Activity**

| Activity | Feedstock procurement | Technology development | Ethanol marketing | Coproduct marketing |
|---|---|---|---|---|
| Enduring transaction hazards | 9.16 | 5.5 | 8 | 7 |

Following extant literature, we used a dichotomous measure for *diversifying entrant* (1 = firm was in another industry prior to bioethanol industry entry; 0 = firm was founded as a bioethanol start-up). Joint ventures represent a hybrid organization structure between diversifying entrants and start-ups (Helfat and Lieberman 2002). Four joint ventures were present in our sample and were classified as diversifying entrants, given that they could benefit from their parents' firm-level experience and transfer of routines. Results remained largely similar when joint ventures were excluded from the analysis.

*Pre-entry activity-level experience* indicated whether a firm or its founder had pre-entry experience related to a given ethanol value chain activity (1 = related pre-entry experience; 0 = no related experience). Because both the diversifying entrants and founders of start-ups came from diverse industry settings and backgrounds, in coding this variable we relied on detailed information about their experience, particularly focusing on whether a firm or founder had prior experience in (1) handling grains (e.g., grain transportation, merchandizing, or trading); (2) research and development activities related to ethanol production (e.g., development of technology for corn milling, distiller grain drying, or corn oil extraction); (3) fuel sales, transportation, or storage; and (4) storage and transportation of agricultural processed goods (e.g., food and industrial starches, food ingredients, and animal feeds).[14] We combined keyword and content searches of descriptions of firms' divisions, product offerings, services, histories, and so forth in the above-mentioned various data sources to address these four primary inquires mapping onto the four value chain activities.

For diversifying entrants, we checked what businesses they had operated in prior to entry; for start-ups, we ascertained the pre-entry work experience of the primary founders. For example, a firm with prior experience in petroleum distribution and marketing would be coded 1 for bioethanol marketing and distribution. For start-ups, we relied on company websites, news releases at founding, and trade journal accounts, which provided rich details on founding teams' prior expertise. For example, if a founder was a farmer, we coded 1 for the firm's procurement value chain activity and 0 for all others. Similarly, if a founder had oil refinery experience, we coded 1 for this firm's bioethanol distribution and 0 for all other activities. For firms with multiple founders, we compiled pre-entry experience by accounting for all the founders' experience; thus, a start-up could have related prior experience in multiple activities, even if any one of its founders had experience in only one.

Control variables included *production capacity*, a variable capturing firm size, representing the potential production of bioethanol in a firm's founding year, or the earliest available information about production capacity (in billion gallons per year). Information was collected

from the RFA's annual industry outlook, completed by other secondary sources described above. Robustness checks confirmed that the results were not sensitive to the use of a logarithm. We also controlled for differences in ownership structure. The RFA distinguishes three dominant types: public firm, locally owned producers, and other private. A "locally owned" ethanol firm is typically organized as a limited liability company (sometimes also as a limited partnership) and represents ownership by investors located in the region in which the plant operates. Investors are typically farmers, local businesspeople, and financial investors. These characteristics stem from the fact that most ethanol plants are in rural communities, and most of their economic impact is local. We followed the RFA's classification and controlled for potential structural effects of ownership types by creating dummy variables for *public firm* (1 = public; 0 = other) and *locally owned firm* (1 = locally owned; 0 = other). The omitted category thus included all other types of private ownership.

## Results

Descriptive statistics and correlations for all variables are in Table 3. Because we observed four distinct value chain activities, simple cross-tabulations for each activity provide useful insight. Table 4 shows the percentage of firms that performed each activity internally or externally and reveals two important patterns. First, examining the row percentages shows that firms with pre-entry activity-level experience are significantly more likely to internalize *each* of the four activities we examine (e.g., 85.7% versus 31.6% for ethanol marketing and distribution). Thus, no single activity is driving the results of our formal analysis reported below. Second, comparing the column percentages shows that, combining those with and without prior experience, firms were most likely to internalize the activity identified as having the highest transaction hazards (procurement, 68.9% internalization) and least likely to internalize the activity identified as having the lowest hazard (technology development, 10% internalization). This finding is consistent with our expectations regarding internalization of activities with different levels of enduring transaction hazards.

