OPTIMAL SUPPLY CHAIN MANAGEMENT

in Oil, Gas, and Power Generation

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CONTENTS

Part 2

Illustrations

Figures

Tables

Foreword

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Supply chain management tools and techniques have been adopted and applied in many industries and businesses to varying levels. In some industries, the full supply chain process is followed, and the supply chain manager is one of the main decision-makers in the organization; in others, the supply chain is only a procurement function, where a number of buyers are ensuring that goods and services are ordered and delivered. Regardless, the core role of supply chain management is to align procurement and supply with the strategic goals of the organization and to ensure that these goals are achieved in the most effective and efficient way.

The challenges in the oil and gas industry involve a continuous search for new ways to reduce time to market, streamline processes, make collaboration easier, increase revenues, and cut costs—all while delivering projects and solutions in time. However, there may be no other industry today that demands a more diverse set of human, political, mechanical, and technological capabilities than oil and gas exploration and production. The technical complexities, the high risks and the impact of these risks, the size of investments, and the continuous rising demand for energy make supply chain management in the oil and gas industry a critical activity for the success of any project in this field.

The breadth of the oil, gas, and power industries requires supply chain practitioners with diverse knowledge—not only on the business side but also on the technical side—to enable them to procure the right tools and services at the most competitive price and quality with minimum risk exposure. Technical managers and engineers require knowledge of the available supply strategies to make sound decisions regarding the technology they should use and the equipment they should request.

This book provides well-defined tools for managing today's risk and cost pressures in oil, gas, and power supply chains. These industries are growing so rapidly that conventional methods have quickly become obsolete, and projects are of such a large scale that risk sharing between owners, operators, contractors, and suppliers needs to be addressed consistently and safely. Large economic decisions have historically been made by gut feeling, but as risks and opportunities increase, our intuition needs to be supplemented by rigorous logic, reliable data, and robust analysis.

The book differs from other supply chain books in two important ways. First, it focuses on unique characteristics and requirements of the oil, gas, and power industries, offering hundreds of examples and case studies to ensure applicability and relevance to various operations. Second, it provides methodologies for making hard business decisions that involve risk, for which there have been missing or inadequate frameworks for measuring and managing that risk (hence, the reliance on instinct and intuition in the past).

The perspective and needs of producers (owners and/or operators) is emphasized. The coverage of shipping operations (in particular, LNG, with less attention to crude) is limited to a brief overview of transport management, since these are specialized areas that may not be relevant to a broad audience of readers.

Traditional logistics functions such as procurement, logistics, and materials management are discussed in detail. In addition, health, safety, environmental, and other regulatory areas are covered that have substantial interfaces with supply chain management decisions. Information technology systems (e.g., warehouse management systems, transportation management systems, and e-procurement) are discussed only in brief, as means to an end, not supply chain management ends in themselves.

The discussion of key processes covers capital expenditure planning, operating cost reduction, asset management, and risk management. Transactional issues, such as electronic data interchange and paperless work flow, are excluded to focus instead on critical supply chain projects involving capital procurement and large risk and the supply chains that support those projects.

This book will serve technical managers and engineers as a reference and guide to various supply strategies, while supply chain professionals will find it to be a comprehensive guide to most oil and gas activities. The real-life case examples provided in this book are refreshing and should provide a welcome resource for readers interested in supply in the oil and gas industry.

Preface

The Growing Importance of Supply Chain Management in Oil, Gas, and Power

In the mid-1800s in the United States, drilling and production was concentrated over only a few geographical areas, and refining was done at small-scale refineries. In the 1930s in Saudi Arabia, workers crushed minerals by hand to create drilling mud. The California-Arabian Standard Oil Company initially employed Bedouin tribes to guard their fields and supply lines, transitioning as its operations expanded to government police and eventually to private security. In 1938, before the advent of domestic refining capacity and regional pipelines, Saudi Arabia exported crude by barge to Bahrain. By the 1940s, tanker trucks were transporting oil from the production site to refineries. Each held 40–50 barrels, compared to 120–215 barrels for tanker trucks today. Pipelines were also used, but they were not the main mode of transportation. From the refinery, finished products were mostly shipped by rail.

Higher well production and improved technology eventually made pipelines the most efficient means of long-distance oil transport. Developers pioneered stronger, more durable materials and more reliable construction methods. Operators also began using electronic flow measurement, developed in-line inspection (smart pigging) and satellite corrosion monitoring, and implemented supervisory control and data acquisition systems to manage the pipelines.

The emergence of megaprojects

The current boom in investment and production—both in oil and gas and in power—has transformed supply chain management into a different game, with high stakes. Capital expenditures within the oil, gas, and power generation industries have grown at more than 15% per year since 2004, with the exception of 2009 and 2010, the years following the financial crisis and of the Macondo disaster in the Gulf of Mexico that caused a temporary shutdown of deepwater drilling.[1] Current investment in infrastructure development is impressive by historical standards. Saudi Arabia's power projects alone represent about $130 billion in total investment between 2010 and 2015.

