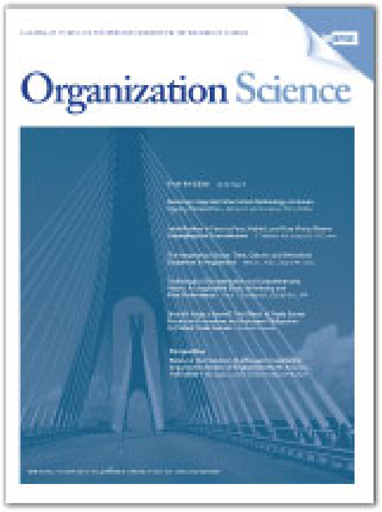
This article was downloaded by: [129.170.194.153] On: 13 September 2016, At: 13:19
Publisher: Institute for Operations Research and the Management Sciences (INFORMS)
INFORMS is located in Maryland, USA



Organization Science

Publication details, including instructions for authors and subscription information:
http://pubsonline.informs.org

The Impact of Dynamic Capabilities on Resource Access and Development

Christian Stadler, Constance E. Helfat, Gianmario Verona

To cite this article:
Christian Stadler, Constance E. Helfat, Gianmario Verona (2013) The Impact of Dynamic Capabilities on Resource Access and Development. Organization Science 24(6):1782-1804. http://dx.doi.org/10.1287/orsc.1120.0810

Full terms and conditions of use: http://pubsonline.informs.org/page/terms-and-conditions

This article may be used only for the purposes of research, teaching, and/or private study. Commercial use or systematic downloading (by robots or other automatic processes) is prohibited without explicit Publisher approval, unless otherwise noted. For more information, contact permissions@informs.org.

The Publisher does not warrant or guarantee the article's accuracy, completeness, merchantability, fitness for a particular purpose, or non-infringement. Descriptions of, or references to, products or publications, or inclusion of an advertisement in this article, neither constitutes nor implies a guarantee, endorsement, or support of claims made of that product, publication, or service.

Copyright © 2013, INFORMS

Please scroll down for article—it is on subsequent pages

INFORMS is the largest professional society in the world for professionals in the fields of operations research, management science, and analytics.
For more information on INFORMS, its publications, membership, or meetings visit http://www.informs.org

Organization Science
Vol. 24, No. 6, November–December 2013, pp. 1782–1804
ISSN 1047-7039 (print) | ISSN 1526-5455 (online)

informs
http://dx.doi.org/10.1287/orsc.1120.0810
© 2013 INFORMS

The Impact of Dynamic Capabilities on Resource Access and Development

Christian Stadler
Warwick Business School, Coventry, CV4 7AL, United Kingdom, christian.stadler@wbs.ac.uk

Constance E. Helfat
Tuck School of Business at Dartmouth, Hanover, New Hampshire 03755, constance.helfat@dartmouth.edu

Gianmario Verona
Bocconi University, Milan, Italy 20136, gianmario.verona@unibocconi.it

This study analyzes dynamic capabilities that support activities directed toward accessing resources and further developing resources to make them commercially usable. We develop theory and empirically investigate the impact of dynamic capabilities on the amount and success of these activities and whether the impact of dynamic capabilities differs between the two types of activities. Using unique data from the upstream oil industry, we develop an objective measure of dynamic capability that is distinct from the outcomes of utilizing these capabilities. We find that firms with more sophisticated dynamic capabilities undertake greater amounts of activity to access resources and further develop them prior to commercial use; they also have greater success in these activities. Finally, these effects of dynamic capabilities are larger for activities directed toward initially accessing resources than those directed toward further developing them, which is consistent with the potential for firms to rely on knowledge gained through resource access activity when conducting subsequent activity to further develop resources.

Key words: dynamic capabilities; resources; exploration; capability measurement; activities
History: Published online in *Articles in Advance* February 28, 2013.

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

Introduction

Resources that firms own, control, or have access to on a semipermanent basis affect competitive outcomes (Amit and Schoemaker 1993, Barney 1991, Helfat and Peteraf 2003, Peteraf 1993, Wernerfelt 1984). Although firms sometimes stumble on valuable resources, firms often purposefully undertake activities to obtain resources and further develop these resources prior to commercial use. In carrying out these activities, firms may use dynamic capabilities, which can serve a variety of purposes, including the creation, extension, and modification of resources (Helfat et al. 2007). In this study, we analyze dynamic capabilities directed toward obtaining resources and further developing them to the point where they are commercially usable. Although new resources frequently require additional development, research on dynamic capabilities generally has not investigated stages in bringing resources to the point of commercial use. Here, we develop a theory and empirically investigate whether dynamic capabilities affect the amount of activity that firms conduct to obtain and further develop resources, as well as the success of these two types of activities. We also investigate whether the impact of dynamic capabilities differs between these two activities.

Research on both firm resources and dynamic capabilities tends to focus on performance outcomes; however, it is important to unpack how these outcomes come about, lest we draw spurious conclusions (see, e.g., Ketchen et al. 2007). For example, dynamic capabilities may affect not only the success of activities directed toward change but also how much of these activities firms undertake in the first place—a distinction generally not addressed in prior research. Moreover, accurate assessment of the direct effect of dynamic capabilities on the success of activities requires that we control for any indirect effect through the amount and type of activity. In addition, research has yet to examine whether the effects of dynamic capabilities differ between the initial obtaining of resources and their further development. In particular, because firms may be able to rely on knowledge gained through the activity of obtaining resources when they are further developing those resources for commercial use, firms may have less need for dynamic capabilities during later stages of resource development.

Following similar usage by Wernerfelt (1984), Amit and Schoemaker (1993), and Helfat and Peteraf (2003), in this study the term "resource" denotes a tangible, intangible, or human asset that a firm owns, controls, or has access to through other means on a semipermanent basis.[1] Firms can obtain resources in many ways, including creating new resources from scratch or recombining existing resources, such as through business unit reorganization (Karim 2009); finding resources that may exist in the external environment but that the

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

firm does not possess, such as not-yet-discovered physical assets; investing in plants and equipment; and buying resources from others, including through mergers and acquisitions (Capron and Mitchell 1998). In this study, we use the term "resource access" (as a noun) to denote the obtainment of resources and "resource access activity" to denote an activity directed toward obtaining resources.[2] In addition, firms sometimes may further develop newly obtained resources, such as through a process of postmerger integration of acquired resources (Capron and Mitchell 1998). Here, the term "resource development" (used as a noun) denotes further development of resources subsequent to resource access, and "resource development activity" denotes an activity directed toward further resource development.

This study deals with access and development of resources prior to commercial use, as opposed to the day-to-day procurement of inputs for ongoing commercial activity. Commercial use of a resource begins when the resource is first used to support the production, delivery, or sales of a product or service that can be sold in the external market. This applies to intermediate as well as final products and services. For example, semiconductors are intermediate products used in computers and other devices downstream in the vertical chain; because semiconductors are products distinct from computers and other downstream products, it is possible to analyze access and development of resources for semiconductors separately.

As noted above, dynamic capabilities may underpin activities directed toward both resource access and resource development. Following Teece et al. (1997), researchers have often viewed dynamic capabilities as especially important in rapidly changing environments. But as Eisenhardt and Martin (2000) observe, dynamic capabilities also matter in "moderately dynamic" environments. In addition, Helfat and Winter (2011) note that firms can and do utilize dynamic capabilities on a regular basis, even in relatively placid environments. In this study, we examine dynamic capabilities in an industry in which the external environment shifted from relatively stable to much more variable—the upstream oil industry. Using unique hand-collected data, we analyze the extent to which dynamic capabilities affect the amount of activity that firms direct toward access and development of resources in the form of oil and gas reserves, as well as the success of these activities.

This study makes several contributions. First, we develop new theory regarding dynamic capabilities through an analysis of (1) stages of resource access and development prior to commercial use; (2) the impact of dynamic capabilities on not only the success but also the amount of these activities; and (3) how knowledge gained during resource access activity may affect the need for, and impact of, dynamic capabilities during resource development activity. In addition, we advance empirical analysis of dynamic capabilities. Such empirical research is relatively sparse and consists largely of case studies (Di Stefano et al. 2010). Quantitative measurement of capabilities has posed a number of challenges, including the difficulty of obtaining objective measures rather than those derived from surveys, as well as the difficulty of measuring capabilities separately from outcomes of capability utilization (Grant and Verona 2013). Here, we empirically test hypotheses derived from our theoretical analysis using an objective, quantitative, relatively fine-grained measure of dynamic capabilities that reflects the potential to conduct activities rather than subsequent outcomes.

In what follows, we first analyze theoretical issues relevant to our study and derive new hypotheses regarding the impact of dynamic capabilities on the amount and success of activities directed toward resource access and development, as well as differences in this impact between the two activities. We then describe the industry setting and our data, followed by an explanation of the variables, including our empirical measure of dynamic capabilities. We also explain our statistical methodology. We then present the empirical results and discuss the findings. The paper concludes with implications for future research.

Theoretical Development

Attributes of Dynamic Capabilities

Teece et al. (1997, p. 516) originally defined dynamic capabilities as "the firm's ability to integrate, build, and reconfigure internal and external competences." They explained that this included "adapting, integrating, and reconfiguring internal and external organizational skills, resources, and functional competences'' (Teece et al. 1997, p. 515). Eisenhardt and Martin (2000, p. 1107) subsequently defined dynamic capabilities as "[t]he firm's processes that use resources—specifically the processes to integrate, reconfigure, gain and release resources" and "the organizational and strategic routines by which firms achieve new resource configurations." Helfat et al. (2007, p. 4) synthesized and refined these definitions in defining dynamic capabilities as "the capacity of an organization to purposefully create, extend, or modify its resource base."

In the definition of Helfat et al. (2007), the term "resource base" includes both the resources and capabilities (also frequently termed "competences" or "skills") of an organization.[3] Additionally, "the word 'capacity' refers to the ability to perform a task in at least a minimally acceptable manner" (Helfat et al. 2007, p. 5), and "implies that the function that a dynamic capability performs is repeatable and can be reliably executed to at least some extent" (Helfat et al. 2007, p. 5). A dynamic capability therefore tends to improve the execution of an activity, relative to one-time ad hoc problem solving

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

(Winter 2003). Helfat and Winter (2011, p. 1244) elaborate that "minimally satisfactory" means that the output of a task or activity is "recognizable as such, and functions at least minimally as intended,"[4] but it "implies nothing about economic viability, much less superior performance."[5] Moreover, "because organizations vary in how well they perform an activity," the definition of dynamic capability does not constitute a tautology with respect to superior performance (Helfat and Winter 2011, p. 1244; see also Helfat et al. 2007). That is, although the definition of a dynamic capability implies the capacity to perform a particular activity at a minimally satisfactory threshold of performance, firms vary in how well their dynamic capabilities enable them to accomplish an activity; to say that a firm has a dynamic capability says little about how well that capability performs its intended function above some minimal standard of functionality or about the resulting economic performance.

An organizational capability has been described in various ways, including as a "high-level routine (or collection of routines)" (Winter 2003, p. 991). Organizational routines are executed by teams of people who understand the routines and utilize them when needed. The characteristics of routines—including the communication and coordination procedures involved—are critical attributes of a capability. A capability and its associated routines confer the potential to carry out an activity. If and when a capability is called into use, that capability enables a firm to carry out an activity, which in turn produces an outcome; through this route, capabilities affect the outcomes of activities. Like all capabilities, dynamic capabilities typically are maintained through exercise (Winter 2003). And like all capabilities, dynamic capabilities may not always be exercised at their full potential. For example, a product development team that executes the routines that comprise a dynamic capability may need to devote more effort when seeking to add many new features to a product than when seeking to add a single, easy-to-configure feature to the product. Thus, the extent to which an organization utilizes a particular capability (dynamic or otherwise) depends on circumstances, including the difficulty of the task.

What differentiates dynamic from nondynamic capabilities is the nature of the activities in question. Nondynamic capabilities, often termed "operational" or "ordinary" (Winter 2003), are directed toward maintaining the status quo. An operational capability "enables a firm to perform an activity on an on-going basis using more or less the same techniques on the same scale to support existing products and services for the same customer population" (Helfat and Winter 2011, p. 1244). In contrast, a dynamic capability is directed toward altering how a firm earns a living (Winter 2003, Helfat and Winter 2011). These capabilities have specific purposes and support specific activities within a particular context; they are not "a generic capacity to undertake change" (Helfat and Winter 2011, p. 1245; see also Winter 2003).

A firm may seek to alter how it makes a living in a variety of ways, such as by changing its products, scale of operations, production processes, or markets served, which often entails alterations in the scale and scope of resources (Winter 2003, Helfat and Winter 2011). Many activities directed toward altering the scale and scope of resources may rely on dynamic capabilities, including activities associated with research and development (R&D), new product development, investments, mergers and acquisitions, and alliances (Helfat 1997, Eisenhardt and Martin 2000, Helfat et al. 2007). Firms also may use dynamic capabilities in an effort to shape or reshape their external ecosystems (Teece 2007), including by altering the scale or scope of resources. For example, a firm may use its (dynamic) strategic planning capabilities to craft and implement an investment in a new plant (a resource) with the intention of affecting the behavior of competitors (Helfat and Winter 2011). In this study, we focus on alterations in the scale and scope of resources, and we examine the impact of dynamic capabilities on the amount and outcome of activities that firms undertake to obtain resources and, if needed, to further develop them prior to commercial use.

