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ANALYSIS

Strategic partnering in oil and gas: A capabilities perspective

Rodrigo Garcia [a], Donald Lessard [b,*], Aditya Singh [c]

[a] Technology and Public Policy Program, MIT, USA
[b] MIT Sloan School of Management. 100 Main Street, Cambridge, MA 02142, USA
[c] New Ventures and Asset Management, Total Exploration & Production, France

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ABSTRACT

A firm's strategy typically is defined in terms of its position in the industry or landscape that operates in and the competitive advantage of the firm on that landscape. This competitive advantage, in turn, derives from a combination of assets (what the firm owns) and capabilities (how the firm does what it does). While the image of the oil and gas industry is that it is all about assets, competitive advantage generally results from a combination of tangible assets, capabilities, and intangible assets such as reputation and intellectual property (IP). The types of capabilities that are most likely to set one firm apart from others in a highly competitive field like oil and gas are complex bundles of complementary capabilities that are required to solve key challenges and that are hard to develop and emulate, particularly when the challenges are new and require new bundles of capabilities. Thus, the differentiating capabilities may be integrative, dynamic, or both. This paper identifies a set of integrative dynamic capabilities that are emerging as differentiators in the oil and gas industry and discusses what these imply for partnering at the company and asset levels.

1. Introduction

The petroleum industry faces challenges of intensifying demands for delivery of both shareholder value and increased output to meet global demand for hydrocarbons, while at the same time ameliorating its environmental and social impact. While the image of the oil and gas industry is that competitive advantage results from tangible assets, in fact it generally results from a combination of tangible assets, capabilities, and intangible assets such as reputation and intellectual property (IP). As chronicled by Zuckerman in *The Frackers* [1], the latest chapter of extraction from shale formations with horizontal drilling and hydraulic fracturing is the result of a combination of assets - land acreage, which in some cases was inherited from earlier business models but in many was the result of a capability of amassing acreage without drawing undue attention — and dynamic drilling and completion capabilities.

The types of capabilities that are most likely to set one firm apart from others in a highly competitive field like oil and gas are complex bundles of complementary capabilities that are required to solve key challenges and that are hard to develop and emulate, particularly when the challenges are new and require new bundles of capabilities.

Even without the specter of climate change, the oil and gas industry is highly dynamic given the inexorable requirement to replace reserves, particularly as the most accessible reserves are exploited first and new opportunities typically involve greater technical challenges, institutional challenges, or both. With increased environmental scrutiny, these challenges become even more complex and dynamic, as resources must be extracted with an eye to both economic efficiency and an environmental footprint that may include local contamination, local social and economic displacement, water use, and greenhouse gas emissions.

Taking the long view, most firms defined solely by extraction will eventually become extinct, as exploitation of carbon producing fuels must ramp down.[1] Even before then, extractive firms may have to

* Corresponding author.
E-mail address: dlessard@mit.edu (D. Lessard).

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[1] IEA's World Energy Outlook [45] estimates that in order to have a 50% chance of limiting the rise in global temperatures to 2 °C, only a third of current fossil fuel reserves can be burned before 2050. The balance could be regarded as "unburnable".

position themselves as clean(er) energy service firms in order to maintain their public legitimacy and sustainable competitiveness, even as they also continue to seek to effectively identify and develop new reserves.

Even those firms whose central focus remains finding and extracting fossil fuels are seeing old sets of capabilities - such as advanced exploration techniques, complex drilling and completion, or processes for assuring safety in operations and the health and safety of employees and adjoining communities - becoming "qualifiers" and no longer differentiating, while new capabilities - such as industrializing the production of hydrocarbons from distributed sources while significantly reducing surface and environmental footprints, rapidly and safely prototyping and proving new technologies at scale, diversifying into new sources of energy, or creating inclusive supply and distribution infrastructures in new regions that engage local talents and entrepreneurship beyond the usual "local content" model — are becoming the new differentiators.

Recognizing that the future is not predetermined, the purpose of this essay is not to provide a crystal ball regarding exactly which suite of capabilities-based strategies will be viable going forward, as this will result from a complex and unpredictable interaction of technological progress, innovation and collaboration in the oil and gas business, public policy, markets, social opinion, the physical realities of climate change. Rather, it is to define the types of capabilities required to meet the various technical and institutional challenges (Section 2), to explore various bundles of capabilities that are emerging and/or that may be called for and the resulting scope and type of organization of firms that possess them (Section 3), and the way that this will play out in partnerships at the asset level (Section 4).

2. Capabilities as the bedrock of strategy in the oil and gas industry

The first layer of capabilities that help the firm drive its operations are usually referred to as operational capabilities that underpin the firm's potential to perform an activity "on an on-going basis using more or less the same techniques on the same scale to support existing products for the same customer population" [2].[2] Operational capabilities are best practices that start in one or two companies and then spread to the entire industry [3]. It is important to emphasize that operational capabilities can entail a dimension of values that hinder innovation and limit the firm's chances of moving beyond its common practice [4].