**Table 4 Cross-Tabs by Pre-Entry Activity-Level Experience and Boundary Choice for Activity**

| | Boundary choice | |
|---|---|---|
| | External (%) | Internal (%) |
| Pre-entry activity-level experience in procurement | | |
| No | 37.5 | 62.5 |
| Yes | 28.8 | 71.2 |
| All firms | 31.1 | 68.9 |
| Pre-entry activity-level experience in technology development | | |
| No | 95.1 | 4.9 |
| Yes | 37.5 | 62.5 |
| All firms | 90 | 10 |
| Pre-entry activity-level experience in ethanol marketing and distribution | | |
| No | 68.4 | 31.6 |
| Yes | 14.3 | 85.7 |
| All firms | 60 | 40 |
| Pre-entry activity-level experience in coproduct marketing and distribution | | |
| No | 60.8 | 39.2 |
| Yes | 6.2 | 93.8 |
| All firms | 51.1 | 48.9 |

Table 5 provides the results of our probit analysis of entrants' internalization decisions for the four value chain activities. The "main effects" model, Model 1, includes the control variables, the baseline hypotheses (H1A and H1B) as they relate to both enduring and transient transaction hazards (year of industry entry is the proxy for the latter), and variables for organizational capability, pre-entry activity-level experience, and diversifying entrant (H2A and H2B). Models 2 and 3 add the interactions between (a) pre-entry activity-level experience and (b) diversifying entrant with transaction hazards (enduring and transient), respectively. The final, fully specified model, Model 4, reports all interactions among the variables of interest. The effects of the control variables are consistent and as expected in all the models reported in Table 5. Larger firms are more likely to internalize, as shown by the largely positive and significant coefficient of production capacity. Locally owned ethanol producers are less likely to choose internalization than are other private firms, whereas public firms are not significantly different from these private firms with other types of ownership structures.

**Table 3 Descriptive Statistics and Pearson Correlations**

| | Mean | S.D. | Min | Max | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. *Production capacity* | 127,000 | 229,000 | 5,000 | 1,400,000 | 1 | | | | | | |
| 2. *Locally owned* | 0.46 | 0.50 | 0 | 1 | −0.27*** | 1 | | | | | |
| 3. *Public firm* | 0.12 | 0.33 | 0 | 1 | 0.46*** | −0.34*** | 1 | | | | |
| 4. *Entry year* (*transient transaction hazards*) | 26 | 6.9 | 1 | 32 | −.36*** | 0.00 | −0.25*** | 1 | | | |
| 5. *Enduring transaction hazards* | 7.42 | 1.35 | 5.5 | 9.16 | 0.00 | 0.00 | −0.00 | 0.00 | 1 | | |
| 6. *Pre-entry activity-level experience* | 0.29 | 0.45 | 0 | 1 | 0.16*** | −0.10* | 0.12** | −0.24*** | 0.46*** | 1 | |
| 7. *Diversifying entrant* | 0.17 | 0.37 | 0 | 1 | 0.14*** | −0.29*** | 0.41*** | −0.35*** | −0.00 | 0.25*** | 1 |

*$p \le 0.1$; **$p \le 0.05$; ***$p \le 0.01$.

**Table 5 Probit Regressions—Internalization (1) or External Development (0) of an Activity**

| | Full sample | | | | Start-up only |
|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) |
| Control variables | | | | | |
| Constant | −0.98 | −1.98** | 0.03 | −0.60 | −0.67 |
| | (0.68) | (0.78) | (1.13) | (1.14) | (1.23) |
| *Production capacity* | 1.10** | 1.15** | 0.79 | 0.80 | 0.61 |
| | (0.51) | (0.57) | (0.55) | (0.61) | (0.66) |
| *Locally owned* | −0.49** | −0.51** | −0.66*** | −0.69*** | −0.78*** |
| | (0.21) | (0.22) | (0.23) | (0.24) | (0.27) |
| *Public firm* | −0.48 | −0.58 | −0.32 | −0.39 | −0.08 |
| | (0.42) | (0.46) | (0.41) | (0.44) | (0.59) |
| Explanatory variables | | | | | |
| *Enduring transaction hazards* | 0.37*** | 0.46*** | 0.50*** | 0.52*** | 0.58*** |
| | (0.06) | (0.06) | (0.07) | (0.07) | (0.07) |
| *Entry year* (*transient transaction hazards*) | −0.08*** | −0.07** | −0.14*** | −0.13*** | −0.14*** |
| | (0.02) | (0.03) | (0.04) | (0.04) | (0.04) |
| *Pre-entry activity-level experience* | 0.71*** | 8.36*** | 0.34 | 6.81** | 9.246** |
| | (0.22) | (2.79) | (0.27) | (2.81) | (3.63) |
| *Diversifying entrant* | 0.18 | 0.14 | −0.98 | −1.32 | |
| | (0.26) | (0.28) | (1.46) | (1.60) | |
| Interactions | | | | | |
| *Pre-entry activity-level experience* ∗ *Entry year* | | −0.16** | | −0.16* | −0.16* |
| | | (0.07) | | (0.08) | (0.09) |
| *Pre-entry activity-level experience* | | −0.38** | | −0.23 | −0.51* |
| ∗ *Enduring transaction hazards* | | (0.19) | | (0.22) | (0.30) |
| *Diversifying entrant* ∗ *Entry year* | | | 0.10** | 0.09** | |
| | | | (0.04) | (0.05) | |
| *Diversifying entrant* | | | −0.25* | −0.18 | |
| ∗ *Enduring transaction hazards* | | | (0.14) | (0.16) | |
| *Diversifying entrant* | | | 1.11** | 0.79 | |
| ∗ *Pre-entry activity-level experience* | | | (0.49) | (0.63) | |
| Regression statistics | | | | | |
| Log likelihood | −174.27 | −167.83 | −166.63 | −162.58 | −129.79 |
| *N* | 360 | 360 | 360 | 360 | 288 |
| Correctly classified (%) | 75.28 | 77.50 | 77.22 | 75.83 | 77.43 |
| Adjusted count $R^2$ | 0.41 | 0.46 | 0.46 | 0.42 | 0.39 |
| McFadden's adjusted $R^2$ | 0.26 | 0.27 | 0.27 | 0.28 | 0.27 |
| $p > \chi^2$ | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |

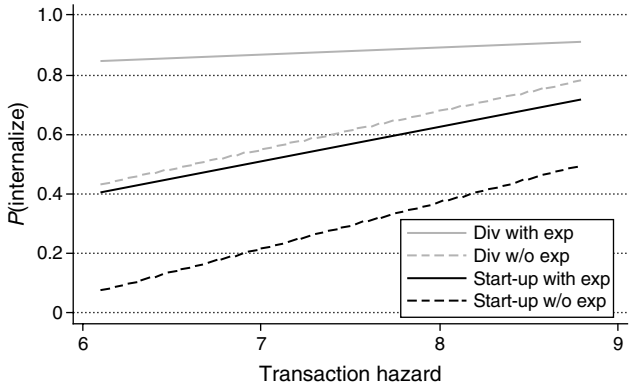
*Notes.* Robust standard errors are in parentheses. Firm fixed effects are controlled with cluster-adjusted standard errors for intragroup correlation, where the firm is a group.

*$p \leq 0.1$; **$p \leq 0.05$; ***$p \leq 0.01$.

We note that when testing interaction terms in probit models in which dummy variables were used to create groups, it is important to check for cross-group unobserved heterogeneity, which can lead to misleading results for interaction terms (Hoetker 2007). Following the method proposed by Williams (2009), we were unable to reject the hypothesis of equal unobserved heterogeneity for either diversifying entrant experience ($p = 0.287$) or activity-level pre-entry experience ($p = 0.657$), and we could therefore use interaction terms with confidence. Furthermore, Hoetker (2007) recommended appending reported coefficients with graphical analysis of predicted effects, both to assist in interpretation and to compute marginal effects for (nonmean) values of the explanatory variables of interest, preferably for values of explanatory variables one standard deviation above or below the mean. Accordingly, we refer to Table 5 and Figures 6 and 7 when discussing results. Figures 6 and 7 depict the probability of internalization ($y$ axes) against enduring transaction hazards and entry year (transient transaction hazards) ($x$ axes), respectively.

Both H1A and H1B, our baseline hypotheses derived from Williamson's (1975) transaction costs theory and Stigler's (1951) prediction on vertical integration over an industry's life cycle, are supported in Model 1 by statistically significant coefficient estimates for these variables. Firms are more likely to internalize value chain activities

**Figure 6 Enduring Transaction Hazards and Probability of Internalization**

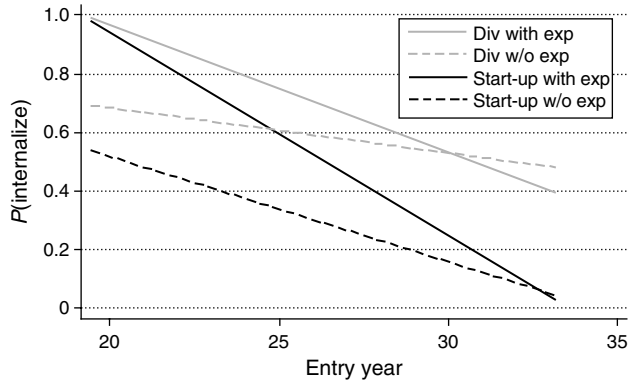



*Note.* Div, diversified entrant; exp, pre-entry activity-level experience.

that are burdened with high enduring transaction hazards. Figure 6 reveals this to be the case, regardless of whether a firm has pre-entry activity-level experience and whether it is a diversifying entrant or start-up. Similarly, firms are less likely to internalize value chain activities if they entered later. Figure 7 depicts the likelihood of internalization for firms entering at different times in the industry's life cycle: though the slopes vary with differences in pre-entry activity- or firm-level experience (i.e., for diversifying entrants), they are consistently negative over time.