Helfat and Winter (2011, p. 1245) note that "although dynamic and operational capabilities differ in their purposes and intended outcomes ... it is impossible to draw a bright line" between the two types of capabilities. Which capabilities then might reasonably be termed "dynamic," in the sense that they have important dynamic aspects? Helfat and Winter (2011, p. 1249) argue that capabilities that aim to "promote economically significant change are dynamic, even if the pace of change appears slow or undramatic." They provided several examples of dynamic capabilities that support arguably nonradical yet economically significant resource change, including Intel's capability to repeatedly create new semiconductor designs and thereby support new product introductions, Walmart's capability to repeatedly open new retail outlets and thereby extend the scale of operations and the geographic scope of markets, and oil company capabilities to repeatedly discover new reserves and thereby extend the scale and characteristics of company resources. As these examples suggest, "dynamic capabilities often support existing businesses" but over time can irrevocably alter "the scale and scope of company resources," despite the seemingly gradual pace of change (Helfat and Winter 2011, p. 1249).

In some cases, resources develop over time through slow processes of resource accumulation (Dierickx and Cool 1989). Dynamic capabilities, however, may enable companies to speed up the process of developing resources, as in Intel's capability to create new semiconductor designs that resulted in the commercial

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

introduction of a new chip every 18–24 months (Helfat and Winter 2011). In many industries, the process through which resources move from inception to commercial use occurs in distinct stages. Although firms obtain some resources that need no additional development prior to commercial use, such as equipment that can be used without modification, many resources do require further development.

Examples of Dynamic Capabilities Underpinning Resource Access and Development Activities

Industries in which firms utilize a staged process of resource access and development activities include pharmaceuticals (Henderson 1994, Severi Bruni and Verona 2009), semiconductors (Leiblein and Madsen 2009), and platform product industries (Shane 2009). For example, when pharmaceutical companies seek new drugs for commercial production and sale, the process begins with research activity directed toward discovery of new molecular compounds, termed "drug discovery." Companies in this industry regularly seek to obtain resources in the form of new molecular compounds for at least two reasons. First, drugs based on new molecular compounds can provide sources of revenue and growth. Second, because drugs are significantly more profitable when they are patented than when they are not, and because patents have a limited lifetime, pharmaceutical companies regularly seek new molecular compounds. This involves screening large numbers of compounds to discover ones that may address a particular disease or health problem. In addition, firms can attempt to create new compounds through molecular manipulation. If drug discovery R&D results in a promising compound, a company may undertake additional preclinical R&D to further analyze the properties of the molecules and assess potential side effects and toxicity, conduct clinical trials in humans, and file for regulatory approval of the drug. The term "drug development" often is used to refer to activities in the preclinical and clinical stages of development, and usage of the term sometimes includes filing for regulatory approval as well.[6]

When firms regularly conduct activities directed toward drug discovery and development, they are likely to invest in developing the requisite capabilities. Such capabilities are dynamic, in that they support activities to obtain new resources (molecular compounds and knowledge) through drug discovery and modify these resources through drug development, enabling firms to extend and modify their resource bases. Although dynamic capabilities that support drug discovery and development activity can result in fundamentally new drugs, these capabilities also can enable firms to obtain and further develop molecular compounds that reflect incremental changes from the past—consistent with the observation that dynamic capabilities need not result in radical change or in qualitatively new types of resources.

The semiconductor industry provides another example of resource access followed by resource development. According to Leiblein and Madsen (2009, p. 721), "Throughout the industry's history, and particularly since the early 1980s, successive innovations in process technology have improved product performance by reducing the physical dimensions of semiconductor devices." Much of the success of this industry has come from obtaining new process technologies (resources) that firms further develop and incorporate into designs for new semiconductor devices. As an example, Leiblein and Madsen (2009) describe the company Silicon Storage Technology, Inc. (SST), which designed a flash memory chip based on its "SuperFlash" process technology.

Other industries in which resource access and development occur in stages include many product platform businesses. A product platform is "a common technological base to which different features are added, to create a family of products each targeted at different customers" (Shane 2009, p. 151). Although a detailed description of product platforms is beyond the scope of this analysis, in Shane's summary description, the common technological base can be considered a resource, which is then further developed by adding different features. Platforms are used in many industries, including automobiles, computers, cameras, video games, and websites.

The foregoing examples revolve around process technology innovation and new product development activities, which often involve stages of resource access and development. These activities are common in many sectors of the economy, including electronics, consumer products, and complex manufacturing. The empirical setting in this study provides yet another example of access and development of resources in the form of oil and gas reserves. We develop hypotheses regarding dynamic capabilities that underpin activities directed toward resource access and development prior to commercial use, and we then test these hypotheses in the upstream U.S. oil and gas industry. Ongoing commercial use of a resource involves operational rather than dynamic capabilities and is not the subject of this study.

The Amount and Success of Resource Access and Development Activities

From an economic perspective, firms conduct activities to obtain and further develop resources in order to generate profits in the future. When deciding whether to conduct specific activities directed toward resource access and development, firms make a forecast of anticipated profits to these activities (even if a rough forecast of whether or not these activities eventually may pay off), and then they decide how much effort and expenditure to devote to them.[7] As we explain next, dynamic capabilities may affect the anticipated financial payoff from

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

undertaking activities directed toward resource access and development.

Within an industry, capabilities tend to vary across firms in their attributes (Nelson 1991; Helfat 1994a, 1994b; Helfat and Peteraf 2003; Hoopes et al. 2003). The attributes of a dynamic capability, i.e., the characteristics of its routines, confer the potential to achieve a particular outcome from conducting an activity. Even when firms have the same type of dynamic capability, the cost of the capability is likely to differ across firms, because the attributes of the capability differ between firms.[8] In addition, differences between firms in the attributes of a dynamic capability are likely to lead to differences in the potential value of output (from the amount or quality of output) or the cost of conducting an activity (other than the cost of the capability itself). In the case of resource access or development, the output of an activity consists of a resource or set of resources that is obtained or developed, and costs include those of the dynamic capability as well as of conducting resource access or development activity. All else being equal, when the attributes of a dynamic capability have the potential to yield lower costs and/or higher value of output from an activity, a firm has an economic incentive to undertake more of the activity that the capability supports. Hypothesis 1 reflects this logic when applied to resource access and development.

Hypothesis 1. *All else being equal, when the attributes of dynamic capabilities confer greater potential for lower costs and/or higher value of output, firms will undertake greater amounts of activity directed toward resource access and greater amounts of activity directed toward resource development.*

Dynamic capabilities and their attributes may also affect the success of activities directed toward resource access and development, independent of an effect on the amount of activity. Certainly, if all else is equal, conducting more of these activities is likely to enable firms to obtain and further develop more resources. However, the impact of dynamic capabilities on the success of an activity does not necessarily come only from an impact on the amount of activity. In particular, because firms face variation in the opportunities available to them, different firms have different opportunities to undertake resource access and development activities. As a result, the attributes of dynamic capabilities do not perfectly predict the amount of activity that firms will undertake to obtain or further develop resources. Instead, firms with similar amounts of activity may differ in the attributes of their dynamic capabilities. Firms whose dynamic capabilities have attributes that confer the potential for lower costs and/or a higher value of output are likely to have more successful outcomes from conducting an activity. This logic implies the following.

Hypothesis 2. *All else being equal, when the attributes of dynamic capabilities confer greater potential for lower costs and/or a higher value of output, firms will have greater success in resource access and in resource development, controlling for the amount of the respective activity.*

Resource Access vs. Resource Development

Both resource access and development can pose significant challenges for firms. The more difficult it is to accomplish these activities, the more useful dynamic capabilities may be, because these capabilities provide the capacity to carry out activities somewhat reliably. Although dynamic capabilities entail costs, firms may be willing to bear them if the returns to the associated activities would otherwise be lower. For less difficult activities, firms may be able to rely more heavily on ad hoc approaches that do not entail costs associated with dynamic capabilities (Winter 2003). That is, even though ad hoc approaches may be less reliable, for less difficult tasks, the benefits conferred by dynamic capabilities may not be high enough to warrant the extra cost.

The relative difficulty of activities directed toward resource access versus resource development depends on many factors. In some cases, it may be easier to obtain a resource (such as purchasing an asset) than to develop it into a commercially usable form. In other instances, it may be at least as or even more difficult to obtain a resource (such as creating a new-to-the-world technology) than to develop it further. In at least one respect, however, the difficulty of obtaining resources and the difficulty of developing them further differs systematically. When seeking to obtain new resources, a firm generally lacks prior direct knowledge of the resources in question because it has yet to obtain them.

For example, in the pharmaceutical industry, firms engaged in drug discovery lack prior direct knowledge of new molecular compounds that they seek but have yet to discover. In contrast, when firms undertake activities to further develop or modify resources, they already have some prior direct knowledge of the resources in question (even for a purchased asset, as a result of prior due diligence). Thus, in the pharmaceutical industry, preclinical R&D activity to further develop a drug relies in part on the knowledge about a molecular compound gained during drug discovery (Severi Bruni and Verona 2009). Holding constant all other factors, the lack of this prior direct knowledge is likely to increase the difficulty of resource access (e.g., drug discovery) relative to the difficulty of resource development (e.g., drug development). Consistent with this logic, drug development activity on average has much higher rates of success than does drug discovery; this is due in part to prior direct knowledge of the compound in question during drug development (McGahan 1995).

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

In some instances, firms may have prior knowledge of resources that are similar but not identical to those that they seek to obtain. This sort of indirect prior knowledge, however, does not entirely eliminate the importance of direct knowledge of the resources in question. In the pharmaceutical industry, for example, prior knowledge of a category of drugs may make it easier to formulate new drugs in this category, but it does not appear to greatly improve knowledge about whether the newly formulated drug will actually work (Severi Bruni and Verona 2009).

These arguments imply that, if all else is equal, firms may have less need to utilize dynamic capabilities for activities directed toward resource development than resource access, because prior direct knowledge of the resources in question reduces the difficulty of developing resources relative to obtaining them. Therefore, dynamic capabilities and their attributes may have less impact on the anticipated returns to resource development activities than on the returns to resource access activities, holding constant factors other than a lack of prior direct knowledge of the resources in question. Thus, when firms decide how much activity to undertake in light of anticipated returns, the attributes of dynamic capabilities are likely to have less impact on the amount of resource development activity than on the amount of resource access activity. The following hypothesis summarizes this logic.

Hypothesis 3. *All else being equal, the attributes of dynamic capabilities will have less impact on the amount of activity directed toward resource development than resource access.*

Finally, the impact of dynamic capabilities and their attributes on the success of an activity may differ for resource access and resource development. As just argued, dynamic capabilities may be less important for resource development than for resource access because of differences in prior direct knowledge of the resources in question. Consequently, holding constant factors other than prior direct knowledge of resources and controlling for the amount of activity, the incremental impact of the attributes of dynamic capabilities on the success of activities directed toward resource development is likely to be less than for resource access. The following hypothesis reflects this logic.

Hypothesis 4. *All else being equal, the attributes of dynamic capabilities will have less impact on the success of activity directed toward resource development than on resource access, controlling for the amount of each activity.*

Empirical Setting: Upstream Oil Industry

The upstream oil industry provides an excellent setting in which to test our hypotheses. Activities in this industry fall into three categories: oil exploration, oil development, and production. Through *oil exploration*, an industry term for activities directed toward obtaining oil and gas reserves, firms seek to obtain new physical resources. Through what is termed *oil development*, firms undertake activities aimed at developing oil and gas reserves to the point where they are commercially usable. If oil development activity is successful, firms can then bring the reserves into commercial use through *production*. Because of our interest in resource access and development, this study analyzes only oil exploration and development and does not analyze extraction of reserves through production.[9]

Oil exploration and development activities have many features in common with resource access and development activities in the pharmaceutical industry. Drugs produced by the pharmaceutical industry rest on the discovery of new resources (molecular compounds); crude oil and natural gas produced by the upstream oil industry rest on the discovery of new resources (underground reserves). Like molecular compounds, no two geologic reservoirs are the same, and they often differ substantially.[10] Moreover, firms in both industries have long since exhausted the easy-to-discover resources; as a result, success in obtaining new resources in both industries is far from assured. In addition, newly discovered resources in these industries require additional resource development activity prior to commercial use, and success in further resource development is not a foregone conclusion. As in the pharmaceutical industry, resource access and development in the upstream oil industry involve activities that can benefit from dynamic capabilities, as explained in more detail below. Additionally, like firms in the pharmaceutical industry, firms in the upstream oil industry regularly conduct resource access and development activities in an effort not only to augment their revenue streams but also to replace previously highly productive resources that have fallen in value (as a result of patent expirations in the pharmaceutical industry and oil reservoir depletion in the upstream oil industry).