The types of capabilities that are most likely to set one firm apart from others in a highly competitive field like oil and gas are complex bundles of capabilities that are required to solve key challenges and that are hard to develop and emulate. Further, the ability to create such bundles is itself a capability. Kogut and Zander [5] define "combinative capabilities" as the ability of firms to generate new applications from existing knowledge. These higher order capabilities have become known as dynamic capabilities [6—11]. Dynamic capabilities are defined as what makes a firm distinct from others by sustaining competitive advantage based on a unique combination of resources [9,12,13]. However, dynamic capabilities have to be more than just what the firm happens to do well. To be considered as capabilities they must be intentional and repeatable [14].

Dynamic capabilities are grounded in the resource-based view (RBV) framework, which claims that competitive advantage is obtained through distinctive bundles of resources. Nevertheless, the RBV does not take into account that the major strategic challenge of the firm is to sustain competitive advantage over time by continuously realigning its capabilities. Dynamic capabilities enhances the RBV of the firm through a repetitive process of integrating resources as a response to the rapidly changing environments [11], which helps the firm continuously learn and reinvent its value chain.

Parallel to the concept of dynamic capabilities, Henderson and Clark have developed the concept of architectural competences that enable the firm to integrate and deploy component competences in new and flexible ways (without necessarily changing the core components). These architectural competencies are difficult to build, may depend on the way the core competences are structured, are difficult to adapt, and as a result can have important consequences for competitive advantage [15—17].[3] From our perspective and considering the oil and gas industry, it is important to merge Henderson and Clark's architectural perspective with the concept of dynamic capabilities in order to emphasize the importance of integrating and recombining core concepts and components at a system level.

Integration takes many forms. In oil and gas it often takes place within the project, in the early stages of opportunity assessment and concept selection, during the FEED stages, during execution, and then during the handoff to operations. It also must work across projects in technology and multiple field development programs. Stage gates are major points of integration, but so are other periodic integration activities focused on value and/or safety. Frontier projects typically are lumpy. So expertise must be integrated across the firm and deployed when opportunities arise. Further, projects are embedded in particular regions with their own supply, commercial, regulatory, and community dynamics, but must draw on common expertise, and experience. Integration also takes place at the level of the supply chain both for technology and quality, and finally at the full ecosystem level including setting standards and integrating the co-creators. In some instances, such as those described by Am and Heiberg [18], this dynamic integration is catalyzed by government initiative, while in others it is led by individual firms but almost always requires some scaffolding of trust and facilitating legislation to thrive.

Both operational and dynamic capabilities can be integrative, as explained by Helfat and Winter, who state that "integrative capability may be dynamic or operational, depending on the nature of the capability and its intended use." [19] Therefore, even though dynamic capabilities as defined by Teece, Pisano, and Shuen [17] are integrative, we maintain the distinction between the two dimensions.

We therefore propose that capabilities can be considered to be integrative dynamic capabilities (IDCs) when they involve system-level orchestration of different elements in order to sustain competitive advantage. Our concept of IDCs is a synthesis of the resource-based view (RBV)[4] — combining "complex bundles" of resources and assets [7]; the dynamic capabilities perspective (DC) — "complementary sets of dynamic capabilities" [9] and architectural capabilities [15].

Drawing on these concepts, we classify capabilities on two dimensions, the degree of integration and the degree of change they entail. Table 1 illustrates these concepts for the oil and gas industry. The degree of integration refers to the extent of the system that knowledge is drawn from and/or whose behavior is influenced by bringing the different parts together, whereas the degree of change corresponds to the need for adaptation that the capability addresses.

Examples of operational capabilities (the upper left cell) in the oil and gas industry include drilling and completion or seismic acquisition and reservoir modeling, Examples of integrative but relatively static

[2] Capabilities that underpin a variety of products or businesses within the firm are often referred to as core competencies [46].

[3] Henderson and Clark initially introduced the notion of architectural competencies with respect to a multi-component product. They later generalized it to the broader organizational system.

[4] The RBV proposes that firms can be organized as bundles of resources, and that these can reach a sustainable competitive advantage once these combination of resources becomes valuable, rare, inimitable and non-substitutable [11].

Table 1
Capabilities, Degree of change, and degree of integration.

Degree of integration	Degree of change	
	Static	Dynamic
Discrete (single activity)	Operational capabilities	Simple dynamic capabilities
System (project, field, company)	Integrative capabilities	Integrative dynamic capabilities
Ecosystem	Integrative capabilities (at the ecosystem level)	Integrative dynamic capabilities (at the ecosystem level)

capabilities (middle left) include project management, process safety, global sourcing of equipment for projects, or the integration of relatively new albeit qualified technologies. Some of these integrative static capabilities may remain differentiators, but many such as safety in operations must in time become qualifiers. Integrative but relatively static capabilities at the ecosystem level (lower left) include the setting of standards and unitization/integration required for sharing infrastructure investments [18]. If a particular firm is the acknowledged standard setter it may retain an ongoing competitive advantage, but by and large these capabilities become generally available to the industry.