Hypotheses 2A is also supported, as shown in Model 1: firms are more likely to internalize a value chain activity if they have pre-entry experience in that activity. In both Figures 6 and 7, firms that have pre-entry experience in an activity (solid lines) are more likely to internalize that activity than their counterparts (dashed lines). Model 5 corroborates this finding for the subsample of start-ups. The coefficient for pre-entry activity-level experience remains positive and significant even when it is a founder rather than a firm that has the

**Figure 7 Entry Year and Probability of Internalization**




*Note.* Div, diversified entrant; exp, pre-entry activity-level experience.

experience, indicating the impact of activity-level experience on boundary choice is independent of the presence of firm-level integrative capabilities.

Hypothesis 2B is also supported: diversifying entrants are more likely than start-ups to internalize any given value chain activity. This is seen more clearly in Figures 6 and 7, because multiple interactions complicate interpretation of the coefficients in Table 5.[15] Figures 6 and 7 account for all statistically significant interaction effects and treat the simple effect of diversifying entrants as null, because it is consistently not statistically significantly different from zero. As seen in Figure 6, diversifying entrants with experience in an activity are more likely to internalize that activity at any level of transaction hazards than are start-ups with such experience, a pattern repeated for diversifying entrants and start-ups without activity-level experience. In Figure 7, we see that all firms become less likely to internalize later in the industry's life cycle. Diversifying entrants are more likely to internalize an activity than are equivalent start-ups, a difference that increases as the industry ages. Thus, overall, we find support for H2B.

Turning to the interaction effect hypotheses tested in Models 2–4, we note that multicollinearity causes some of the coefficients to lose statistical significance when all interaction terms are entered in Model 4.[16] A test of the interaction items reveals them to be jointly significant at the 5% level. Thus, below we utilize Models 2 and 3 for interpretation of results, with reference to Model 4.

We find support for H2C, regarding the enabling role of integrative capabilities in transferring pre-entry activity-level experience, with a positive and significant coefficient estimate from Model 3. We also find support for our hypotheses related to pre-entry activity experience and transient hazards related to industry life-cycle effects. As predicted in H3A, the coefficients in Models 2 and 4 show a statistically significant, negative interaction effect of entry year and pre-entry activity-level experience. This support for H3A is further evident in Figure 7, showing that whether a firm is a diversifying entrant or a start-up, the slope is steeper (more negative) over time given pre-entry activity-level experience. Put differently, we find that such experience has a weaker positive impact on the decision to internalize an activity for later entrants. However, contrary to our Hypothesis H3B, though diversifying entrants who entered early are no more likely to internalize value chain activities than start-ups, later diversifying entrants are significantly *more* likely to internalize than later start-ups. Given the nonsignificant simple effect of diversifying entrant and the negative, significant simple effect of entry year, an alternative interpretation is that later start-ups are much less likely to internalize activities than early start-ups, but this pattern is not true for diversifying entrants. Thus, the lack of support for H3B shows that start-ups are much more sensitive to transient transaction hazards

than diversifying entrants: as outside options for external development of a value chain activity become more available, start-ups—with or without experience in an activity—are much less likely to internalize it than late-entering diversifying entrants.

As predicted in H4A, the role of enduring transaction hazards in promoting the internalization of an activity is weaker when firms have pre-entry experience in that activity. The coefficients of the relevant explanatory variables in Models 2 and 4 and the predicted likelihood of internalization in Figure 6 strongly support this hypothesis. For both diversifying entrants and start-ups, the slope is steeper (more positive) for firms that lack pre-entry activity-level experience as enduring transaction hazards increase; that is, firms with pre-entry experience in an activity are generally more likely to internalize that activity (as predicted in H2A), and the differential is higher at lower levels of enduring transaction hazards than at higher levels.

Finally, we find support for H4B. Figure 6 shows that firm-level experience possessed by diversifying entrants causes them to be less sensitive to increases in enduring transaction hazards across activities. Even though diversifying entrants are more likely to internalize (as predicted in H2B), the differential is lower for higher levels of enduring transaction hazards.

### Robustness Checks

We perform several robustness checks to ensure that our results are not sensitive to the type of firms comprising our sample and our measure of enduring transaction hazard. As noted above, our empirical setting includes a distinctive ownership structure that the Renewable Fuels Association refers to as "locally owned." A locally owned ethanol firms is typically organized as a limited liability company or a limited partnership and represents ownership by investors (e.g., farmers, local businesspeople, and financial investors) located in the region in which the plant operates. Many of these locally owned producers have complex governance structures and may be responding to different incentives than other firms. There are important and interesting questions regarding why farmers sometimes organize into these cooperative structures, including as a means of diversifying into the ethanol production industry. In the context of our study, an important robustness check thus relates to confirming that these firms are not driving our results.