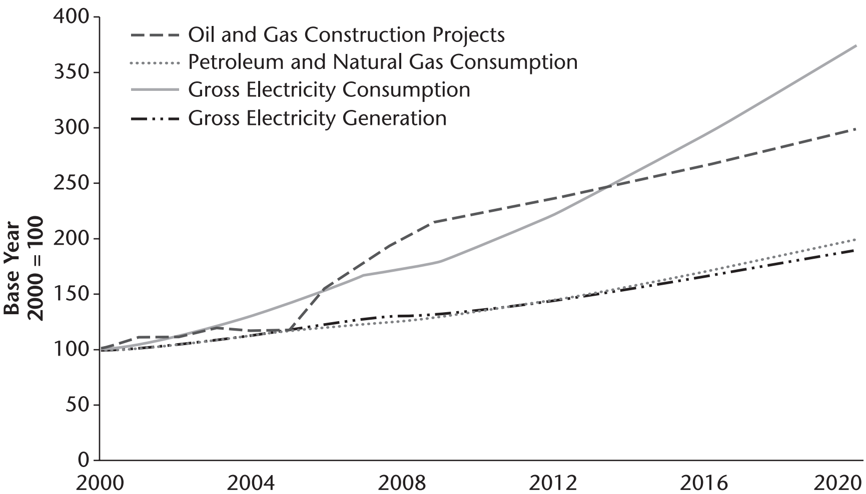

Fig. P–1. Evolution of growth in oil, gas, and electricity markets[2]

Megaprojects are underway in various countries including the United Arab Emirates, Kuwait, Qatar, and Egypt. In the Emirates, "Abu Dhabi is planning three large-scale power projects, and the government awarded a $20.4 billion contract for four nuclear reactors to a consortium led by Korea Electric Power (KEPCO) in 2009. The first reactor is expected to come onstream in 2017, and all four will be producing electricity by 2020. Kuwait is conducting the feasibility study for a $20 billion nuclear power project with France. Qatar has been busy building more conventional power infrastructure, with a $5 billion upgrade to its power transmission network including 54 new substations, a $5 billion coal-fired power plant in Raysut, and a $5 billion solar power capability. Qatar Petroleum's Ras Laffan Independent Power Project (IPP) is budgeted at about $4 billion (not counting Ras Laffan C), and Kahramaa's West Coast Independent Water and Power Plant (IWPP) will have cost about $3 billion."[3] In addition to projects in specific countries, the Gulf Cooperation Council (GCC) power grid project will link the GCC's grid, creating the opportunity for a massive smart grid, and Saudi Arabia and Egypt are working on an $8 billion, 1,370-kilometer interconnection project using overhead transmission lines.

As these and other megaprojects move through their planning, construction, and operating phases, the number of actors required to realize them has transformed supply chain management into a critical tool. All parties have to manage cost and risk up and down the value chain to meet schedule and budget projections. In the financing and planning stages, the demand or revenue forecast could be wrong.[4] At this stage, owners and financiers may also make erroneous assumptions about the cost of disposal of used fuel and radioactive waste. In the construction stage, estimates of materials and services costs may be off, and so may assumptions about exchange rates, bottlenecks at engineering, procurement, and construction contractors and subcontractors and about the extent and cost of design changes. In the operation phase, volume, seasonality, and growth curves may not be on target. Volatile and escalating electricity tariffs and fuel costs are hard to forecast. The rate of return on invested working capital and earmarked funds may be more or less than anticipated. Government regulations, such as the laws governing investment and repatriation of profits, and institutional frameworks, such as the mechanics and limits for trading electricity on the open market, may change.

New global challenges and their supply chain implications

Supply chain risks are further exacerbated by nontraditional challenges: raw material depletion, technological complexity, resource nationalism, environmental pressures, and globalization are making coordination up and down the supply chain more critical than ever.

Resource depletion has raised the cost and created shortages of critical raw materials, requiring a search for new technologies and substitute products. According to the global management consulting firm McKinsey, the 21st century needs a resource revolution akin to the labor revolution of the 20th century—during which labor productivity soared owing to information technology—to fulfill the rapidly growing needs of our global population.[5]

Water resource depletion is affecting the market for steel, which is becoming ever more critical in the oil and gas sector because of its use in huge offshore platforms and associated pipelines. The supply of iron ore is crucial to steel production and in turn relies heavily on water to reduce the ore. McKinsey notes that almost 40% of iron ore mines are in areas with moderate to high water scarcity, and a large amount of steel is produced in places where water is relatively scarce.[6]

Scarce mineral resources are driving up costs for drilling fluids and bits. The gradual depletion of barite, which is used as a weighting agent, is driving costs up dramatically. The world's identified barite reserves will be depleted in little more than a decade.[7] In addition, China, the largest barite exporting country, vowed in its latest five-year plan to restrict the environmental impact of mining for minerals such as barite and to control their export more tightly, which could drive barite prices up. Major suppliers are scouring the globe to develop alternative barite sources. Tungsten, a material used to harden drill bits and increase their durability, was in tight supply in 2008 when rig counts rose rapidly, creating both price inflation and bottlenecks. Similar to barite, the mineral is mostly mined in the interior of China and is vulnerable to supply disruptions from the country's ongoing mining-sector reforms.