As often occurs in the pharmaceutical industry, activities directed toward resource access and development in the upstream oil industry do not necessarily result in radical changes to company resources, but they nevertheless may have a substantial impact on the resource base of a firm. Finch et al. (2002, p. 969) observe that "[a] critical activity for companies involved in the upstream oil and gas industry is deciding whether or not to invest in developing hydrocarbon prospects." As explained below, activities directed toward obtaining and further developing reserves in this industry rely on capabilities to deploy sophisticated and complex seismic imaging and well drilling technologies, which are key to identifying hydrocarbon reservoirs and managing their development

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

(Acha 2002). These core activities have important strategic implications. As Weston et al. (1999) note, oil companies tend to face declining stock prices when they fail to replace depleted oil reserves.

Resource Access and Development in Upstream Oil

The process that firms undergo in an effort to find and develop crude oil and natural gas reserves prior to production is as follows.[11] Companies first purchase or lease land in anticipation of searching for oil in a specific location. Then they collect and interpret seismic data regarding geologic formations underground, from which they form a preliminary estimate of the number of hydrocarbons that a tract may hold. (In some instances, firms may also be able to conduct preliminary seismic imaging studies prior to purchasing or leasing land.) Seismic technology has advanced from two-dimensional (2D) to three-dimensional (3D), and more recently to four-dimensional (4D), imaging.[12] All upstream oil firms in operation today can utilize 2D technology. 3D technology was less common in the 1990s and is becoming more standard today; 4D imaging represents cutting-edge technology, and only a small number of firms can carry out this sort of imaging.

This process of seismic imaging entails the utilization of highly sophisticated equipment in the field, along with advanced computing technology and interpretation of information gained from its use, involving the coordination of teams of geologists, geophysicists, engineers, and project management personnel. As Helfat and Winter (2011) note, the complexity and coordination of the tasks involved in seismic imaging activity, as well as its repeated nature, point to an underlying capability and associated routines.

If the results of the seismic imaging studies appear promising, firms undertake exploratory drilling to obtain additional information about how much oil a tract of land may contain. The simplest and least technologically sophisticated approach is to drill a vertical well using a rotary drill. Although this technology has been in use since the early 20th century, it is still commonly employed today because of its relatively low cost. In some cases, however, the topography of an oil reservoir makes it impossible to drill effectively using only vertical wells. In the 1940s, the first experiments took place using directional wells, which are drilled at an angle from the surface. A further advancement involved horizontal well drilling, in which wells start as vertical shafts below the surface and then deviate at an angle. Finally, the most sophisticated drilling technology is multilateral drilling, in which a drilled well starts with a single entry point and then splits into several deviated boreholes, increasing drilling reach.

The drilling of wells requires the deployment of technologically sophisticated equipment, often in physically challenging terrain. Obtaining and interpreting information from deployment of this equipment requires teams of geologists, geophysicists, and engineers. As the preceding description of some of the more sophisticated technologies indicates, these are complex and difficult tasks requiring extensive organizational coordination, suggestive of an underlying capability and set of routines for well drilling. The coordination required may include that with specialized drilling firms. Nevertheless, particularly for the more sophisticated technologies, it is difficult to interpret the results accurately without having an in-depth understanding of the technologies gained from experience using them (Stadler 2011). As a result, upstream oil companies rarely outsource all exploratory drilling activities, and upstream oil companies rather than specialist drilling firms often pioneer new drilling technologies.

If exploratory drilling indicates a high probability that a tract contains oil, firms estimate and report the number of "proved" reserves, which are defined in the United States as reserves that are predicted to be economically viable under current price and cost conditions and to have a 90% probability of successful recovery using existing technologies (U.S. Securities and Exchange Commission 1978).

Firms cannot immediately use proved reserves to produce oil and gas. Instead, they must ascertain whether tracts for which exploration activity was successful in fact contain economically viable amounts of oil and gas and then develop tracts to the point where production can occur. Firms again use the above-mentioned processes described to conduct additional seismic imaging studies to map reservoirs in detail. They then conduct additional drilling of what are termed development wells to ascertain whether the tract contains commercially viable amounts of oil or gas.

The capabilities that underpin activities directed toward resource access and development in the upstream oil industry are dynamic in that they are directed toward economically significant change. In particular, over time these capabilities can irrevocably alter the scale and scope of company resources. Seismic imaging and well drilling activities can enable firms to locate and develop reserves in what are often qualitatively new and different types of geologic formations. The capabilities that underpin these activities support augmentation and replenishment of resources, or what Helfat et al. (2007) refer to as extending and modifying resources. Over a period of years, application of these capabilities can substantially extend and reconfigure the composition of company resources that are essential for survival in the upstream oil industry. As Helfat and Winter (2011) observe, capabilities that support economically significant yet gradual change for an organization in its existing business nevertheless qualify as dynamic.

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

As the preceding description indicates, resource access and development in the upstream oil industry consist of similar activities and use similar capabilities. Although this similarity of dynamic capabilities for resource access and development does not apply in every industry, it is especially helpful for empirical testing: we can conduct particularly clean tests of the hypotheses because we can examine the impact of the same dynamic capabilities on both resource access and development.

In this industry, obtaining new resources in the form of reserves is particularly challenging. Although firms often have had prior experience undertaking such activities, they always lack prior direct knowledge of geologic formations on new tracts. Even on new tracts in close proximity to existing proved reserves, many tracts turn out not to contain hydrocarbons in economically viable quantities. In addition, as noted earlier, no two reservoirs are the same, and their features often differ substantially. As a result, even when seismic imaging studies suggest that reservoirs are promising enough to merit exploratory drilling, success at finding proved reserves is far from assured; for example, only 52% of exploratory wells in our data resulted in proved reserves. In contrast, oil field development is much less challenging, in part because firms gain a great deal of information about the geologic formations in question through the process of obtaining reserves (Stadler 2011, Stoneley 1995). In our data, for example, 91% of development wells successfully located economically viable amounts of oil and gas.

In summary, in the upstream oil industry, technologically sophisticated and organizationally complex activities directed toward obtaining and further developing reserves are likely to be underpinned by dynamic capabilities. As explained below, these capabilities vary substantially across firms, making this industry an appropriate setting in which to test Hypotheses 1 and 2. Resource development also relies heavily on prior direct knowledge of the resources in question—namely, proved reserves on specific tracts. This provides an appropriate setting in which to test Hypotheses 3 and 4 regarding the impact of the attributes of dynamic capabilities on resource access versus resource development.

Methods

Sample and Data

Our sample consists of publicly owned companies that appeared at least once in the annual list in the *Oil and Gas Journal* (the primary industry trade journal) of the largest companies (in terms of assets) operating in the upstream oil industry in the United States between 1993 and 2006.[13] We included only publicly held companies in our sample, because we could not reliably obtain financial and oil and gas-related data for privately held and state-owned companies. We also included only firms that had 30% or more of their total assets in upstream oil and gas for at least one year in which they appeared in the listing, because firms for which upstream oil and gas was not an important business might make decisions regarding upstream oil activities based on factors in their other businesses.[14] For example, an oil refining company might seek to obtain and further develop oil and gas reserves in order to ensure crude oil supply for its downstream business (Weston et al. 1999). (A lower cutoff of 25% does not substantially alter the results reported here.) Most of the excluded firms were electric utility, chemical, or oil refining companies.

Table 1 reports descriptive statistics. Our sample consists of 244 firms, including large publicly owned foreign companies such as Shell and British Petroleum that file annual reports with the U.S. Securities and Exchange Commission (SEC). The sample also includes relatively small firms: the four smallest firms in the sample, as measured by asset size in the first year for which we have data, had asset values ranging from $1,580 to $67,140. The inclusion of these firms suggests that the sample includes most publicly owned upstream oil companies with U.S. operations. The firms also vary widely in their expenditures on oil exploration and development, their proved reserves, and their operating income (EBITDA). In addition, Table 1 shows that during the sample time period, 19% of the observations are of firms that were vertically integrated into downstream operations, and 45% are of firms that had offshore oil reserves in addition to onshore reserves. Finally, most of the firms had primarily domestic reserves, with only 15% of proved reserves outside the United States.

Of the 244 firms, 44 reported data in all years in the sample. Firms exited the sample partway through the time period either because they were acquired by/merged with another firm (92 companies) or because they declared bankruptcy and ceased to operate (37 firms). The firms that entered our sample after 1993 did so for one of four reasons: (1) they resulted from mergers between firms not previously in the sample (such as privately held firms that merged and became publicly held) (28 firms), (2) they were spin-offs of other firms (6 firms), (3) they were newly established firms (24 firms), or (4) they were firms that existed previously as stand-alone entities that were not publicly held but became so partway through the sample period (63 firms).

To compile the data, we first consulted the 10-K reports (20-F reports for foreign firms) that companies file annually with the SEC, which contain financial information as well as data specific to oil and gas operations.[15] The reports also contain descriptive information regarding offshore and foreign oil operations, whether or not the firms were vertically integrated, the seismic imaging and well drilling capabilities of firms, and the backgrounds of firms that had not previously reported to the SEC. We supplemented these data with information on mergers and acquisitions (M&A) from

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

Table 1 Descriptive Statistics, 1993–2006 ($n = 1{,}897$)

Variable	Mean	Std. dev.	Min	Max
EBITDA, lagged (billion US$)	0.98	4.57	−0.14	82.20
Total reserves, lagged (thousand barrel oil equivalent)	638,973.00	2,476,297.00	0	22,400,000.00
Log(*Total reserves, lagged*)	9.98	2.90	0	16.92
Foreign reserves/Total reserves, lagged	0.15	0.29	0	1
Exploration expenditures (US$ × 0.001)	139,000.00	467,000.00	0	12,000,000.00
Log(*Exploration expenditures*)	14.61	5.64	0	23.20
Presample exploration expenditures (US$ × 0.001)	66,900.00	223,000.00	0	1,800,000.00
Log(*Presample exploration expenditures*)	14.18	5.30	0	30.14
Development expenditures (US$ × 0.001)	306,000.00	1,060,000.00	0	13,600,000.00
Log(*Development expenditures*)	15.88	4.46	0	23.33
Presample development expenditures (US$ × 0.001)	163,000.00	639,000.00	0	4,920,000.00
Log(*Presample development expenditures*)	15.06	3.68	0	27.39
Successful exploratory wells drilled	9.00	23.00	0	344.00
Log(*Successful exploratory wells drilled* × 100)	4.04	3.11	0	10.45
Presample successful exploratory wells drilled	3.50	9.00	0	60.00
Log(*Presample successful exploratory wells drilled* × 100)	2.80	2.92	0	8.70
Successful development wells drilled	94.00	222.00	0	1,972.00
Log(*Successful development wells drilled* × 100)	6.22	3.40	0	12.19
Presample successful development wells drilled	34.00	84.00	0	472.00
Log(*Presample successful development wells drilled* × 100)	4.80	3.39	0	10.76
CEO with upstream expertise only, lagged	0.28	0.45	0	1
CEO with both upstream and nonupstream expertise, lagged	0.37	0.48	0	1
Dynamic capability, lagged	3.83	1.38	2	7
Nonintegrated, lagged	0.81	0.39	0	1
M&A, lagged	0.10	0.30	0	1
Offshore operations, lagged	0.45	0.50	0	1
New entrant without prior experience, lagged	0.01	0.10	0	1
New entrant with prior experience, lagged	0.04	0.20	0	1
Exit due to M&A	0.05	0.21	0	1
Exit due to bankruptcy	0.02	0.14	0	1
Crude oil price, lagged (US$ per barrel oil equivalent)	23.63	6.95	17.27	44.45

SDC Platinum. In addition, we conducted a search of media coverage using LexisNexis to obtain information on mergers and acquisitions not covered by SDC Platinum (primarily small firms or firms acquired by foreign companies), as well as reasons why firms exited the sample. We also collected data on CEO education and work experience from biographical descriptions in annual proxy statements filed with the SEC, the Marquis Who's Who database, ZoomInfo, and articles in LexisNexis. To obtain information missing from these sources, we conducted 117 brief interviews asking for factual information on CEO backgrounds, such as a CEO's university degree, with the CEOs, their spouses, administrators from the CEOs' former schools, the human resources departments of their former firms, or fellow board members.

To gather additional information on firms' seismic imaging and well drilling capabilities, we supplemented descriptive information in the 10-K and 20-F reports with articles from the *Journal of Petroleum Technology*, the *Oil and Gas Journal*, and *Geology* (the main journal of the Geological Society of America). For 188 firms for which publicly available information on capabilities was incomplete, we contacted these companies' senior technical staff to obtain factual information. For some of the larger firms, we conducted multiple interviews, because this information could not be obtained from a single informant (e.g., the head geologist provided us with information on seismic imaging, and a senior reservoir engineer did the same for drilling technology).