To do so, we replicated our analysis on a sample that omitted all locally owned firms. As shown in Table 6, the estimated coefficients relating to our hypotheses are *all* in the anticipated direction and of similar magnitude to the coefficients for the entire sample (see Table 5). All of the main effect hypotheses and three of the five interaction terms remain statistically significant in Models 2 and 3 (the others take on $p$-values in the 0.20 range), despite the exacerbated multicollinearity issue resulting from reduced sample size (maximum variance inflation factor values for Models 2, 3, and 4 are 50.6, 46.4, and 75.0, respectively). We note, however, that the interaction items involving enduring transaction hazards remain significant and consistent with our hypotheses. The interaction items involving entry year lose statistical significance but retain the same direction. Furthermore, the four interaction terms are jointly significant in Model 4 at the $p = 0.025$ level. In summary, we find strong support for seven of our nine hypothesized relationships when excluding locally owned producers (as opposed to eight of nine relationships for the full sample).

In an additional analysis (available from the authors upon request), we also ran our main effects regression on several subsets (start-ups, diversifying firms, locally owned producers, nonlocally owned producers). We found support for the hypothesized relationship for all subsets, as is also implicit from the comparisons of the main results in Table 5 and the analysis reported in Table 6 (excluding locally owned), as well as in column 5 of Table 5 (for the start-up subsample). In particular, we found that the results for locally owned producers were similar to those estimated for the sample with no locally owned producers.

Furthermore, we conducted robustness checks on our measure of enduring transaction. The analysis, available from the authors upon request, used (1) dummy variables for each of the value chain activities and (2) a simple ordinal variable running from 1 (lowest hazards) to 4 (highest). Both robustness checks provided results that are significant and in the expected direction. In the dummy variable regression, relative to the omitted activity (technology development, the lowest transaction hazard), we found that the other activities are all significantly more likely to be integrated, with procurement (the highest transaction hazard) having the highest coefficient, as expected. In the regression using ordinal measures, we found a positive and significant coefficient for enduring transaction hazard, as hypothesized.

Taken together, these results give us confidence that our main results, as reported in Table 5, are a fair representation of the entire sample and are not driven by any single type of firm, in particular, locally owned producers. They also give us confidence that the locally owned producers and other firms respond similarly to our theoretical variables. Also, they confirm that firms are less likely to internalize activities that have greater enduring transaction hazards, regardless of how these are measured.

## Discussion and Conclusion

This paper builds on work in organizational economics, organizational capabilities, and industry evolution to examine firms' boundary choices at the time of their entering an industry. Specifically, we argued that these

**Table 6 Probit Regressions—Internalization (1) or External Development (0) of an Activity: Robustness Check Omitting Locally Owned Firms**

| | (1) | (2) | (3) | (4) |
|---|---|---|---|---|
| Control variables | | | | |
| Constant | −0.98 | −2.17** | 1.97 | 1.27 |
| | (0.71) | (0.89) | (3.91) | (3.69) |
| *Production capacity* | 1.02** | 1.03* | 0.28 | 0.30 |
| | (0.50) | (0.60) | (0.61) | (0.667) |
| *Public firm* | −0.35 | −0.42 | −0.10 | −0.15 |
| | (0.39) | (0.46) | (0.39) | (0.727) |
| Explanatory variables | | | | |
| *Enduring transaction hazard* | 0.31*** | 0.45*** | 0.47*** | 0.53*** |
| | (0.07) | (0.08) | (0.10) | (0.000) |
| *Entry year (transient transaction hazards)* | −0.06*** | −0.06** | −0.20 | −0.19 |
| | (0.02) | (0.03) | (0.14) | (0.141) |
| *Pre-entry activity-level experience* | 0.76** | 6.88*** | 0.17 | 4.85* |
| | (0.30) | (2.35) | (0.41) | (0.057) |
| *Diversifying entrant* | 0.10 | −0.04 | −2.64 | −3.32 |
| | (0.33) | (0.35) | (3.99) | (0.380) |
| Interactions | | | | |
| *Pre-entry activity-level experience* | | −0.07 | | −0.05 |
| ∗ *Entry year* | | (0.06) | | (0.259) |
| *Pre-entry activity-level experience* | | −0.51** | | −0.36 |
| ∗ *Transaction hazard* | | (0.22) | | (0.151) |
| *Diversifying entrant* | | | 0.15 | 0.15 |
| ∗ *Entry year* | | | (0.14) | (0.243) |
| *Diversifying entrant* | | | −0.30* | −0.20 |
| ∗ *Transaction hazard* | | | (0.16) | (0.258) |
| *Diversifying entrant* | | | 1.36** | 0.83 |
| ∗ *Pre-entry activity-level experience* | | | (0.65) | (0.74) |
| Regression statistics | | | | |
| Log likelihood | −101.39 | −96.85 | −94.84 | −92.87 |
| *N* | 196 | 196 | 196 | 196 |
| Correctly classified (%) | 72.96 | 73.47 | 74.49 | 75 |
| Adjusted count $R^2$ | 0.45 | 0.46 | 0.49 | 0.50 |
| McFadden's adjusted $R^2$ | 0.20 | 0.21 | 0.22 | 0.22 |
| $p > \chi^2$ | 0.000 | 0.000 | 0.000 | 0.000 |

*Notes.* Robust standard errors are in parentheses. Firm fixed effects are controlled with cluster-adjust standard errors for intragroup correlation, where firm is a group.