Dynamic capabilities differ from static ones because they enable firms to address those challenges that pose unfamiliar problems. An example of a simple dynamic capability (upper right) in the past was the ability to move from 2-D to 3 or 4-D modeling. A current example is the incorporation of geomechanics in reservoir analysis to deal with fracturing of reservoirs for production from source rock and other (tight and not so tight) reservoirs or HPHT reservoirs. Following Teece, Pisano, and Shuen [9] the dynamic capability is not the ability to do the higher order modeling, but rather the ability to bring together the various technologies and disciplines that make this possible.[5] Some simple dynamic capabilities may remain differentiators for extended periods of time as one firm leapfrogs the field with new technologies or processes, but as they often are developed in partnership by oil and gas companies and service providers for cost sharing and ease of shared use they tend to get diffused across the complex web of relationships that characterize oil and gas so that they quickly become "generally available."

Integrative dynamic capabilities (middle and lower right), involve shaping and orchestrating multiple component capabilities on a firm-wide or perhaps ecology-wide basis and are only open to those few firms able to marshal the necessary underlying capabilities and resources and to orchestrate the various components to bring about a coherent, differentiated meta capability.[6] While these are included in the broad definition of dynamic capabilities [20] as (almost) all dynamic capabilities involve some degree of combination of component capabilities, we reserve the term integrative dynamic capabilities (IDCs) for those capabilities that lead to (eco) system-level changes. Examples of IDCs are (a) a company's ability to reinvent its value chain [21,22], and (b) the ability of a company (or a complementary partnership of government and several companies as chronicled by Am and Heiberg [18] to create a new shared technology and infrastructure.

A vivid way to think about these differing types of capabilities is by analogy to cooking. A discrete static capability is the ability to prepare an ingredient; an integrated static capability is the ability to follow a recipe; while an integrative dynamic capability is the ability to create a recipe or, better yet, modify it on the run as something does not work out as planned or as circumstances change. As noted by Heiberg, our source of this analogy, "in order to meet future challenges we need to breed chefs with the ability to write recipes and not those that just follow them" [23].

Helper and Henderson provide a striking example of being able to follow a recipe vs. being able to create a recipe in the case of GM's attempt to emulate the Toyota production system [16],

> "[GM management] appeared to have believed that the essence of Toyota's advantage lay in tools like the fixtures designed to change stamping dies rapidly, or in the use of "just in time" inventory systems, rather than in the management practices that made it possible to develop and deploy these techniques."

There are several reasons why developing and exercising IDCs is difficult and rare. First, almost by definition they require a departure from the existing pecking order of disciplines and power within the firm, leading to the well-known difficulty that incumbents face in innovating radically [4,24–26]. Second, they involve multiple individual capabilities, rooted in different disciplines and expertise, and as such require an overarching systems perspective and process to put them in place. Changing them thus requires a new set of architectural perspectives.[7] Third, the sheer complexity – in terms of the number of elements, disciplines or stakeholders involved, differences among those elements,[8] interdependencies among those elements, and the dynamism of the elements—creates a higher order of difficulty and risk that only a few firms succeed in mastering.[9] Fourth, important elements and linkages often span multiple firms or stakeholders, and thus are embedded in relational contracts that are difficult to master [27]. This complexity is exacerbated by the fact that energy firms increasingly must manage to multiple objectives – shareholder value, environmental impact and trust with host societies, and safety – requiring complex tradeoffs at each level of the organization.[10]

3. Relating challenges, capabilities, and strategic choice in oil and gas

Capabilities matter strategically in that they enable firms to take on particular challenges in ways that cannot be readily matched by others. Strategy involves the choice of which challenges to take on, but the firm's existing assets and capabilities in turn inform its strategy. In this section we explore a set of the challenge-capability-strategy connections.

In order to identify and illustrate the hierarchy of capabilities and their relation to strategy, we focus on a set of challenges that oil and gas firms currently face that require that they follow or create complex recipes. We recognize that the dividing line between the two is fuzzy as almost all oil and gas projects, unless they are "copy exact" within the same geologic and regulatory context, require some degree of dynamism due to differences in geological conditions, the commercial and regulatory context, and technological progress.

Since capabilities are intangible, they cannot be readily assessed through external quantitative data. They are best observed through detailed examination of the processes of capability identification,

[5] Garcia documents several such instances as oil and gas companies diversified into geothermal energy production [47].

[6] Lessard and Miller [48] describe this shaping role in the case of major projects.

[7] While Henderson and Clark [15] refer to physical components and architectures, their framing is very similar.

[8] For simplicity, we refer only to elements but also include disciplines and stakeholders.

[9] According to Lessard, Sakhrani, and Miller [48] these features define complexity at the project level. They can be extended readily to capabilities.

[10] Greenhouse gases are not the only social concern, and may not be even the primary one with many host societies. Energy firms, whether exclusively extractive or involved in producing energy services, increasingly also are judged on their ability to engage local business and society at large, going beyond local content to local entrepreneurial engagement and value sharing.

development, and application within firms.[11] In the absence of in-depth access such as that afforded to Feiler and Teece [28], we draw on our own experience from engagement with many major oil and gas projects over the years and on generally available knowledge.