Estimation

All the variables were constructed using annual data. The data for the dependent variables span the years 1993–2006. We omitted 1999, because the Asian crisis caused oil prices to fall precipitously for a single year; this anomalous situation could have caused companies to lower their expenditures on activities directed toward resource access and development regardless of their dynamic capabilities. (Inclusion of this year in the sample does not change the substance of the results reported here.) To mitigate the possibility of reverse causation, most right-hand-side variables are lagged one year. This is an appropriate lag structure for the expenditure equations, in light of the decision-making processes in the upstream oil industry, in which firms finalize their budgets for each year in the last month of the preceding fiscal year (see Quick and Buck 1984, Kukalis and Jungemann 1995, Grant 2003). This lag structure also is appropriate for the regressions that analyze the success of resource access and development

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

activity, because drilling outcomes are generally reported with a lag of approximately a year from when drilling commences. Data for all dollar-denominated variables are converted to real values expressed in 2000 dollars, using the U.S. gross domestic product chain-type implicit price deflator (http://www.eia.doe.gov/aer/txt/ptb1601.html, accessed June 23, 2010).

Dependent Variables. We use two dependent variables to test Hypothesis 1: annual expenditures on oil exploration (resource access) and annual expenditures on oil development (resource development). We use expenditures to measure the amount of resource access and development activity that companies undertake, because this measure enables comparisons between companies. For example, even when companies drill wells using similar technologies, some wells may entail greater effort and cost more to drill than others as a result of differences in geologic formations and tract locations. Oil exploration expenditures include up-front payments to lease a property (e.g., from the government) or purchase land, as well as expenditures incurred during exploration activity.[16] The latter include the costs of topographical, geographical, and geophysical studies; drilling and equipment costs; and personnel costs. Oil development expenditures are incurred in fields where exploration has been successful and companies have booked proved reserves. Development expenditures include costs of seismic and land surveys, drilling of additional wells, and personnel and equipment. Expenditures on exploration and development include all expenditures in a given year, regardless of whether they are capitalized or expensed for accounting purposes.

Expenditures on oil exploration and development are highly skewed because of a few large values and many smaller values. To achieve a normal distribution, we converted the dollar values of expenditures to natural logarithms. Because some firms had zero exploration or development expenditures in some years (equivalent to a negative value in logarithmic terms), we followed a procedure similar to that suggested by Cameron and Trivedi (2009, p. 532) by first converting the zero values to a value of one dollar and then applying the natural log transformation (resulting in a natural log value of zero).[17]

In a second set of regressions that tests Hypothesis 2 regarding the success of upstream oil resource access and development activity, we use measures of success that are directly traceable to these activities. The industry metric for the success of oil exploration and development activity is the number of wells drilled for which oil was found, termed "successful wells drilled." To measure the success of resource access activity, we use the number of successful exploratory wells drilled; these are wells for which proved reserves are booked, because they are anticipated to contain economically viable amounts of oil. To measure the success of resource development activity, we use the number of successful development wells drilled; these are wells for which the presence of commercially viable amounts of oil is confirmed.[18] Like expenditures, the distribution of the number of successful wells of both types is highly skewed, and some firms have zero successful wells in some years. We therefore used the same procedure as for expenditures to convert the number of successful exploratory and development wells to natural logarithmic values (for a similar approach, see Acs et al. 2002, Leiblein and Madsen 2009). Because of data limitations, we are unable to assess the impact of dynamic capabilities on financial performance. Available measures of financial performance, such as return on assets or Tobin's q, depend on factors other than upstream oil exploration and development that are difficult to control for (notably, oil production) and include nonupstream businesses for some firms.

Explanatory Variable: Attributes of Dynamic Capability. Our explanatory variable captures the attributes of dynamic capabilities that have the potential to affect the value of output (namely, oil and gas reserves) from resource access and development activities. As explained earlier, these activities rely heavily on seismic imaging and well drilling technologies. To develop a proxy measure of the attributes of dynamic capabilities, we used the technological sophistication of a firm's seismic imaging and well drilling technologies. Key attributes of a capability are the characteristics of its routines, and as noted earlier, the use of both imaging and well drilling technologies is likely to entail a set of routines. In addition, for a set of routines to qualify as a capability, the routines must be sufficiently reliable to serve as a basis for regular use. In the upstream oil industry, to say that a technology can be used on a reliable basis means that, at a minimum, the technology can be used in full-scale applications, which are large-scale projects aimed at obtaining and further developing oil and gas reserves that have commercial potential. Because mistakes in using a new imaging or drilling technology in projects at full scale can be extremely costly, firms generally conduct pilot (test) projects on a small scale first. Only when the firm's use of the technology has reached a level of reliability sufficient for full-scale applications does the company deploy the technology in such projects. (This was confirmed during interviews with company personnel.) Thus, we focus on technologies used in full-scale projects.

Seismic imaging technologies have a hierarchy of sophistication, as do well drilling technologies. Within each hierarchy, use of a more sophisticated technology requires a thorough understanding of the less sophisticated ones.[19] Nevertheless, more sophisticated technologies require somewhat different routines than less sophisticated ones, because the technologies differ. For

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

example, use of 3D imaging technology requires walking through a room of images, whereas 2D technology does not. Greater technological sophistication provides greater potential to locate and develop new reserves, because firms can conduct oil exploration and development in a wider range of geologic formations. As a result, the extent of technological sophistication, as a proxy for attributes of dynamic capabilities, provides an indicator of the potential value of output of using these capabilities (i.e., reserves). Although we are unable to directly measure the costs of deploying dynamic capabilities, in the empirical analysis we control for firm-level effects and other factors that are likely to capture some of these costs.

In constructing a measure of the attributes of dynamic capabilities for each firm in each year, we began by identifying the year in which a firm first utilized each level of technological advancement for seismic imaging (2D, 3D, and 4D imaging) and for well drilling (vertical, directional, horizontal, and multilateral drilling) in a full-scale application. Given that oil exploration and development is ongoing in upstream oil companies, once a firm starts to deploy one of these technologies in a full-scale application, it generally retains its knowledge of the technology in subsequent years.[20] (This was confirmed in the interviews.) Therefore, for each level of technological sophistication in imaging or well drilling, a firm was coded as having this attribute in the first year of full-scale use and all subsequent years.

To create a summary variable for the attributes of each firm's dynamic capabilities in each year, we first assessed the level of technological sophistication per firm for imaging and drilling separately. Firms that had never conducted seismic imaging or well drilling would have received a value of 0 for the level of sophistication of each technology, but no firms fell into this category. For drilling, firms that possessed only the least sophisticated technology of vertical drilling received a value of 1, firms that also had directional drilling technology received a value of 2, firms with horizontal drilling technology received a value of 3, and firms with multilateral drilling technology received a value of 4. For seismic imaging, firms that possessed only the least sophisticated technology (2D imaging) received a value of 1, firms with 3D technology received a value of 2, and firms with 4D technology received a value of 3.

Although imaging and drilling are distinct from one another and entail different technologies and knowledge bases, the two activities are interdependent. In particular, well drilling utilizes the results from prior seismic imaging, but imaging alone does not determine drilling outcomes. Because these two technologies work in concert, we combined imaging and drilling into a single measure of the attributes of dynamic capabilities.

As noted at the start of this paper, empirical research on capabilities has often lacked data with which to construct objective rather than subjective measures of capabilities. Our measure clearly is objective, rather than derived from survey data. Even when researchers have been able to utilize objective measures, these have sometimes taken the form of a single binary $(0, 1)$ variable that indicates whether a firm possesses a capability of a particular type (Grant and Verona 2013). The measure that we use is finer-grained, in that it incorporates a scale associated with level of technological sophistication. Our measure of the attributes of dynamic capabilities also has the advantage that it does not reflect how successfully firms have used these technologies beyond a minimal threshold of initial deployment. Instead, by using a measure that reflects key underlying attributes of dynamic capabilities, we capture the potential for a firm to obtain and develop new resources. In particular, as noted above, firms with more technologically sophisticated capabilities for seismic imaging and well drilling have the potential to undertake a broader range of projects than firms with less sophisticated capabilities. This greater technological sophistication in turn provides the potential to locate and develop new resources with a greater quantity and/or quality of output. Note, however, that technological sophistication is measured independently of the amount and success of resource access and development activity.

Control Variables. The regressions include several variables that control for influences other than dynamic capabilities on the amount and success of resource access and development activity. Table 2 explains the reasons for including each control variable in the regressions and the construction of each variable. The regressions for oil exploration and development expenditures contain controls for crude oil price, CEO expertise, total number of reserves, type of reserves (foreign, U.S. offshore, U.S. onshore), availability of internal funds (cash flow), integration into downstream operations, new entrant status, firm exit, merger and acquisition activity, and fixed firm effects through a presample dependent variable. The last item is explained in more detail below. The regressions for the success of oil exploration and development control for expenditures on each activity and include all the control variables in the expenditure regressions except oil price, cash flow, and integration, because these do not directly affect whether drilled wells yield oil. We do not include dummy variables for individual years as controls, because they are highly correlated with oil prices in the expenditure regressions and with expenditures in the success regressions. The time period of our analysis, 1993–2006, covers a period of relatively stable oil prices and a more variable period with sharply increasing output prices.[21]

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

Table 2 Control Variables

Variable	Description
	Expenditure regressions
Crude oil price (lagged)	Firms generally spend more to locate reserves and develop them when the price of the eventual output is higher. Annual crude oil price is measured as the U.S. year-end refiner acquisition cost of crude oil per barrel, available from the U.S. Energy Information Agency.[a] Refiner acquisition cost reflects how much a firm can earn from selling a barrel of crude oil to refiners in the United States and is a composite price for imported and domestic oil.
CEO expertise (lagged)	Because exploration and development of oil and gas reserves is both expensive and critical to firm performance, top management is likely to play a role in decisions regarding these activities. In making these decisions, top managers may rely on their accumulated expertise. Because complete information on the educational backgrounds and work experience of the entire top management team for upstream oil companies is not available, we collected data on CEOs. Research shows that CEOs can have a significant impact on firm performance in general (e.g., Daily et al. 2000, Bertrand and Schoar 2003) and in the oil industry in particular (Adner and Helfat 2003). For education, we were able to code the types of degrees that CEOs had received, which fell into three categories: (1) technical (primarily engineering, geology, geophysics), (2) nontechnical (primarily business, finance, economics, and law), and (3) both (typically, a technical degree plus an MBA). For prior work experience, the only information that we could obtain for the entire sample pertained to the functional areas and/or divisions in which the CEOs had previously worked, based on their prior titles and the descriptions of their careers. From this information, we were able to ascertain whether a CEO had any upstream work experience. We also could ascertain whether the CEO had prior staff experience (including finance), which we denote as nonupstream experience. These data enabled us to create three binary (0, 1) variables: (1) *CEO with upstream expertise only*, for CEOs with only technical education and upstream experience (28% of the executives); (2) *CEO with nonupstream expertise only*, for CEOs with only nontechnical education and nonupstream experience (36% of the executives); and (3) *CEO with both upstream and nonupstream expertise*, for CEOs with a mix of educational backgrounds and work experience (36% of the executives). We include the first and third variables in the regressions because these CEOs have upstream oil expertise. The reference case (and omitted variable) is *CEO nonupstream expertise only*.
Logarithm of total reserves (lagged)	Firms with greater upstream assets may engage in greater oil exploration and development activity. Not all firms report assets for their upstream operations, and publicly reported asset values do not include an estimated value of oil and gas reserves. Therefore, we use the number of proved reserves at year end as a proxy for upstream asset size. In addition, for development expenditures, because firms conduct development activity only for proved reserves, the number of reserves directly controls for the potential that each firm has to undertake new development. Because the distribution of total reserves is skewed, we use natural logarithmic values, computed using the same procedure as for expenditures.
Foreign reserves/Total reserves (lagged) and *Offshore operations* (lagged)	Firms differ in the types of reserves that they hold. Some geologic formations are more difficult to explore and develop than others; this tends to vary by geographic location. Some of the most promising locations for exploration and development are outside the United States or offshore. Exploration and development of foreign reserves also is subject to different laws and regulations than in the United States. To measure the relative importance of foreign reserves for each firm, we divided the number of proved foreign reserves by total proved reserves at year end. Unlike for foreign reserves, firms do not report the number of U.S. offshore reserves. To ascertain whether firms had offshore operations and reserves, we read the description of operations for all firms in the 10-K and 20-F reports and confirmed this in the interviews that we conducted with companies. Based on this information, we coded a binary (0, 1) variable indicating whether each firm had offshore reserves in each year. The omitted variable is that for U.S. reserves onshore.
Cash flow (lagged)	The availability of internal funds may affect spending on exploration and development. We use *EBITDA* to measure cash flow available to fund operations (Compustat item 13). Because EBITDA often has negative values, it is not converted to logarithms.
Level of integration (lagged)	All else being equal, firms that concentrate on upstream operations may be more likely than firms with more diverse operations to undertake larger amounts of exploration and development. We coded a binary (0, 1) variable to indicate whether firms had nonupstream activities (a value of 1 indicates that a firm had only upstream operations, or were *nonintegrated*), based on the description of operations in the 10-K and 20-F reports and information obtained from LexisNexis. (We were unable to construct a quantitative measure of the extent of integration, because firms were not required to report relevant asset data on a divisional basis. An alternate measure based on revenues would overestimate the size of downstream operations drastically because of accounting conventions.)