*$p \leq 0.1$; **$p \leq 0.05$; ***$p \leq 0.01$.

factors are intertwined and developed an integrative framework. Our empirical testing in the U.S. bioethanol industry provided strong empirical support for our theoretical framework.

Notwithstanding the differences in the views of Stigler (1951) and Williamson (1975) about the role of economies of scale and transaction costs in explaining vertical integration choice, we found support for both views. On the one hand, we found that firms are more likely to internalize value chain activities with high transaction costs. Our activity-specific measure derived from industry expert opinions shows that the uncertainty surrounding the key activities may differ, as may their frequency. In this setting, uncertainty and frequency are enduring factors that lead to enduring transaction costs. On the other hand, the asset specificity of a transaction may vary over an industry's life. Knowledge accumulation and spillovers promote emergence of specialized suppliers for various value chain activities and may reduce, but not eliminate, overall asset specificity over time (Gort and Klepper 1982, Stigler 1951). Therefore, our results support a long-standing tenet of the literature on industry evolution: later entrants are less likely to internalize any given stage of a value chain and can take advantage of a more fully developed market to avoid internalization.

Argyres and Bigelow (2007) found that misalignment of governance structure penalizes firms more at later stages than at early stages of an industry's life cycle, pointing out that it can be misleading to assume uniformly severe selection pressures over an industry's life while applying transaction costs theory. Our results corroborate this argument, showing that firms encounter varying degrees of transaction costs at different industry

life stages. This variation is especially notable if we take into account firms' historical commitment (Argyres and Liebeskind 1999) or experience in a focal industry (Bigelow and Argyres 2008), because our findings are based on a sample of new entrants into the bioethanol industry.

Our findings on organizational capabilities show that a firm's experience prior to entry shapes the scope of its activities in the focal industry, and that different types of pre-entry experience have different impacts on decisions to internalize. Our logic is broadly consistent with the large literature on the advantages possessed by diversifying entrants (Helfat and Lieberman 2002, Wernerfelt 1984) in that we find that firms are more likely to internalize an activity if they or their founders have had experience related to it. Furthermore, we advance this literature by distinguishing pre-entry experience with a given activity from broad firm-level pre-entry experience related to integrative capabilities. We separate underlying mechanisms previously bundled together via the diversifying entrant/start-up dichotomy. This distinction recognizes that both start-ups and diversifying entrants can have pre-entry activity-level experience and permits us to isolate the effects of firm-level integrative capabilities. In doing so, we show that both pre-entry experience with an activity and integrative capabilities can and do transfer across value chains to shape decisions about firm scope. Furthermore, firm-level experience possessed by diversifying entrants enhances the effect of activity-level experience.

The support for H3A (effect of pre-entry activity-level experience on transient transaction hazards, proxied by entry year) but lack of support for H3B (similar effect of diversifying entry) has interesting implications. The relevance of *activity* experience to the decision to internalize attenuates as more specialized outside options become available with industry maturity, which is consistent with Bigelow and Argyres' (2008) study showing a weak trend toward vertical disintegration in an industry over time. In contrast, *if one controls for activity-level experience*, as we did here, diversifying entrants are less influenced by the availability of specialized suppliers of value chain activities when they enter the industry later. Thus, integrative capabilities (Chen et al. 2011, Helfat and Campo-Rembado 2010, Helfat and Raubitschek 2000) appear to be a different or higher-order construct than activity-level experience and may act in a different way on boundary choice. Integrative capabilities are related to communication and coordination of activities, and this may be the reason that their effect on the probability of internalization persisted even as the industry matured, given that later diversifying entrants are much more likely to choose internalization than later start-up entrants.

Our findings also highlight the value of pre-entry experience for managing relationships with external suppliers or related partners (Hoetker 2005), and they add to the growing body of research on dual governance (Mayer and Salomon 2006, Parmigiani 2007). By examining a firm's choice of organization of boundaries for value chain activities as it leverages *pre-entry* experience, either in a given activity level or in the firm, we add to this literature by examining the effect of transfer or spillover of capabilities from one industry to another and the concomitant ability to buffer the effect of transaction costs. We find that the benefits of such experience or associated capabilities can transfer across value chains under conditions of high transaction hazards, whether enduring or transient.