Complex recipes involve both technical and institutional dimensions. A platform like BP's Thunderhorse was extreme in its technical complexity, but fairly benign in terms of institutional challenges given that the project took place within a well-established regulatory framework in a region with a deep supply base and with well-defined operatorship. In contrast, major pipeline projects such as the now historic BTC, or the current Keystone or TXL are fairly straightforward from a technical perspective, but highly complex in terms of the institutional fields they face. Finally, many projects are complex in both dimensions. Kashagan stands out as the "mother of technical and institutional complexity" given the high pressure and toxic nature of the reservoir, its location in an environmentally sensitive region, the absence of a well developed local supply base, the relative immaturity and dynamism of the regulatory context, and the contention over operatorship given the large number of majors holding similar stakes.

3.1. Examples of capabilities

As examples, we explore six sets of challenges that oil and gas firms face[12] that differ in their technical and institutional complexity[13]:

- Extreme environments and reservoirs, which by and large represent primarily technical challenges,
- Unconventionals, which present a mix of technical and institutional challenges and where both sets of challenges are evolving as the exploration, development and operations of unconventional resources are still in a nascent stage,
- Extended/enhanced production/recovery in well-established regions which again present technical and institutional challenges,
- Integrated gas transport networks that extend across national boundaries and represent a complex combination of technical and particularly institutional challenges,
- Enhanced local economic and social engagement in new regions that present primarily institutional challenges,
- Reduced surface and environmental footprint including carbon capture & storage facilities that involve highly complementary institutional and technical challenges.

3.1.1. Extreme environments and reservoirs

A select set of IOCs, e.g. BP, Chevron, Exxon, Shell, Total,[14] and only a few NOCs, e.g. Petrobras, engage in deep/ultra deep-water developments due to the enormous capital, technological challenges, uncertainty, risks and integrative dynamic capabilities required. The same is true for developments in extreme environments such as the Arctic, where the lead is being taken by the IOCs (BP, Shell, etc.). Development in these extreme environments requires specific and integrative capabilities including identification, development, qualification and integration of multidisciplinary technologies to large-scale management of complex projects with high level of uncertainty and risks (think NASA). Developments of HP/HPHT reservoirs again are primarily led by IOCs (e.g. BP, Statoil, etc.) due to the sheer technological complexity and risks involved. Development of HPHT reservoirs requires capabilities in interdisciplinary development, qualification and management of technology, management of interfaces and integration of technologies.

Managing the supply chains of technology development and production for these large, complex projects calls for integrative capability even in relatively stable circumstances. Integrative dynamic capabilities are called for when key elements are shifted to new locations such as that experienced by the majors when platforms shifted from North Sea yards to Asian yards or as new technologies and standards are developed.

Integrative dynamic capabilities also come to the fore as the industry moves to new frontiers. For example, the key development challenges in the emerging lower tertiary play in the ultra deep water Gulf of Mexico (GOM) encompass a number of disciplines with greatly increased drilling depths in remote areas (deep subsalt reservoirs, 30 000 ft. + from sea level), higher reservoir pressures (>24 000 psi), and viscous crude trapped in low permeability reservoirs. These challenges require industry advances in several technologies such as subsalt imaging, completion and casing designs, subsea production equipment rated in access of 15 000 psi (above the current working limit of subsea equipment), subsea High Integrity Pressure Protection Systems (HIPPS), and subsea processing, for the extreme development characteristics. The fluid and reservoir characteristics will require artificial lift, and enhanced oil recovery technologies, early on in the field life, to improve the recovery factor from the reservoirs, and hence economics. It will require the design, engineering and qualification of subsea high integrity pressure protection system (HIPPS) to de-rate the subsea system downstream of the well (or else, the downstream architecture will have to be qualified for higher pressure, making the field development technically infeasible, and uneconomic).

The qualification and deliverability of these technologies, along with the development of these fields in extreme environments, miles away from the closest infrastructure, in the tough post Macondo regulatory, and political environment, requires evolved integrative dynamic capabilities. It will require static and integrative dynamic capabilities for the design and qualification of individual technologies, with superior integrative dynamic capabilities at the project and ecosystem level to lead consortia of operators, engineering contractors, and equipment suppliers, managing the interfaces, working with the regulatory authorities, and all key stakeholders for safe, reliable, acceptable, and value creating developments [29] and (re) shape the whole ecosystem.[15]

3.1.2. Unconventionals

The rapid rise in the production of unconventional oil and gas in the US is in large part the result of the creation of new recipes by independents such as Devon Energy, Pioneer Natural Resources, EOG Resources, and Continental Resources. It is now extending to other regions, and is gradually being transformed by the entry of IOCs.

Unconventional development context and challenges are characterized by large aerial extent (ex. Barnett Shale, Texas: 5000 miles^2); geological horizontal & vertical heterogeneity over short distances; oil and gas production driven by large numbers of wells & associated growth in services, equipment, manpower, infrastructure and facilities; large scale development & operations; and large environmental & surface footprint.

[11] See Garcia [47] for an in-depth micro-level study of capabilities in the entry of oil firms into geothermal in the early 1970s.

[12] See Shuen, Feiler, and Teece [20] for an extended discussion of the current context and the resulting challenges. See also [49].

[13] Following [47] we define technical complexity in terms of the number and similarity of elements and disciplines involved, the dependency among them, and the dynamics involved; and institutional complexity by the number of external stakeholders involved, the alignment of interests among these stakeholders, the dependency among the various parties, and the dynamics involved.