RIGHTSLINK Copyright Clearance Center

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

Table 2 (cont'd)

Variable	Description
New entrant with prior experience (lagged) and *New entrant without prior experience* (lagged)	When firms first enter a market, they may behave differently from established firms. New entrants to the sample were of two qualitatively different types: those that previously existed in some form (including as part of another company) and those that were completely new to the world. Based on data in the 10-K and 20-F reports and information from LexisNexis, we coded two binary (0, 1) variables indicating whether a firm was in each of the foregoing categories. The new entrant variables have a value of 1 only for the year of entry of a firm; because the variables are lagged, they reflect entry in the year prior to the year of observation for the dependent variables. These dummy variables also control for any partial-year reporting of other lagged right-hand-side variables such as income for new entrants. The omitted variable and reference case is for firms that were not new entrants in a given year.
Exit due to M&A and *Exit due to bankruptcy*	Firms that cease to exist might behave differently in anticipation of ending operations as a stand-alone company in their last full year of existence. (Firms do not report information to the SEC in their final year of existence if they exit midyear, as most companies do.) We coded two binary (0, 1) variables: one for firms that exited through bankruptcy in the following year and one for firms that exited via merger or acquisition in the following year. The omitted variable and reference case is for firms that did not exit the sample in a given year.
M&A (lagged)	Firms may behave differently in years when they make acquisitions or merge with another company. For example, this could result in additional costs that might affect the availability of funds for exploration and development. Consistent data on the size of acquisitions are difficult to obtain, in part because companies in this industry often acquire private firms or firms from abroad. We therefore coded a binary variable (0, 1) to indicate whether the firm completed any mergers or acquisitions in each year.
Presample dependent variable	This variable is included as a control for firm-level fixed effects. For each firm, this variable is the one-year lag of the first year in which the dependent variable is included in the sample.
	Successful wells drilled regressions
Logarithm of expenditures on oil exploration or oil development (lagged)	All else being equal, firms that undertake more resource access or development activity are likely to have more success in each activity. For each activity, we therefore control for expenditures in the prior year. The expenditure variables for oil exploration and development are calculated in the same way as the dependent variables in the expenditure regressions.
CEO expertise (lagged)	Because top management may play a role in deciding which projects firms undertake, which in turn may affect the success of resource access and development activity, we control for CEO expertise.
Logarithm of total reserves (lagged)	Large upstream companies may have preferred access to tracts of land awarded by governments or national oil companies, which control some of the most promising reserves worldwide. These entities often use a noncompetitive process to award exploration and development rights and frequently have a preference for large, well-known companies with a track record of undertaking large-scale projects. The number of total reserves serves as a proxy for scale of upstream assets.
Foreign reserves/Total reserves (lagged) and *Offshore operations* (lagged)	The type of reserves may affect drilling success. Some foreign reserves may present richer opportunities for successful drilling than onshore U.S. reserves in particular. Other foreign reserves are in difficult locations for exploration and development (e.g., the Siberian tundra). The technologically challenging nature of offshore exploration and development could decrease drilling success. However, U.S. offshore fields often have larger anticipated reserves than U.S. onshore fields.
New entrant with prior experience and *New entrant without prior experience*	New entrants could differ from established firms in the success of their activities. For example, for equivalent amounts spent on exploration or development, new entrants could have fewer successful wells drilled than established firms because they are still trying to establish efficient procedures.
Exit due to M&A and *Exit due to bankruptcy*	Firms that cease to exist might behave differently in anticipation of ending operations as a stand-alone company in their last full year of existence. This may affect the success of resource access and development activity. For example, personnel may not work so hard in firms on the verge of bankruptcy.
M&A (lagged)	Firms may behave differently in years when they undertake mergers or acquisitions, which could affect the success of resource access and development. For example, if oil exploration and development staff must coordinate integration of an acquired firm, they may devote less attention to resource access and development, reducing their success. Alternatively, if an acquired firm has performance-enhancing procedures that an acquiring firm can easily adopt, this may improve success.
Presample dependent variable	This is included as a control for firm-level fixed effects. For each firm, this variable is the one-year lag of the first year in which the dependent variable is included in the sample.

[a]See U.S. Energy Information Administration (2012).

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

Statistical Methods

Because the dependent variables in the regressions cannot take on negative values and are censored at 0, we use Tobit maximum likelihood estimation. We use random effects Tobit estimation to control for firm-level effects that the included right-hand-side variables may not capture. Because the value of the capability variable changes slowly within firms over time, we cannot estimate standard fixed effects regressions, because this would make it impossible to estimate the capability effects. In addition, standard fixed effects estimation cannot be used for Tobit analysis.[22] Instead, to control for firm-level fixed effects, we include a presample dependent variable on the right-hand side of the regressions. Blundell et al. (1995) suggest this approach for situations in which traditional fixed effects estimation cannot be used. Blundell et al. (1995) apply this approach to dynamic panel regressions for count data. Following Blundell et al. (1995), a number of studies in management have used a presample dependent variable to control for fixed effects (e.g., Ahuja and Katila 2001, Ziedonis 2004). The presample variable is the same (that is, fixed) for all observations of an individual firm. As Ahuja and Katila (2001, p. 204) note, the presample dependent variable provides an instrument that "serves as a 'fixed-effect' for the firms in the panel and helps to partial out unobservable differences across firms." Blundell et al. (1995) use three years of data prior to the start of the sample to construct a presample dependent variable. Because of data limitations, in our study the presample dependent variable is the value of this variable in the year immediately preceding the first year in which the dependent variable for each firm appears in the sample. We also conduct a robustness test that controls for firm-level fixed effects using ordinary least squares, as explained later.

Because there is a lag between the time when firms conduct activities for resource access and development and the time when the success of each of these activities is known (about a year on average), this implies a recursive system of equations, such that firms first make expenditures directed toward resource access and development and subsequently learn how successful each of these activities were. When equations are recursive, the error terms are uncorrelated, and therefore the regression for the amount of each activity can be estimated independently of the regression for the success of each activity (Pindyck and Rubinfeld 1998). All regressions are estimated using Stata 11.

Results

Table 3 reports correlation coefficients for the variables in the regressions. Our explanatory variable for the attributes of dynamic capabilities is positively correlated with several control variables. We calculated the variance inflation factor (VIF) for this variable when used

Table 3 Correlation Matrix ($n = 1,897$)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1 *EBITDA, lagged* (billion US$)	1.00																	
2 Log(*Total reserves, lagged*)	0.42	1.00																
3 *Foreign reserves/Total reserves, lagged*	0.38	0.44	1.00															
4 Log(*Exploration expenditures*)	0.23	0.56	0.25	1.00														
5 Log(*Development expenditures*)	0.28	0.76	0.27	0.57	1.00													
6 Log(*Successful exploratory wells drilled*)	0.26	0.61	0.27	0.69	0.58	1.00												
7 Log(*Successful development wells drilled*)	0.27	0.79	0.23	0.55	0.77	0.59	1.00											
8 *CEO with upstream expertise only, lagged*	0.05	0.00	0.02	−0.01	0.01	0.01	−0.02	1.00										
9 *CEO with both upstream and nonupstream expertise, lagged*	0.03	0.11	−0.01	0.07	0.08	0.07	0.13	−0.48	1.00									
10 *Dynamic capability, lagged*	0.36	0.53	0.31	0.46	0.50	0.49	0.45	0.03	0.09	1.00								
11 *Nonintegrated, lagged*	−0.38	−0.43	−0.33	−0.21	−0.31	−0.22	−0.35	−0.06	−0.07	−0.26	1.00							
12 *M&A, lagged*	0.07	0.22	0.06	0.15	0.17	0.21	0.20	0.00	0.05	0.12	−0.04	1.00						
13 *Offshore operations, lagged*	0.23	0.53	0.35	0.41	0.42	0.44	0.34	−0.02	0.01	0.47	−0.15	0.12	1.00					
14 *New entrant without prior experience, lagged*	−0.02	−0.11	−0.04	−0.06	−0.06	−0.06	−0.09	0.00	0.03	−0.05	0.05	−0.01	−0.07	1.00				
15 *New entrant with prior experience, lagged*	−0.04	−0.18	−0.07	−0.17	−0.20	−0.16	−0.16	−0.02	0.01	−0.15	0.07	−0.04	−0.11	−0.02	1.00			
16 *Exit due to M&A*	−0.03	0.06	0.00	0.00	0.07	0.03	0.07	0.02	−0.01	0.03	0.03	0.03	0.04	−0.02	−0.05	1.00		
17 *Exit due to bankruptcy*	−0.03	−0.08	0.02	−0.11	−0.12	−0.09	−0.11	0.01	−0.01	−0.05	0.00	−0.05	−0.06	−0.01	−0.03	−0.03	1.00	
18 *Crude oil price, lagged* (US$ per barrel)	0.11	0.00	0.01	0.08	0.09	0.11	0.07	0.02	0.00	0.23	0.04	0.04	0.02	−0.01	−0.10	−0.03	0.02	1.00

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

in conjunction with the other variables in the full models that test the hypotheses, and the results indicate that multicollinearity is unlikely to affect the regression estimates. In all cases, the VIF for the dynamic capability variable is below 1.7, well below the value of 10 or above commonly used to indicate that multicollinearity could pose a problem (see, e.g., Kutner et al. 2004). The VIF statistics for all of the other right-hand-side variables used in the full models are also low; all are below 3.65, and most values are well below 2.

Tables 4–7 report the regression results. These tables report marginal effects in addition to the coefficient estimates, because the marginal effects adjust for the number of censored observations (Greene 1997) and enable comparisons across regressions. In discussing the results, we focus on the estimated marginal effects, which are often nearly identical to the estimated coefficients. Given the number of control variables, we utilize hierarchical regressions and estimate three models per dependent variable. Model 1 includes financial and resource endowment control variables (along with the presample variable); Model 2 adds controls for other firm characteristics; and the full model, Model 3, adds the dynamic capability variable. Because of space constraints, we discuss results only for the full models.

Tables 6 and 7, which report the results of regressions for the success of oil exploration and development activity, pertain to Hypothesis 2. In both regressions, in the full models, the marginal effects of the control variables for expenditures on the activity in question, total reserves, and the presample dependent variable are positive and statistically significant. For oil exploration, merger and acquisition activity has a positive and statistically significant effect. In contrast, experienced entrant status has a negative and statistically significant effect; many of the experienced entrants were young firms that may have had less effective organizational processes for the firm as a whole, which in turn may have impaired their development activities. For oil development, exit due to bankruptcy and foreign reserves have a negative and statistically significant effect; the latter result suggests that foreign reserves were in geographic locations that were more challenging to develop.

Tables 4 and 5, which report the results of regressions for expenditures on oil exploration and development, pertain to Hypothesis 1. For both types of expenditures, in the full models, the marginal effects of the control variables for oil price, total reserves, and the presample dependent variable are positive and statistically significant, and the marginal effects of foreign reserves and experienced entrant status are negative and statistically significant. Exit via acquisition is significant (and negative) for oil exploration activity, and exit due to bankruptcy is significant (and negative) for oil development activity. Not surprisingly, firms appear to cut back on oil exploration and development activity in the year prior to exit. The marginal effect of offshore oil reserves is positive and significant only for oil exploration; the same holds for merger and acquisition activity. Surprisingly, CEO upstream expertise is negative and significant for exploration activity; perhaps when CEOs have

Table 4 Amount of Resource Access Activity (Oil Exploration) ($n = 1{,}897$)

	Model 1		Model 2		Model 3 (Full model)			
Variable	Coeff.	SE	Coeff.	SE	Coeff.	SE	Marg. effect	SE
Crude oil price, lagged	0.0847***	0.0120	0.0807***	0.0122	0.0616***	0.0129	0.0615***	0.0129
Log(*Total reserves, lagged*)	0.4340***	0.0699	0.4136***	0.0724	0.3546***	0.0728	0.3542***	0.0727
Foreign reserves/Total reserves, lagged	−1.4519**	0.6086	−1.3125**	0.6099	−1.3997**	0.6038	−1.3982**	0.6031
EBITDA, lagged	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Offshore operations, lagged	1.0120***	0.3549	1.0188***	0.3542	0.7049**	0.3579	0.7042**	0.3575
Presample dependent variable	0.6932***	0.0484	0.7043***	0.0492	0.6913***	0.0481	0.6905***	0.0480
CEO with upstream expertise only, lagged			−0.7069**	0.3494	−0.7906**	0.3467	−0.7896**	0.3462
CEO with both upstream and nonupstream expertise, lagged			−0.4006	0.3077	−0.4506	0.3054	−0.4501	0.3050
Nonintegrated, lagged			0.8198	0.6109	0.8657	0.5987	0.8645	0.5977
M&A, lagged			0.4388	0.2762	0.4574*	0.2752	0.4570*	0.2750
New entrant without prior experience, lagged			−0.6093	0.8385	−0.6783	0.8354	−0.6774	0.8340
New entrant with prior experience, lagged			−1.1883***	0.4018	−1.1504***	0.4002	−1.1485***	0.3993
Exit due to M&A			−0.7998**	0.3696	−0.9624***	0.3702	−0.9609***	0.3695
Exit due to bankruptcy			−0.6121	0.6134	−0.6788	0.6105	−0.6778	0.6095
Dynamic capability, lagged					0.4796***	0.1095	0.4791***	0.1094
Constant	3.5656***	0.8690	−2.3327**	1.1477	−2.7175**	1.1300		
Log likelihood	−4,814.2		−4,803.2		−4,793.7			

Notes. The dependent variable is log(*Oil exploration expenditures*). Models are estimated using Tobit random effects maximum likelihood.
*Significant at the 0.10 level or less; **significant at the 0.05 level or less; ***significant at the 0.01 level or less.