Integrating organizational capabilities and organizational economics and exploring contingent conditions also permit us to contribute to the dynamic perspective on the role of boundary choice in capability formation as distinct from the role of superior capabilities in the boundary choice for an asset or activity (Argyres and Zenger 2008). Our empirical results underscore the importance of both transaction costs and capability stocks for boundary choices at a time of entry and point to the importance of initial boundary choice to a firm's capability development over time (Helfat and Peteraf 2003). This further has implications for entrepreneurial start-ups' industry entry decisions as it relates to entry timing, structure design, and capability development.

We are cognizant of limitations in our study. First, we assumed that the transferability of pre-entry experience is the same for different value chain activities. Value chains are more or less related overall, which will affect the transferability of pre-entry experience. Even in a pair of value chains, the degree to which each activity is related may vary systematically. Future work might try to quantify such transferability in a more refined way, rather than with a dummy variable. Second, though our distinction between pre-entry activity- and firm-level experience provided more insights than a dichotomous measure (diversifying entrant versus start-up), and our results also show that integrative capabilities enable transferring activity-level experience across value chains, further explorations along these dimensions would provide insights into the more specific advantages and disadvantages of diversifying entrants. Third, our study is based on an industry that is approaching maturity but has not yet arrived at the shake-out stage. Ideally, an examination of our theoretical predictions in the entire life of an industry would make for a more complete story. Replicating this study in other industries would indeed be even more useful than usual.

Notwithstanding the above-mentioned limitations, this paper contributes to understanding of the intertwined relationships between organizational economics and organizational capabilities factors in an evolving industry. It is among the first that theorizes and empirically examines interactions of these factors. We hope to have answered Williamson's (1999) question as to how,

given certain initial resources and capabilities, a firm should organize a given activity. Our findings indicate that firms can leverage pre-entry activity-level experience, which helps reduce the impacts of both enduring and transient transaction hazards. In contrast, although we found some evidence that firm-level integrative capabilities help reduce the impact of enduring transaction hazards, causing firms to prefer internalization, these capabilities cause them to internalize even when transaction hazards related to availability of specialized suppliers and/or knowledge have been mitigated. By doing so, we contribute to transaction cost economics literature by highlighting the differences in strategies undertaken by firms with heterogeneous capabilities in response to similar hazards encountered within or across time periods. Similarly, we contribute to the capability development literature by adding to recent efforts to join organizational capability and transaction costs (Hoetker 2005, Leiblein and Miller 2003, Madhok 2002), revealing how a firm's initial bundle of resources and capabilities may lay the foundation for capability development and governance choice strategies after entry into an industry. Furthermore, we contribute to the industry evolution and entrepreneurship literatures (Helfat and Lieberman 2002, Klepper and Simons 2000) by enriching the construct of pre-entry experience to distinguish specific activity-related capabilities (e.g., marketing, technology) that both diversifying firms and founders of start-ups may have (Agarwal et al. 2004, Helfat and Lieberman 2002) from a firm's integrative capabilities (Chen et al. 2011, Helfat and Campo-Rembado 2010). By examining the effect of pre-entry experience on value chain configuration at industry entry, we also complement the often-studied relationships between pre-entry experience and firm performance (growth and survival). Thus, this study is a first step for further inquires about the coevolving relationships among governance choice, capability development, and industry evolution. Our framework highlights the need for an integrative approach to theory development, emphasizing that organizational capability, organizational economics, and industry evolution explanations work in tandem rather than in isolation. Further work along these dimensions would help disentangle the complex web of relationships among firm capabilities and firm scope in a constellation of evolving industries.

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## Appendix A. Questions on Measuring Transaction Hazards for an Activity

Based upon your industrial knowledge, with a scale from 1 to 5, where 5 means a great deal, and 1 means not much, how would you rate the following aspects for a typical ethanol producer?

1. How frequently does an ethanol producer need to conduct feedstock procurement? (Please give a number between 1 to 5, and the same for the rest.)
2. How frequently does an ethanol producer need to conduct technology development?
3. How frequently does an ethanol producer need to conduct ethanol distribution?
4. How frequently does an ethanol producer need to conduct coproduct distribution?
5. To what extent is the feedstock procurement uncertain to an ethanol producer? (Please give a number between 1 to 5, and the same for the rest.)
6. To what extent is the technology development uncertain to an ethanol producer?
7. To what extent is ethanol distribution operation uncertain to an ethanol producer?
8. To what extent is coproduct distribution operation uncertain to an ethanol producer?

## Appendix B. Questions on Enduring/Transient Aspects of Transaction Hazards for an Activity

Please provide a response to the following questions, stating whether you agree or disagree with the statements. It would also be helpful if you could provide us with reasons substantiating your assessment.