[14] The firms associated with each challenge in this section are intended to be illustrative, not exhaustive.

[15] Am & Heiberg [18] describe the historic collaborations among government(s) and industry in Norway's development of major breakthrough technologies and infrastructure.

Economics are driven by the identification of best 'geological' areas, technological improvements including both incremental and step changes, and operating efficiencies; with strong drivers for continuous improvement, experimentation and innovation.

Exploration, development and operations of unconventional resources require development and integration of a variety of underlying capabilities, many of which themselves could be defined as integrative dynamic capabilities. These include: early identification of core development areas; dynamic development planning; large scale development and operations; supply chain, logistics and operations optimization; drilling, completion & fracture treatment optimization; water management optimization; innovative early production systems; and a safe, acceptable, low cost, innovative, modular and standardized development framework. At the highest level, these involve working with regulators and the public in order to establish new standards to assure safety and limit environmental damage.

US independent oil and gas companies and new entrants have taken lead in accessing land, and accelerating the pace of exploration, development and operations of unconventional resources. The majors are playing catch-up to build the integrative dynamic capabilities, and the associated organizations and mindset, to create value in these manufacturing-style operations. Only now with the "second generation" improvements focused on integrated development planning and architecture, surface and environmental footprint, optimization of water management, and safety in operations can some majors compete.

Relating challenges with capabilities, some US independents have adopted innovative business models such as the vertical integration of services. They own and operate horizontal drilling rigs and pumping equipment for hydraulic fracturing. This is to control schedule, costs, and safety in the large-scale operations typically characteristic of unconventional developments. Similarly, some have backward integrated to own sand mines, to control the supply chains for critical components and keep costs down [30]. Others, such as Statoil, have partnered with industrial firms to pioneer new technologies that change the economics and environmental impact of distributed production [31].

3.1.3. Extended/enhanced production/recovery in well-developed regions

IOCs, NOCs, and independent oil & gas companies are extending the field life of producing oil and gas fields by sophisticated enhanced oil recovery techniques such as water flooding, polymer flooding, gas and C02 injection together with the development of industrial models to bring costs down, coupled with the need to manage the complexity of brownfields. Brownfields are characterized by: declining reserves and production; ageing infrastructure leading to safety and integrity issues; legacy positions leading to deep social, economic, and political embeddedness; and challenging profitability with decreasing revenues and increasing costs. Economics are driven by incremental technological improvements to increase recovery of reserves, and operating efficiencies to reduce costs. Management of brownfields requires a different set of underlying capabilities from extreme environments and unconventionals.

All of the above types of firms are trying to differentiate themselves on their enhanced oil recovery (EOR) prowess, especially since EOR not only improves value creation by increased recovery but also signals a commitment to responsible and sustainable development of resources to the shareholders and host communities. The fact that these developments take place in regions with well established oil and gas operations, and often after periods of decline, also call for a set of community facing, regulatory, and fiscal capabilities, especially since advanced recovery often requires adjustment in fiscal terms that must be justified in terms of local employment and other benefits.

3.1.4. Integrated gas transport

The creation of new integrated gas transport networks (involving LNG terminals, pipelines, and storage facilities) is led primarily by IOCs (Chevron, Total, Shell, Exxon etc) due to the integrative dynamic capabilities required. The development and operation of LNG requires underlying capabilities in: negotiations with multiple stakeholders; stringent regulatory approvals; management of engineering and design; management of global contracts; management of intercontinental supply chains; management of global vendors & manufacturers; and the management of an international team spread across different global locations. It also includes managing relationships with the governments involved, often touching on geopolitical concerns that must be addressed at the highest level within firms and governments. This in turn presents a challenge for vertical integration of decision-making within the lead firms in order to assure alignment between their grand strategies and what actually takes place on the ground.

3.1.5. Enhanced local economic and social engagement

NOCs, IOCs and some geographically-focused independent oil and gas companies, e.g. Afren plc [32], seek greater social and economic engagement; going beyond local content that is largely managed by contractors. Examples of this include Statoil's development of First Nation truckers in Alberta [33]. At a larger scale this involves the creation of industrial clusters in new regions, something that only a few firms view as a dynamic capability at home and hence one that they should be able to take to new regions e.g. Statoil given its early role as a developmental NOC. This engagement is likely to be especially important in unconventional developments as well as brownfield industrial developments, since these often are more dispersed, and thus involve deeper interactions with local communities and supply ecologies.

Going forward, enhanced local and economic engagement on the basis of intentional capabilities could be a differentiating factor for particular oil and gas companies. This would involve going beyond the standard corporate social responsibility (CSR) practices by engaging with the local community of the project to build entrepreneurial skills and implementing strategies for social value.[16]

3.1.6. Reduced surface & environmental footprint

Leadership in environmental stewardship involves primarily IOCs and some NOCs. In many cases, this emphasis varies substantially across regions. This also includes Carbon Capture and Storage (CCS), where at scale a few IOCs as well as electric energy companies are the leading experimenters.