RIGHTSLINK

Table 5 Amount of Resource Development Activity (Oil Development) ($n = 1,897$)

	Model 1		Model 2		Model 3 (Full model)			
Dependent variable	Coeff.	SE	Coeff.	SE	Coeff.	SE	Marg. effect	SE
Crude oil price, lagged	0.0708***	0.0080	0.0679***	0.0081	0.0572***	0.0085	0.0572***	0.0085
Log(*Total reserves, lagged*)	0.8846***	0.0458	0.8887***	0.0471	0.8547***	0.0477	0.8547***	0.0477
Foreign reserves/Total reserves, lagged	−1.4211***	0.3861	−1.2735***	0.3882	−1.3328***	0.3864	−1.3328***	0.3864
EBITDA, lagged	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Offshore operations, lagged	0.0803	0.2265	0.0298	0.2263	−0.1476	0.2298	−0.1476	0.2298
Presample dependent variable	0.4694***	0.0418	0.4774***	0.0426	0.4657***	0.0424	0.4657***	0.0424
CEO with upstream expertise only, lagged			−0.0084	0.2234	−0.0604	0.2227	−0.0604	0.2227
CEO with both upstream and nonupstream expertise, lagged			0.0147	0.1985	−0.0147	0.1977	−0.0147	0.1977
Nonintegrated, lagged			0.7812**	0.3734	0.8148**	0.3709	0.8148**	0.3709
M&A, lagged			−0.0216	0.1845	−0.0101	0.1838	−0.0101	0.1838
New entrant without prior experience, lagged			0.6489	0.5500	0.6170	0.5478	0.6170	0.5478
New entrant with prior experience, lagged			−0.6279**	0.2615	−0.6059**	0.2605	−0.6059**	0.2605
Exit due to M&A			0.2750	0.2444	0.1912	0.2444	0.1912	0.2444
Exit due to bankruptcy			−0.7644**	0.3902	−0.7990**	0.3888	−0.7990**	0.3888
Dynamic capability, lagged					0.2736***	0.0714	0.2736***	0.0714
Constant	−1.5893**	0.6372	−2.3069***	0.8129	−2.4668***	0.8083		
Log likelihood	−4,290.2		−4,281.5		−4,274.22			

Notes. The dependent variable is log(*Oil development expenditures*). Models are estimated using Tobit random effects maximum likelihood.
*Significant at the 0.10 level or less; **significant at the 0.05 level or less; ***significant at the 0.01 level or less.

Table 6 Success of Resource Access Activity (Oil Exploration) ($n = 1,897$)

	Model 1		Model 2		Model 3 (Full model)			
Dependent variable	Coeff.	SE	Coeff.	SE	Coeff.	SE	Marg. effect	SE
Log(*Oil exploration expenditures, lagged*)	0.3402***	0.0227	0.3314***	0.0228	0.3142***	0.0229	0.2722***	0.0201
Log(*Total reserves, lagged*)	0.3339***	0.0499	0.3103***	0.0509	0.2644***	0.0519	0.2290***	0.0451
Foreign reserves/Total reserves, lagged	−0.5538	0.4025	−0.5800	0.4021	−0.6430	0.4002	−0.5569	0.3469
Offshore operations and reserves, lagged	0.4979**	0.2379	0.4824**	0.2375	0.3231	0.2398	0.2802	0.2081
Presample dependent variable	0.3269***	0.0572	0.3483***	0.0577	0.3476***	0.0574	0.3010***	0.0497
CEO with upstream expertise only, lagged			0.3422	0.2403	0.2845	0.2391	0.2477	0.2091
CEO with both upstream and nonupstream expertise, lagged			−0.1230	0.2118	−0.1695	0.2109	−0.1465	0.1820
M&A, lagged			0.3847**	0.1891	0.4056**	0.1880	0.3561**	0.1673
New entrant without prior experience, lagged			−0.5651	0.6518	−0.6277	0.6506	−0.5279	0.5298
New entrant with prior experience, lagged			−0.7318**	0.3359	−0.6747**	0.3334	−0.5674**	0.2715
Exit due to M&A			0.0759	0.2586	−0.0135	0.2581	−0.0117	0.2233
Exit due to bankruptcy			0.2920	0.4796	0.2223	0.4769	0.1942	0.4203
Dynamic capability, lagged					0.2704***	0.0727	0.2341***	0.0632
Constant	−6.0727***	0.4816	−5.8178***	0.5088	−5.9991***	0.5065		
Log likelihood	−3,327.8		−3,320.6		−3,313.7			

Notes. The dependent variable is log(*Successful exploratory wells drilled*). Models are estimated using Tobit random effects maximum likelihood.
*Significant at the 0.10 level or less; **significant at the 0.05 level or less; ***significant at the 0.01 level or less.

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

Table 7 Success of Resource Development Activity (Oil Development) ($n = 1{,}897$)

	Model 1		Model 2		Model 3 (Full model)			
Dependent variable	Coeff.	SE	Coeff.	SE	Coeff.	SE	Marg. effect	SE
Log(*Oil development expenditures, lagged*)	0.1571***	0.0200	0.1597***	0.0202	0.1500***	0.0203	0.1494***	0.0202
Log(*Total reserves, lagged*)	0.7271***	0.0457	0.7149***	0.0461	0.6899***	0.0464	0.6874***	0.0462
Foreign reserves/Total reserves, lagged	−1.2315***	0.3025	−1.1851***	0.3023	−1.2289***	0.3027	−1.2243***	0.3016
Offshore operations and reserves, lagged	−0.1545	0.1763	−0.1622	0.1759	−0.2675	0.1787	−0.2665	0.1781
Presample dependent variable	0.2770***	0.0379	0.2721***	0.0380	0.2707***	0.0383	0.2697***	0.0381
CEO with upstream expertise only, lagged			−0.0255	0.1739	−0.0674	0.1741	−0.0672	0.1735
CEO with both upstream and nonupstream expertise, lagged			0.2368	0.1545	0.2128	0.1544	0.2120	0.1538
M&A, lagged			0.1380	0.1415	0.1430	0.1408	0.1425	0.1403
New entrant without prior experience, lagged			−0.2532	0.4714	−0.2576	0.4690	−0.2564	0.4666
New entrant with prior experience, lagged			0.1029	0.2141	0.1270	0.2130	0.1266	0.2123
Exit due to M&A			0.1276	0.1873	0.0733	0.1872	0.0731	0.1865
Exit due to bankruptcy			−0.7522**	0.3303	−0.7928**	0.3294	−0.7878**	0.3262
Dynamic capability, lagged					0.1697***	0.0532	0.1691***	0.0530
Constant	−4.7896***	0.3529	−4.7707***	0.3756	−4.9204***	0.3778		
Log likelihood	−3,488.1		−3,482.7		−3,477.7			

Notes. The dependent variable is log(*Successful development wells drilled*). Models are estimated using Tobit random effects maximum likelihood.

*Significant at the 0.10 level or less; **significant at the 0.05 level or less; ***significant at the 0.01 level or less.

greater upstream expertise, their expertise leads them to take fewer risks and therefore to undertake less exploration activity. Neither CEO variable is significant for development activity.

Tables 4 and 5 provide support for Hypothesis 1. The marginal effect of the dynamic capability variable is positive and statistically significant in the regressions for both resource access (oil exploration) and resource development (oil development). These effects are economically important as well. The estimated marginal effects indicate that for a one-unit increase in the dynamic capability variable, expenditures on exploration increase on average by 0.48 (48%) and expenditures on development increase by 0.27 (27%). In addition, a likelihood ratio test that the effect of the dynamic capability variable is smaller for resource development (oil development) than for resource access (oil exploration) is significant at less than the 0.001 level (based on the chi-squared statistic), indicating strong support for Hypothesis 3.

Tables 6 and 7 provide support for Hypothesis 2. The marginal effect of the dynamic capability variable is positive and statistically significant for both resource access (oil exploration) and resource development (oil development). These effects are economically important as well. The estimated marginal effects indicate that for a one-unit increase in the dynamic capability variable, the number of successful exploratory wells drilled increases on average by 0.23 (23%) and the number of successful development wells increases by 0.17 (17%). In addition, a likelihood ratio test that the effect of the dynamic capability variable is smaller for resource development than for resource access is significant at less than the 0.01 level (based on the chi-squared statistic), indicating strong support for Hypothesis 4. Of note, all these results hold after controlling for any indirect effect of dynamic capabilities through expenditures on these activities.

Robustness Tests

We conducted several robustness tests. To begin, we used ordinary least squares (OLS) estimation with fixed effects as a robustness test to control for unobserved heterogeneity among firms. As noted above, the dynamic capability variable does not vary greatly over time within firms, making it difficult to use a standard fixed effects model. Therefore, following Reitzig and Puranam (2009), we employed a two-stage estimation technique to control for firm-level fixed effects. For each dependent variable, we first estimated a fixed effects OLS panel regression, omitting the dynamic capability variable and the presample variable from the right-hand side. We then regressed the firm-specific residual from the first-stage regression on the average value of the dynamic capability variable for each firm. Reitzig and Puranam (2009, p. 776) note that estimates "obtained in the second stage are unbiased in the sense that they do

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

not spuriously capture other elements of heterogeneity at the firm level." Table 8 reports the results for all four dependent variables. The dynamic capability variable is positive and statistically significant in all the regressions, providing additional support for Hypotheses 1 and 2. In addition, these results provide support for Hypotheses 3 and 4. A Chow test indicates that the coefficient on the dynamic capability variable in the second-stage regressions is statistically significantly greater (at less than the 0.01 level) for expenditures on oil exploration than for those on development, and it is also statistically significantly greater (at less than the 0.05 level) for success of exploratory wells than for development wells.

We conducted a number of additional robustness tests (detailed results are available from the authors upon request). First, to investigate whether smaller firms might have disproportionately affected the results, we reran the Tobit regressions for a subsample of firms that had more than $25 million in assets at the start of the first year in which they were in the sample. We also conducted this analysis for only firms with more than $50 million in assets. Both sets of results are substantively the same as those reported here. Second, we omitted property acquisition costs from the dependent variable in the expenditure regressions and included only expenditures directly on exploration activity. The results

Table 8 Robustness Tests Using Two-Stage OLS Estimation

	Stage 1: Dependent variables							
	Log(*Oil exploration expenditures*)		Log(*Oil development expenditures*)		Log(*Successful exploratory wells drilled*)		Log(*Successful development wells drilled*)	
Variable	Coeff.	SE	Coeff.	SE	Coeff.	SE	Coeff.	SE
Crude oil price, lagged	0.0885***	0.0116	0.0639***	0.0082				
Log(*Oil exploration expenditures, lagged*)					0.1335***	0.0136		
Log(*Oil development expenditures, lagged*)							0.0764***	0.0160
CEO with upstream expertise only, lagged	−0.7350**	0.3692	−0.0586	0.2613	0.4289**	0.2089	0.0394	0.1864
CEO with both upstream and nonupstream expertise, lagged	−0.4058	0.3161	0.0915	0.2238	0.0468	0.1785	0.3238**	0.1592
Log(*Total reserves, lagged*)	0.2367***	0.0815	0.8384***	0.0577	0.2836***	0.0460	0.6077***	0.0439
Foreign reserves/Total reserves, lagged	−1.6887**	0.6933	−0.9830**	0.4907	0.1316	0.3929	−0.3561	0.3506
EBITDA, lagged	0.0000	0.0000	0.0000	0.0000				
Nonintegrated, lagged	3.3079***	1.0633	2.0342***	0.7527				
M&A, lagged	0.4952*	0.2559	−0.0347	0.1811	0.3667**	0.1460	0.1259	0.1296
Offshore operations, lagged	0.8033**	0.3903	0.1929	0.2763	0.8625***	0.2189	0.5118***	0.1947
New entrant without prior experience, lagged	−0.6558	0.7780	0.6552	0.5507	−0.6554	0.4405	−0.1530	0.3930
New entrant with prior experience, lagged	−0.9835***	0.3563	−0.5551**	0.2522	−0.3303	0.2019	−0.0593	0.1801
Exit due to M&A	−0.7313**	0.3393	0.2581	0.2401	0.1139	0.1920	0.1213	0.1715
Exit due to bankruptcy	−0.4728	0.5408	−0.5485	0.3828	0.2378	0.3063	−0.3458	0.2739
Constant	7.7916***	1.1709	4.4209***	0.8288	−1.2515***	0.4730	−1.3435***	0.4162
	$F(243, 1,640) = 13.12$ Prob $> F = 0.0000$		$F(243, 1,640) = 8.56$ Prob $> F = 0.0000$		$F(243, 1,642) = 6.66$ Prob $> F = 0.0000$		$F(243, 1,642) = 6.90$ Prob $> F = 0.0000$	
	Stage 2: Dependent variable = *Firm-specific residual of stage 1*							
	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE	Coeff.	Robust SE
Dynamic capability (*firm average*), *lagged*	2.1806***	0.2630	0.9247***	0.1344	0.3588***	0.0818	0.1796**	0.0852
Constant	−8.4895***	1.0815	−3.6056***	0.6081	−1.3749***	0.3196	−0.7029*	0.3609
	$F(1,242) = 68.75$ Prob $> F = 0.0000$		$F(1,242) = 47.33$ Prob $> F = 0.0000$		$F(1,242) = 19.22$ Prob $> F = 0.0000$		$F(1,242) = 4.44$ Prob $> F = 0.0361$	

Notes. In Stage 1, $n = 1,897$; in Stage 2, $n = 244$. Stage 1 is estimated using OLS with fixed effects. Stage 2 is estimated using OLS with robust standard errors.