1. Compared to the early years of the ethanol industry, ethanol producers can now rely more on external service providers to conduct activities, such as feedstock procurement, technology development, and marketing/distribution of products.
2. Compared to the early years of the ethanol industry, it is much easier to specify contracts with external service providers, because the knowledge of conducting an activity has become more understandable.
3. Compared to the early years of the ethanol industry, it has also become much easier to evaluate the service quality by the external providers.
4. Over the years, ethanol producers keep facing substantial uncertainties in market demand for ethanol, fluctuations in corn/feedstock prices, and government policies.
5. Due to the nature of seasonal harvest of feedstock, ethanol producers need to conduct feedstock procurement, ethanol distribution, and coproduct distribution in a certain frequency. And the typical frequency for conducting an activity has largely remained the same, ever since the early years of the ethanol industry.

6. Aside from the recent development of cellulosic technology, the grain ethanol processing technology has followed a rather steady progress over the years. There have not been dramatic changes in the processing technology in the last two decades.

## Endnotes

[1]Prior research has defined diversifying entrants as preexisting firms that enter a focal industry and start-ups as firms that are born in the focal industry context (Helfat and Lieberman 2002).

[2]The concept of economies of scope can be expressed as follows: $C(X, Y) < C(X) + C(Y)$, where $X$ and $Y$ are two activities, and $C$ is the cost of carrying out these activities. Economies of scope exist if the cost of jointly conducting $X$ and $Y$ is smaller than the sum of costs incurred when each is conducted separately (Carlton and Perloff 2005).

[3]In line with Hoetker (2006), we expect that although market efficacy will improve over time, integrative challenges will remain. Also, as noted previously, certain aspects of asset specificity will remain nontrivial. Thus, although its marginal benefit will decrease as an industry evolves, prior experience may remain relevant for many transactions.

[4]Dry milling grinds the grain before water is added and produces distillers' dried grains as a coproduct along with ethanol. Wet milling separates the grain into separate components for a greater variety of coproducts (e.g., corn oil, corn gluten meal, and corn gluten feed).

[5]Currently, a few pioneers specialize in cellulosic ethanol production, testing technologies in pilot plants. We do not include such firms in our sample.

[6]See http://www.bbiinternational.com/.

[7]See http://ethanolproducer.com/.

[8]More than 50% of the firms had 10-K filings, and more than 90% maintained "history," "about us," and "partners" pages on their websites. For the few firms that do not have SEC fillings or websites, we used LexisNexis to gather historical information from general and industry-specific news articles and releases.

[9]Responses by industry participants to questions presented in Appendix B showed that frequency and uncertainty were two of the most important parameters in evaluations of enduring transaction hazard, because their urgency had not declined over the years (in contrast, the industry experts agreed that the importance of asset specificity, availability of specialized suppliers, and competition had changed). The industry participants' consensus was that ethanol producers consistently faced substantial uncertainties related to market demand for ethanol, corn/feedstock prices, and government policies. One expert even said, "Our whole business is dealing with uncertainties." The frequency with which different value chain activities were done varied over time but within each activity frequency did not substantially change over the years.

[10]Because both activity and respondent contributed to variations in ratings, we specify ICC(2, 6) for this calculation, where 2 represents two-way random effects and 6 represents the number of raters. We obtained ICC(2, 6) statistics for the ratings of frequency and uncertainty separately.

[11]Fleiss's kappa is more appropriate than Cohen's kappa when evaluations are provided by more than two judges.

[12]We note that this measure is based on questions asking for evaluation of a typical ethanol producer, not the ethanol producer to which the respondent was connected.

[13]Please refer to questions regarding changes in transaction frequency, uncertainty, and asset specificity over time in Appendix B. Although the managers did not use the term "asset specificity" per se, they all agreed that the availability of specialized suppliers, ease of setting up contractual agreements, and ability to verify quality had increased over time. Some excerpts from these responses are as follows: "In the early years, most producers sourced their own grain, marketed their own product and the technology providers were few" (on the availability of specialized suppliers). "Now it is much easier to specify contracts with external service providers, and producers can evaluate various proposals from alternative service providers" (on contractual agreements). "People running the plants are more knowledgeable and experienced to evaluate such contractual services" (on evaluating the quality of external providers' services).

[14]None of the firms in our sample were active in these activities in the ethanol industry itself prior to beginning ethanol production. Showing a pattern that fits Stigler's (1951) conception, several specialized suppliers emerged later in the industry's life (e.g., ethanol marketing and distribution), but none of them backward integrated into production.

[15]Both figures report the mean value of the independent variable, plus and minus one standard deviation.

[16]In Model 4, the variance inflation factor (VIF) for pre-entry activity-level experience is 65, and the VIF for the interaction between pre-entry activity-level experience and enduring transaction hazard is 61, both much higher than the threshold value of 10. Similarly, the condition number for this model is 37.6, higher than the threshold value of 30. We follow recent advice against mean centering as a solution for multicollinearity (Echambadi and Hess 2007).

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