Development and operations of projects with reduced surface and environmental footprint requires capabilities in identification, development, qualification and integration of technologies to reduce surface footprint (such as multiphase pipeline versus dual liquid and gas pipeline, minimal facilities design, unmanned facilities etc.) and environmental footprint (emissions, air quality, water quality). Again, pushing the boundaries of CCS technologies often requires collaboration with technology-based suppliers, such as that of Maersk Oil with Siemens in TriGen, a project that allows distributed economic use of high C02 content gas [34].

The notion of competing on capabilities does not apply only to majors. Independents including private equity backed companies are engaged in frontier exploration of a single geologic concept, e.g., for late cretaceous plays for Kosmos Energy [35], and for deep-water oil reservoirs trapped in subsalt and pre-salt layers for Cobalt [36]. Others, such as Afren already mentioned above, engage in social development, and many smaller firms are advancing the state of the art in managing

[16] See Ngoasongq [50] for a recent comparison of the local content practices of five IOCs.

the oil/gas-water-GHG frontier. An intriguing case in point is Pacific Rubiales in Colombia that has developed its own technology for processing produced water so that it can be used for irrigation of energy yielding crops [37].

3.2. Capabilities and strategy

Some of the DCs discussed above apply to a variety of challenges, while others are specific to a particular challenge. For example it is difficult to imagine an oil major (or NOCs or independents for that matter) that does not seek to develop/enhance the dynamic capability to effectively manage technical and non-technical risks, to improve the accuracy of subsurface volume and risk predictions, or to match human resources with their potential to preserve or add value. However, some will limit the extent of these by concentrating on well-understood regions and/or particular types of geology. Further, the organizational architectures that support them differ as well. A firm pursuing developments in multiple ultra-deep water or extreme environments will require substantial functional centralization both because of the frontier nature of the technologies involved and the lumpiness of individual projects, while firms seeking greater local economic and social engagement will require considerable local embeddedness and differentiation in various regions [38]. Only a firm that masters the centralization-localization dilemma without seeing it as a battle for the supremacy of one over the other is likely to be able to successfully pursue dynamic capabilities-based strategies at these extremes. Similarly, firms pursuing industrial type and/or extended field life developments will have to be able to manage the tradeoffs involved in simultaneously operating across different stages of the life cycle, something that is not required in frontier greenfields development. Again a firm may choose to do one or the other, but typically not both.

Strategy is about choice, and capabilities-based strategy is no exception. According to Niall Henderson of BP [39],

> "The IOC's are each positioning for growth but in different ways. For example, Shell's corporate strategy is to be a leader in global LNG, BP is heavily weighted to deep-water oil but is largely absent greenfield LNG and oil sands, and XOM is a clear leader in unconventionals following its acquisition of XTO in 2010."

We note that most integrated oil companies (IOCs) play successfully in more than one of these arenas, but only a very few in all. This contrasts with the 1990s, when being an IOC was a license for being able to pursue any opportunity or overcome any challenge, as long as it grew reserves and production. We now see that this "luxury" is being limited by increasing breadth of challenges faced as well as the new specialized entrants that have undercut the unique capabilities associated with being an IOC. Whether fad or reality, the rhetoric of the annual reports of IOCs now say much more about value and capability, and less about reserves and volume.

In some cases, the new focus represents a substantial deepening of existing capabilities, e.g. Shell with LNG or most of the IOCs with high-pressure/temperature, ultra deep water, and/or extreme locations. In others, it takes the form of dropping some existing activities, e.g. Devon, Pioneer, & Marathon exiting international and offshore in order to focus on onshore "industrial" development, or BP focusing on complex refineries and long-lived fields. Finally, it also takes the form of entry into new activities/capabilities, particularly the IOCs moving into unconventionals, e.g. Statoil and Chinese NOCs, seeking to access technology to then apply to unconventional basins worldwide or at home in China.

The pattern that we see emerging is one where the majors seek to develop certain DCs. Few if any, however, appear to be chasing all of these with equal vigor. Perhaps this is the beginning of a capabilities-centered specialization of IOCs. In fact, the traditional definition of IOC — integrated vertically across production and markets in different countries — appears to be giving way to a new definition — integrated around a set of differentiated capabilities. The old vertical integration becomes less relevant with the emergence of markets at the various vertical stages but the new integration becomes more important given the sheer complexity of the challenges faced, both individually and at the portfolio level. Independents almost by definition focus on a narrower set of challenges and DCs, gaining competitive advantage through this focus and the corresponding reduced complexity.

Capabilities accordingly (should) play a central role in value as opposed to reserves and production strategies being followed by many companies including ExxonMobil, Chevron, BP, Shell, Total, COP, Hess, and Marathon. Henderson [39] notes that these firms are divesting significant tranches of their portfolios to others that may be able to extract greater value. The value of an asset that for some reason happens by itself to have a high return can be realized either by sale or operation, and therefore is "strategy agnostic". An asset whose value to the firm is "naturally advantaged" by complementary physical assets or relationships is "locally strategic", since realizing its value would require selling the related block of assets. Assets that are advantaged because the owner exercises differential capabilities, in contrast, are the most important basis for strategy at the corporate level.