*Significant at the 0.10 level or less; **significant at the 0.05 level or less; ***significant at the 0.01 level or less.

RIGHTSLINK
Copyright Clearance Center

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

are substantively the same as those reported here. Third, in the model for exploration expenditures, we added a variable for net purchases of reserves (lagged) to control for the possibility that firms might substitute purchases of reserves for oil exploration activity. Firms can purchase reserves through purchases of land or by acquiring firms that have proved reserves; firms also frequently sell proved reserves through sales of land (Finch and Acha 2009).[23] This variable was not statistically significant. Fourth, we combined the two CEO dummy variables into one, indicating whether the CEO had any upstream expertise at all. This variable was not significant. Fifth, to investigate the possibility that CEOs might have a larger impact in smaller firms, we reran the regressions for the subsample of firms with assets values of \$25 or less. The CEO variables remained insignificant for these firms.

As a sixth robustness test, in the model for successful development wells drilled, we added a variable for successful exploratory wells drilled in the prior year to control for the possibility that firms with greater prior success in exploration might have greater development success. This variable was not significant. Seventh, in the model for development expenditures, we added a variable for prior exploration expenditures and a variable for prior exploration success, both separately and together in the same model. In these regressions, the marginal effects of these variables were positive and statistically significant, but the dynamic capability variable remained positive and statistically significant at the 0.01 level, with similar marginal effects to that reported in Table 5. Finally, we constructed an alternate dynamic capability variable for the extent of technological sophistication for seismic imaging alone. Because imaging precedes drilling, imaging might have a disproportionate impact on the amount and success of resource access and development activity. The substantive results reported earlier continue to hold. The alternate dynamic capability variable is positive and statistically significant in all the regressions, providing additional support for Hypotheses 1 and 2. The marginal effect also is substantially larger for exploration than for development, providing additional support for Hypotheses 3 and 4.

Discussion

These results demonstrate the effect of dynamic capabilities on both the amount and the success of activities directed toward resource access and development in the upstream oil industry. When firms have more sophisticated dynamic capabilities, they undertake more activity directed toward both resource access (oil exploration) and resource development (oil development), consistent with Hypothesis 1. The estimated marginal effects are statistically and economically significant. In addition, the results show that dynamic capabilities have a direct effect on the success of activities directed toward both resource access and resource development, even after controlling for the amount of each activity; this is consistent with Hypothesis 2. Again, the estimated marginal effects are statistically and economically significant.

The results also show that, not surprisingly, upstream oil companies that undertake more resource access and development activity have greater success in these activities. The expenditure variables, which reflect the amount of activity undertaken, have economically important marginal effects on the success of these activities. The marginal effect of expenditures on the success of resource access (oil exploration) is 0.27 (27%), and the marginal effect of expenditures on the success of resource development (oil development) is 0.15 (15%). The economic and statistical significance of these expenditure variables points to the importance of controlling for the amount of activity when analyzing the impact of dynamic capabilities on the success of activities directed toward change.

We can compare the direct effect of dynamic capabilities on the success of resource access and development activities with the indirect effect through the amount of activity undertaken. To estimate the indirect effect of the dynamic capability variable on the success of each activity, we can multiply the estimated marginal effect of the dynamic capability variable in each expenditure regression by the estimated marginal effect of expenditures in the associated regression for successful wells drilled.[24] For resource access (oil exploration), this indirect marginal effect is 0.13 (0.48×0.27); for resource development (oil development), the indirect marginal effect is 0.04 (0.27×0.15). This brings the combined direct and indirect marginal effects of dynamic capabilities to 0.36 for resource access and to 0.21 for resource development. The indirect effects constitute approximately 35% of the combined effects of dynamic capabilities for resource access and approximately 20% of the combined effects for resource development. Thus, the indirect effects are economically important, but the direct effects of dynamic capabilities on the success of each activity are much larger.

The results also support Hypotheses 3 and 4, that dynamic capabilities have a smaller effect on the amount and success of activity for resource development than for resource access. Our analysis provides a particularly appropriate test of these hypotheses, in that resource development in the upstream oil industry relies heavily on prior direct knowledge of oil and gas reserves gained through resource access activity. Moreover, because the same dynamic capabilities underlie activity directed toward both resource access and development, this makes it more likely that differences in the estimated effects of dynamic capabilities for the two activities stem from differences in prior direct knowledge of resources,

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

as opposed to differences in the capabilities themselves. Notably, the difference in the estimated marginal effects for resource access and resource development is sizeable. For expenditures, the marginal effect of the dynamic capability variable is 1.78 times greater for resource access than for resource development. For successful wells drilled, the marginal effect of the dynamic capability variable is 1.35 times greater for resource access than for resource development.

Of the control variables, not surprisingly, firms with more upstream assets in terms of proved reserves tended to conduct more activity directed toward resource access and development, and they had greater success. Oil prices also have a large impact on the amount of expenditures for resource access and development activity. When prices are high, firms undertake more of these activities, and vice versa when prices are low. The significance of this variable points to the importance of controlling for key factors in the external environment when analyzing the impact of dynamic capabilities. Otherwise, there is a risk of misattributing the influence of factors in the external environment to dynamic capabilities. To investigate the potential for this sort of misattribution in our setting, we omitted the oil price variable from the expenditure regressions. The estimated marginal effects of the dynamic capability variable rose substantially, particularly during the second half of the time period when prices were rising; this illustrates the danger of omitting key environmental variables.

In most of the regressions, the CEO variables were insignificant. Unfortunately, we could not obtain as precise information regarding CEO expertise as desirable. In addition, most firms had relatively few CEOs—an average of 1.7 CEOs per firm; this low variation within firms makes it more difficult to detect CEO effects in a fixed effects type of model that primarily captures variation within firms over time. Nevertheless, the results suggest that CEO expertise may be less important for resource access and development than dynamic capabilities within the organization.

This analysis used a measure of the attributes of dynamic capabilities based on uniquely detailed data specific to the industry in question. The results show that not only do dynamic capabilities have statistically significant effects but the magnitudes of the effects are economically important as well. Firms in the upstream oil industry that had more technologically sophisticated dynamic capabilities relied on them to conduct greater amounts of activity directed toward resource access and development. Dynamic capabilities also had a direct effect on the success of these activities—suggesting that dynamic capabilities may contribute to competitive advantage in resource access and development.

Conclusion

This study enhances our understanding of dynamic capabilities in several ways. First, the analysis advances our theoretical understanding of dynamic capabilities. We examine how dynamic capabilities affect stages of resource access and development in order to better understand the potential impact of dynamic capabilities on resource extension and modification. The analysis shows that dynamic capabilities are likely to affect not only the success of activities directed toward change but also the requisite investments in terms of expenditures to fund these activities. Additionally, the analysis suggests that a lack of prior direct knowledge of the resources in question may cause dynamic capabilities to have greater importance for resource access than for resource development.

Second, we empirically analyze dynamic capabilities in new ways. We separate the amount of each activity that firms undertake from the success of the activity, and we estimate the effect of dynamic capabilities on each. We also estimate the indirect effect of dynamic capabilities on the success of activities through the amount of such activities firms undertake. In addition, we analyze how the impact of dynamic capabilities may differ for resource access and development. Finally, we measure the attributes of dynamic capabilities separately from the extent of success in utilizing these capabilities.

This study has several limitations. Notably, it is limited to one industry, and future research is needed to ascertain whether the findings hold in other industries. In addition, because of data limitations, we were unable to examine the impact of dynamic capabilities on financial performance. Available measures of financial performance, such as return on assets or Tobin's q, depend on factors other than resource access and development that are difficult to control for in this industry (notably, oil production) and include nonupstream businesses for some firms.

This study contains new theoretical analysis and findings that provide a foundation for future research on the impact of dynamic capabilities on stages of resource access and development. More generally, the question of how prior direct knowledge of resources, and the difficulty of an activity in general, affects the usefulness and impact of dynamic capabilities is an issue that would benefit from future research. Our results suggest an important contingency in the study of dynamic capabilities—namely, that the impact of these capabilities may depend on the type of activity in question.

Acknowledgments

The authors gratefully acknowledge the assistance of Herold Inc. in providing them with data on the oil industry. The first author also benefited from a fellowship from the Austrian Academy of Sciences while in residence as a Visiting Scholar at the Tuck School. In addition, the authors received research funding from the Tuck School of Business and from KiTeS at Bocconi University. The usual caveat applies.

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

Endnotes

[1]As Helfat and Peteraf (2003) and Amit and Schoemaker (2013) note, "resources" can be defined to include inputs to production as well as assets. In most cases, inputs derive from assets of some type. In this study, we focus on assets.

[2]This usage is consistent with dictionary definitions such as that in the *Merriam-Webster* online dictionary (http://www.merriam-webster.com/dictionary/access, accessed February 10, 2012), where access (as a verb) means "to gain access to" or "to obtain." Firms can have access to a resource through a variety of means, including owning or controlling the use of the resource.

[3]Firm resources include tangible assets such as plants and equipment; intangible assets such as reputation, relationships, and knowledge; and human assets such as human capital (Amit and Schoemaker 1993, Grant 2005). Helfat et al. (2007) follow Amit and Schoemaker (1993) in distinguishing an asset, termed a "resource," from the ability to utilize it, termed a "capability." Teece et al. (1997) do not provide a precise definition of "competence" or "skill," and the literature contains a variety of definitions and usages of the terms "capabilities," "competences," and "skills." These terms are often used synonymously, as we do here.

[4]Helfat and Winter (2011, p. 1244) note that "important concepts rarely have edges that are entirely sharp, and this case [of dynamic capabilities] is no exception ... an important 'matter of degree' issue lurks in the words 'minimally satisfactory' and also in 'reliable.' Historical contexts and prevailing competitive standards are generally relevant to the practical interpretation here."

[5]Economic viability depends on demand for the output of an activity and on competition in the market for the product that the resource supports, in addition to at least minimally satisfactory performance of an activity (see Helfat et al. 2007).

[6]Wikipedia contributors, "Drug development." *Wikipedia, The Free Encyclopedia*. Accessed February 10, 2012, http://en.wikipedia.org/wiki/Drug_development.

[7]Although future profits from resource access depend on further development of the resources, resource access activities may have different characteristics than resource development activities, as explained below. It therefore is appropriate to analyze resource access and development separately.

[8]These costs include both fixed and marginal costs. In general, fixed costs include ongoing overhead costs as well as costs expended prior to deployment. For dynamic capabilities, the latter are often sunk (nonrecoverable) (Winter 2003).

[9]In this industry, oil and gas reserves are considered assets (or resources, in the terminology used here) and are treated this way for accounting purposes.

[10]A reservoir essentially is a "rock sponge." Hydrocarbons are trapped in the pores of the rock. Differences in reservoirs are due to the type of rock (e.g., sandstone, limestone), the structure of the reservoir (e.g., flat layers, curved, fractured rock), the depth and physical location in which the reservoir is located, the pressure in the reservoir, and the composition of the reservoir (e.g., how much water it contains). These factors result in an endless variety of reservoirs.

[11]This process is well known in the industry (see, e.g., Stoneley 1995, Finch et al. 2002, Society of Petroleum Engineers 2004).

[12]2D technology provides two-dimensional images of the subsurface. In 3D technology, three-dimensional images are presented in special rooms that enable geologists and geophysicists to literally walk in the image while they interpret the data. 4D seismic imaging adds an additional parameter of time, enabling specialists to simulate the development of a reservoir over time and calculate how production would affect a reservoir, enabling firms to better estimate the amount of oil they may be able to extract (Dubinsky and Baecker 1999).

[13]When we began data collection in early 2008, the most recent publicly available data were for 2006. Given the lagged values of the right-hand-side variables, the earliest year of data for the sample is 1992. We did not collect data for earlier years for two reasons. First, oil prices were extremely volatile in the years immediately preceding 1992, which could confound the analysis. Second, it is difficult to obtain data for the full sample of firms prior to 1992. Financial and oil and gas operating data are not available from online sources for years prior to 1992, and other sources of information this far back in time can be difficult to obtain. In addition, some of these data are not available at all farther back in time, because firms were not required to report them.