Looking forward, we expect that IDCs[17] and the groups of firms characterized by them will evolve upward in four nested tiers:

1) IDCs that improve individual business cases and company performance on an enduring basis (for example IDCs for supply chain, logistics and operations optimization in exploration, development and operations of Unconventionals; IDCs for large scale management of complex projects/architecture and uncertainties and risks in exploration, development and operations of deep water reservoirs).
2) IDCs that improve asset performance over their lifetime with dynamic changes in the value chain to maintain optimal partnerships between public and private and international and local players and interests, e.g. complementing IDCs for development & operations of projects with those required to reduce surface and environmental footprint, or IDCs for development and operations of projects with enhanced local economic and social engagement with IDCs in the case of extended/enhanced oil recovery projects or unconventionals.
3) International IDCs to mobilize and orchestrate the development of local capabilities in others countries and settings — as industrial cluster orchestrators creating a valid and enduring business case for themselves in the process, e.g. local development of supply chain, equipment, manpower and logistics to complement IDCs for exploration, development and operations of unconventionals in S. America, Europe, and Asia.
4) IDCs that actively contribute to the transformation of the larger energy system, navigating the wide swings in prices and "permissions" that will accompany it, for example IDCs to integrate development of distributed renewable energy projects with exploration, development & operations of unconventionals or with development and operations of extended/enhanced oil recovery projects).

The first of these two tiers are largely defined by specific technological challenges. Moving up through these tiers involves a greater degree of shaping of individual opportunities, local energy-supply ecosystems,[18] and the overall energy systems of regions and,

[17] For simplicity we refer only to integrative dynamic capabilities (IDCs), but include those integrative capabilities (ICs) and simple dynamic capabilities (DCs) that provide competitive advantage.

[18] For an exposition of the importance of the shaping of opportunities and projects, as well as the engineering, design, and execution of projects, see Lessard and Miller [51].

ultimately, the globe. In time, many of the integrative dynamic capabilities that address technical challenges in tiers 1 and 2 will become qualifiers or, perhaps, generally available, while those in the third and forth tiers that involve more local engagement or total system transformation will remain the prime differentiators.

Of course, the complexity of strategies that involve multiple IDCs can be addressed through partnerships as well. This already is the case with oil-field operational integration, much of which is outsourced, or the recent frame agreement between Shell and Worley—Parsons for the design and engineering of surface facilities for unconventionals [40]. Further, it could take the form of IOCs with particular IDCs, say for example subsea, becoming integrators for other major operators that do not possess this DC, at least not at the same level, but do possess perhaps more differentiating local-engagement DCs. This already is the case in aerospace where firms that are lead integrators "at home" also play a key second-tier integration role in the other countries.

4. Implications for partnering at the asset level

Oil and gas firms collaborate for two reasons – because they have to and because they want to. In a sense, all oil/gas undertakings are joint ventures with the property owners and fiscal authorities and in many cases, the national oil company. Several papers in this volume [18,41,42], describe how public and private interests can be aligned in order for such required partnerships to be more efficient for both sides.

Firms also may have to partner because although they individually have the technical and organizational capabilities to develop the assets they have acquired through exploration, asymmetric information and other issues may make it difficult for them to buy in or sell in order to simplify ownership interests. Joint ventures, unitization and similar mechanisms are long-standing solutions to allow unitary governance with distributed ownership. Further, the emergence of liquid markets for asset swaps or purchase/sales through open auctions increase the ability of companies to re-shape and optimize their portfolios and simplify asset-level engagements.

However, firms also partner because they want to. Each firm brings a different combination of capital and risk bearing capacity, capabilities, complementary physical assets, and legitimacy for access. The set of these that can be brought to bear by a set of firms often is superior to the set that any single firm can bring. If a particular asset is potentially "capabilities advantaged" for more than one firm but for different reasons, there is a clear rationale for partnering. From a capabilities perspective, a firm can be a lead/operator, a non-operating contributor of that capability, or a learner.

Many of the changes described by Shuen, Teece, and Feiler [20] and others - including increasingly limited access to easy to develop resources/assets, the resurgence of national oil companies, the advent of new geographically-focused oil and gas companies with access to assets and local political, economic, social and geologic knowledge; increased availability of E&P-focused capital through private equity, public equity, and debt; and stronger requirements for local engagement – will lead to more extensive asset level partnering that increasingly will be driven by integrative dynamic capabilities.

We observe four categories of asset-level partnering that are driven by capabilities:

1) Asset level partnering to develop/enhance resource driven IDCs. Very recent partnering by IOCs and NOCs with US independent oil and gas companies has been driven by the desire to learn the technologies and processes used in the exploration, appraisal, delineation, development and operations of shale gas and light tight oil fields in North America. The ultimate global objective of these IOCs is to master and then export the technologies, processes and best practices from N. America to other geographic locations such as S. America, Europe, China, Australia etc. where similar unconventional plays will be developed in the future. Initially, the partner assumes a non-operated learning role.[19] Examples of this type of partnering are Statoil buying into Marcellus, Eagle Ford, and Bakken and CNOOC into Eagle Ford and Niobrara. As noted by Eric Hagen of Lazard Capital Markets [43] "CNOOC is seeking access to technology more than U.S. assets."
2) Asset level partnering in order to monetize the successes of new firms with geologically focused IDCs. Start-ups and independent oil companies that are successful in frontier exploration along a geologic concept often partner (i.e. farm-out) with IOCs for early value creation and subsequent sharing of risks. The partner initially takes a non-operated role for access to resources. The larger partners may take a more active role or even the lead in the subsequent appraisal and development if it is perceived that the partner's IDCs can lead to superior value creation. Examples of this type of partnership include Statoil's entry into the Peregrino field in Brazil, smaller companies and midcaps with high equity positions in the frontier east-African plays that are reducing their exposure ahead of drilling programs, e.g. Tanzania, and changing structure of upstream partnerships, e.g. Mozambique, to include established LNG players.
3) Asset level partnering driven by complementary technical IDCs. IOCs will partner with other IOCs on development of large-technically challenging projects where each has leadership in complementary capabilities. Of course, the firm best able to meld these, an IDC in itself, will emerge with the advantage in the long run. Partners bring to the project complementary bundles of IDCs, co-lead, and share the financial and technical risks. Examples of these types of partnerships include the gas export project from Azerbaijan to Europe; the consortium of Petrobras, Shell, TOTAL, CNPC, and CNOOC Ltd to appraise and develop Brazil's giant pre-salt Libra field; and Tanzania LNG where consortia of BG/Ophir, and Statoil/ExxonMobil, owning different blocks, are evaluating a joint development for cost savings.
4) Asset level partnering driven by differentiated technical and "relational" IDCs such as those that characterize enhanced oil recovery/deep-water/extreme environments. NOCs often partner with IOCs for exploration and development and operations in deep-water or other challenging environments. The partner 'IOC' with the technical IDCs takes the lead for access to technical resources/ assets and the ability to orchestrate these complex undertakings. The NOC, in turn, takes greater responsibility for development of the local ecosystem that requires a different set of IDCs. To develop these, it may also want to partner with the same or different IOCs that have relevant experience and capabilities. It will be interesting to see how these play out in Mexico with the opening of the upstream petroleum sector.

Overall, we believe that asset level partnerships will increasingly be based on complementary capabilities rather than who accessed the asset in the first place.

5. Conclusions

We do not have a crystal ball regarding which suite of capabilities-based strategies will be viable going forward. However, we do provide a sense of various bundles of integrative dynamic capabilities that are emerging and the scope and type of organizations of firms that possess them.

The differentiation in the oil and gas companies will come not only from the assets that the firm owns but also from the dynamic

[19] Before assuming a leading role in the development and operations of unconventional resources, Statoil acquired an unconventional focused US independent and assumed learning role in two asset level partnerships.

integrative capabilities that the firm develops in order to solve the key challenges. These IDCs will determine whether the firm will be able to truly create value. Of course, over time firms will align asset portfolios and capabilities, so that it will be hard to disentangle the two.

Value creation will come from an in-depth understanding of the challenges both at the corporate and asset level and by being able to realistically assess how those challenges match with the IDCs the firm possesses. Understanding the gaps between the required IDCs and those the firm currently exercises should be a key if not the key consideration in the acquisition of new assets and the entry into asset-level partnerships.

Despite the compelling logic and numerous conceptual articles focusing on capabilities, there still is little hard evidence regarding their role in competitive performance or in shaping overall corporate strategies or asset-level partnerships. Assessing the impact of ICs, DCs, and IDCs on performance is difficult as it involves the admittedly difficult task of identifying capabilities as well as the counterfactual - what would the performance have been absent a particular (quality of a) capability. In large scale studies, this would require relating reported financial outcomes for firms such as those reported by Weijermars, Clint, and Pyle [44] to ex ante assessments of their capabilities from internal sources,[20] external expert opinion,[21] or quantitative measures associated with capabilities such as R&D expenditures.[22] Alternatively, one could assess project outcomes (timeline from access to development, schedule and cost overruns, local social and economic engagement, reduction in surface and environmental footprint, economic value added, and operational performance), identify the specific technical and institutional challenges confronted and capabilities that were brought to bear.[23] Finally, using some of the same measures, it would be interesting to determine in a more formal fashion how firms cluster into strategic groups, and whether capabilities play a central role in this grouping logic as well as whether asset-level partnerships are becoming more capabilities-centric.

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[20] Feiler-Teece [28] document the identification of DCs in one part of a super major, but they do not report the assessment of the initial "quality" of the capability or the target level.

[21] Nohria and Garcia-Pont [52] follow this approach in the auto industry.

[22] Helfat [10] used R&D expenditures as a proxy for dynamic capability of internal complementary know-how for the petroleum industry during the 1970s and early 1980s, and found that firms with a larger complementary R&D activity and complementary assets undertook larger R&D in related business fields. Denicolai, Ramirez, and Tidd [53] explore how knowledge-intensive firms (as a proxy for dynamic capability of internal know-how) define their knowledge sourcing strategy. See also Lev, Radhakrishnan, and Zhang [54] for estimates of organizational capital, which includes capabilities, and their impact on subsequent performance for a large sample of firms and Weijermars [55] for estimates of a similar construct for oil majors.

[23] Garcia [47] does this for a number of projects undertaken by Unocal and Phillips in their diversification into geothermal in the 1970s and 1980s.

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