[14]Total assets that companies report do not include the estimated value of proved reserves.

[15]We obtained some data contained in these reports from Compustat (income and asset data) and from Herold Inc., a leading upstream oil research firm (data on proved oil reserves, wells drilled, and exploration and development expenditures). We obtained the remainder of the information in these reports from the SEC website via the EDGAR database.

[16]For further explanation, see U.S. Securities and Exchange Commission (1975, 1978).

[17]No nonzero expenditure values were as low as one dollar, so this transformation preserves the censoring threshold in our original data.

[18]Data are not available on the estimated amount of recoverable oil from newly drilled successful wells.

[19]Studies of the evolution of oil and gas technology that document aspects of this hierarchy include those by Graebner et al. (1981), Dubinsky and Baecker (1999), Lubinski (1950), Longbottom and Herrera (1997), and the *Journal of Petroleum Technology* (1999a, 1999b). Although firms that have the ability to deploy a more sophisticated technique also possess the ability to deploy less sophisticated techniques, a firm does not have to have experience using the less sophisticated techniques in order to deploy the more sophisticated ones. Information obtained during the factual interviews with company technical personnel described earlier also confirmed the existence and nature of such a hierarchy of technological sophistication.

[20]Most firms in the sample undertake a positive amount of either exploration or development (and often both) activity in a given year, through which they maintain their capabilities. Although some firms may not use each technology every year, use of more advanced technologies enables firms to maintain their capabilities for less advanced technologies (as explained in endnote 19). In addition, if firms fail to maintain their capabilities through use of the technologies, we will not find empirical support for our hypotheses.

[21]Crude oil prices remained largely within a relatively stable \$20–\$30 per barrel range from 1992 to 1998, before temporarily dipping below \$10 per barrel during the Asian financial

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

crisis of 1999. Annual average oil prices then rose in fits and starts from \$20 per barrel in mid-2000 to more than \$50 per barrel at the end of 2006.

[22]Wooldridge (2002, p. 541) provides an alternate technique for obtaining consistent coefficient estimates that control for fixed effects in Tobit regressions. Because this technique relies on the use of per-firm mean values of the right-hand-side variables, which are highly correlated with the slowly changing capability variable, we cannot use Wooldridge's technique for the same reasons as noted in the text.

[23]The net purchases variable is calculated as additions of new proved reserves through land purchases or company acquisitions minus proved reserves sold through land sales. Because net purchases of reserves can be negative as a result of sales of reserves, the values are not converted to natural logarithms.

[24]By definition, the first derivative of well drilling success with respect to dynamic capabilities via expenditures (the indirect marginal effect) equals the first derivative of well drilling success with respect to expenditures (the marginal effect of expenditures on well drilling success) multiplied by the first derivative of expenditures with respect to dynamic capabilities (the marginal effect of dynamic capabilities on expenditures).

References

Acha VL (2002) Framing the past and future: The development and deployment of technological capabilities by the oil majors in the upstream petroleum industry. Ph.D. thesis, University of Sussex, Brighton, UK.

Acs ZJ, Anselin L, Varga A (2002) Patents and innovation counts as measures of regional production of new knowledge. *Res. Policy* 31(7):1069–1085.

Adner R, Helfat CE (2003) Corporate effects and dynamic managerial capabilities. *Strategic Management J.* 24(10):1011–1025.

Ahuja G, Katila R (2001) Technological acquisitions and the innovation performance of acquiring firms: A longitudinal analysis. *Strategic Management J.* 22(3):197–220.

Amit R, Schoemaker P (1993) Strategic assets and organizational rent. *Strategic Management J.* 14(1):33–46.

Amit R, Schoemaker P (2013) Resources and capabilities. Teece DJ, Augier M, eds. *The Palgrave Encyclopedia of Strategic Management* (Palgrave Macmillan, Basingstoke, Hamphire, UK). Forthcoming.

Barney J (1991) Firm resources and sustained competitive advantage. *J. Management* 17(1):99–120.

Bertrand M, Schoar A (2003) Managing with style: The effect of managers on firm policies. *Quart. J. Econom.* 118(4):1169–1208.

Blundell R, Griffith R, Van Reenen J (1995) Dynamic count data models of technological innovation. *Econom. J.* 105(429):333–344.

Cameron AC, Trivedi PK (2009) *Microeconometrics Using Stata* (Stata Press, College Station, TX).

Capron L, Mitchell W (1998) Bilateral resource redeployment and capabilities improvement following horizontal acquisitions. *Indust. Corporate Change* 7(3):453–483.

Daily CM, Certo ST, Dalton DR (2000) International experience in the executive suite: The path to prosperity? *Strategic Management J.* 21(4):515–523.

Dierickx I, Cool K (1989) Asset stock accumulation and sustainability of competitive advantage. *Management Sci.* 35(12):1504–1511.

Di Stefano G, Peteraf MA, Verona G (2010) Dynamic capabilities deconstructed: A bibliographic investigation into the origins, development, and future directions of the research domain. *Indust. Corporate Change* 19(4):1187–1204.

Dubinsky VS, Baecker DR (1999) An interactive drilling-dynamics simulator for drilling optimization and training. *J. Petroleum Tech.* 51(2):46–47.

Eisenhardt KM, Martin JA (2000) Dynamic capabilities: What are they? *Strategic Management J.* 21(10–11):1105–1121.

Finch J, Acha V (2009) Making and exchange of a second-hand oil field, considered in an industrial marketing setting. *Marketing Theory* 8(1):45–66.

Finch JH, Macmilan FE, Simpson GS (2002) On the diffusion of probabilistic investment appraisal and decision-making procedures in the UK's upstream oil and gas industry. *Res. Policy* 31(6):969–988.

Graebner R, Wason C, Meinardus H (1981) Three-dimensional methods in seismic exploration. *Science* 211(4482):535–540.

Grant RM (2003) Strategic planning in a turbulent environment: Evidence from the oil majors. *Strategic Management J.* 24(6): 491–517.

Grant RM (2005) *Contemporary Strategy Analysis*, 5th ed. (Blackwell, Malden, MA).

Grant RM, Verona G (2013) Measuring organizational competence. Teece DJ, Augier M, eds. *The Palgrave Encyclopedia of Strategic Management* (Palgrave Macmillan, Basingstoke, Hampshire, UK). Forthcoming.

Greene WH (1997) *Econometric Analysis*, 3rd ed. (Prentice-Hall, Upper Saddle River, NJ).

Helfat CE (1994a) Firm-specificity in corporate applied R&D. *Organ. Sci.* 5(2):173–184.

Helfat CE (1994b) Evolutionary trajectories in petroleum firm R&D. *Management Sci.* 40(12):1720–1747.

Helfat CE (1997) Know-how and asset complementarity and dynamic capability accumulation: The case of R&D. *Strategic Management J.* 18(5):339–361.

Helfat CE, Peteraf MA (2003) The dynamic resource-based view: Capability lifecycles. *Strategic Management J.* 24(10): 997–1010.

Helfat CE, Winter SG (2011) Untangling dynamic and operational capabilities: Strategy for the (n)ever-changing world. *Strategic Management J.* 32(11):1243–1250.

Helfat CE, Finkelstein S, Mitchell W, Peteraf MA, Singh H, Teece DJ, Winter SG (2007) *Dynamic Capabilities: Understanding Strategic Change in Organizations* (Blackwell, Malden, MA).

Henderson R (1994) The evolution of integrative capability: Innovation in cardiovascular drug discovery. *Indust. Corporate Change* 3(3):607–630.

Hoopes DG, Madsen TL, Walker G (2003) Why is there a resource-based view? Toward a theory of competitive heterogeneity. *Strategic Management J.* 24(10):889–902.

Journal of Petroleum Technology (1999a) Horizontal and multilateral wells: Increasing production and reducing overall drilling and completion costs. *J. Petroleum Tech.* 51(7):20–24.

Journal of Petroleum Technology (1999b) Seismic technology: Evolution of a vital tool for reservoir engineers. *J. Petroleum Tech.* 51(2):22–28.

Karim S (2009) Business unit reorganization and innovation in new product markets. *Management Sci.* 55(7):1237–1254.

RIGHTSLINK

Downloaded from informs.org by [129.170.194.153] on 13 September 2016, at 13:19 . For personal use only, all rights reserved.

Ketchen DJ Jr, Hult TM, Slater SF (2007) Toward greater understanding of market orientation and the resource-based view. *Strategic Management J.* 28(9):961–964.

Kukalis S, Jungemann M (1995) Strategic planning for a joint venture. *Long Range Planning* 28(3):46–56.

Kutner MH, Nachtsheim CJ, Neter J (2004) *Applied Linear Regression Models*, 4th ed. (McGraw-Hill Irwin, Chicago).

Leiblein MJ, Madsen TL (2009) Unbundling competitive heterogeneity: Incentive structure and capability influences on technological innovation. *Strategic Management J.* 30(7):711–735.

Longbottom J, Herrera I (1997) Multilateral wells can multiply reserve potential. *Amer. Oil Gas Reporter* 40(9):53–58.

Lubinski A (1950) A study of the buckling of rotary drilling strings. *API Drilling and Production Practices* (American Petroleum Institute, Washington, DC), 178–215.

McGahan A (1995) The pharmaceutical industry in the 1990s. HBS Case 9-796-058, Harvard Business School, Boston.

Nelson RR (1991) Why do firms differ, and how does it matter? *Strategic Management J.* 12(S2):61–74.

Peteraf MA (1993) The cornerstones of competitive advantage: A resource-based view. *Strategic Management J.* 14(3):179–191.

Pindyck RS, Rubinfeld DL (1998) *Econometric Models and Economic Forecasts*, 4th ed. (Irwin/McGraw-Hill, Boston).

Quick A, Buck N (1984) *Strategic Planning for Exploration Management* (Prentice-Hall, Boston).

Reitzig M, Puranam P (2009) Value appropriation as an organizational capability: The case of IP protection through patents. *Strategic Management J.* 30(7):765–789.

Severi Bruni D, Verona G (2009) Dynamic marketing capabilities in science-based firms: An exploratory investigation of the pharmaceutical industry. *British J. Management* 20(S1):S101–S117.

Shane S (2009) *Technology Strategy for Managers and Entrepreneurs* (Pearson Prentice Hall, London).

Society of Petroleum Engineers (2004) Petroleum reserves and resources definitions. Accessed June 23, 2010, http://www.spe.org/industry/reserves.php.

Stadler C (2011) Process innovation and integration in process oriented settings: The case of the oil industry. *J. Product Innovation Management* 28(7):44–62.

Stoneley R (1995) *Introduction to Petroleum Exploration for Non-Geologists* (Oxford University Press, Oxford, UK).

Teece DJ (2007) Explicating dynamic capabilities: The nature and microfoundations of (sustainable) enterprise performance. *Strategic Management J.* 28(13):1319–1350.

Teece DJ, Pisano G, Shuen A (1997) Dynamic capabilities and strategic management. *Strategic Management J.* 18(7):509–533.

U.S. Energy Information Admistration (2012) Crude oil prices (collars per barrel). *Petroleum Marketing Monthly* (February) http://www.eia.gov/pub/oil_gas/petroleum/data_publications/petroleum_marketing_monthly/current/pdf/pmmtab1.pdf.

U.S Securities and Exchange Commission (1975) Financial accounting and reporting for oil and gas producing activities pursuant to the Federal securities laws and the Energy Policy and Conservation Act of 1975. Rule 17 CFR §210.4-10, Securities and Exchange Commission, Washington, DC.

U.S. Securities and Exchange Commission (1978) Financial accounting and reporting by oil and gas producing companies. Statement of Financial Accounting Standards 19, Department of Energy, Washington, DC.

Wernerfelt B (1984) A resource-based view of the firm. *Strategic Management J.* 5(2):171–180.

Weston JF, Johnson BA, Siu JA (1999) Mergers and restructuring in the world oil industry. *J. Energy Finance Development* 4(2):149–183.

Winter SG (2003) Understanding dynamic capabilities. *Strategic Management J.* 24(10):991–996.

Wooldridge JM (2002) *Econometric Analysis of Cross Section and Panel Data* (MIT Press, Cambridge, MA).

Ziedonis RH (2004) Don't fence me in: Fragmented markets for technology and the patent acquisition strategies of firms. *Management Sci.* 50(6):804–820.

Christian Stadler is an associate professor of strategic management at Warwick Business School. He received his Ph.D. from the University of Innsbruck in Austria. His research interests include dynamic capabilities, ambidexterity, and corporate diversification.

Constance E. Helfat is the J. Brian Quinn Professor in Technology and Strategy at the Tuck School of Business at Dartmouth. Her research focuses on firm capabilities and knowledge, with an emphasis on technological innovation and firm adaptation and change. She also has conducted research on corporate executives, including women executives.

Gianmario Verona is the Telecom Italia Mobile Professor of Market Innovation at Bocconi University, where he is also a member of the faculty of the SDA Bocconi School of Management. His research interests include dynamic capabilities, knowledge integration, and open and user innovation.

RIGHTSLINK