Increasing technological complexity related to depletion of petroleum reserves requires fewer and larger suppliers that have the capacity, the financial resources, and the broad technical skills needed to develop the extraordinary new technology at the edge of science and to support megaprojects. Offshore and deepwater projects are unlocking huge reserves but require capital investment many times that of traditional, onshore developments. Unconventional gas projects across the United States, oil sands and heavy oil projects in Canada, drilling in the Arctic, and ultra-deepwater discoveries off the coasts of Brazil and Angola are increasing net available energy resources, but they require unprecedented capital and technology. Major research and development efforts are underway to produce heavy oil economically and to treat oil with high dissolved hydrogen sulfide content that will allow production to continue in fields across Asia and the Middle East that would have otherwise been plugged. Finally, Australian offshore natural gas deposits, such as the Icthys gas field, are extending the limits of science on a daily basis, but the conditions are so harsh that only the majors need apply.

Enhanced oil recovery is being combined with carbon capture and sequestration (CCS), which requires ultralarge compressors that only a handful of suppliers have the technology and scale to produce. Enhanced oil recovery, the method of increasing oil yield from older oil wells by injecting gases or chemicals to increase the pressure and output, has been around for years (e.g., Norway began injecting carbon dioxide into the North Sea in 1996), but the search for carbon dioxide and the injection thereof has been done on a well-by-well basis. Connection of existing sources of carbon dioxide to oil fields benefits both power generators and oil drillers: power generators get lower emissions, and oil drillers can increase recovery rates by up to 75% in some cases.[8] However, the economics of CCS are far from proven, which leaves large companies to manage the initial projects.

The application of information technology to obtain real-time intelligence about downhole conditions is helping operators to minimize fluid loss, manage flows within the reservoir, and reduce the need for interventions, thereby maximizing production. However, given the opportunity cost of well production, operators trust only suppliers with proven solutions.

Resource nationalism is propelling a trend toward more local content, which requires developing suppliers that otherwise may not have been prequalified. According to one source, since 1970 national oil companies (NOCs) have increased their control over the world's hydrocarbon reserves from 15% to 85%,[9] while international oil companies (IOCs) have shrunk from 85% to 15%. This transition has occurred through the changing nature of production sharing agreements, which are increasingly oriented to provide NOCs with title to hydrocarbons, control over operations, upside risk on oil price and volume movements, and a greater share of the profit upside. As NOCs have taken more control of their countries' resources, they have increasingly required foreign contractors to use a greater share of domestically produced goods and services. Countries actively setting local content levels include Kazakhstan, China, Brazil, and Azerbaijan.

Growing public environmental conscience is making tight process integration with suppliers a requirement for survival. Two high-profile incidents in 2010—the Macondo disaster and a public outcry over possible health risks posed by the fracturing fluids used heavily in shale plays—intensified scrutiny of safety and security in the oil and gas supply chain. The first major deadline for registration of chemical substances affected by the European Union's regulation on the Registration, Evaluation, and Authorisation of Chemicals (REACH) kept the public eye focused on environmental impact, and in the United States an Environmental Protection Agency subpoena invoked the Toxic Substances Control Act of 1976, the Clean Water Act of 1972, and the Resource Conservation and Recovery Act of 1976 to force public disclosure of certain formulations that would have previously been considered trade secrets or proprietary ingredients. As a result, new competitors have been able to enter the market, but in the longer term, innovation may be stifled; the ultimate impact on industry structure remains to be seen.

The increasingly global nature of oil and gas operations has driven suppliers to expand their manufacturing and sales networks worldwide. Most floating production, storage, and off-loading (FPSO) projects are in emerging countries, which are forecast to grow at two to three times the rate of the developed countries.[10] Of 194 global FPSO projects, 115 are in Brazil, Africa, or Southeast Asia. Of these, 51% are in deepwater (1,000–1,500 meters) or ultra-deepwater (>1,500 meters).[11] Furthermore, India is emerging as a substantial oil and gas player because of large-scale drilling projects at state-run oil producers Oil and Natural Gas Company (ONGC), Indian Oil Company (IOC), and Gas Authority of India (GAIL). Suppliers have been aggressively migrating to the growth areas, notably China, India, and Malaysia. Moreover, the regional basis of oil demand has shifted in recent years (2008–2012)—with patterns of trade and transportation moving from countries in the Organisation for Economic Co-operation and Development (OECD) to non-OECD countries and from West to East. According to 2012 International Energy Agency projections, demand for crude oil has decreased 2.2% annually in Europe since 2008 and 0.9% in North America. Conversely, demand for crude oil from non-OECD countries in Asia has grown 4.7% annually over the same period. As a result, Asia now makes up 32% of global crude oil demand, as compared to 29% in 2008. Meanwhile, the share of global demand has dropped from 18% to 16% in OECD Europe and from 28% to 26% in North America.[12]

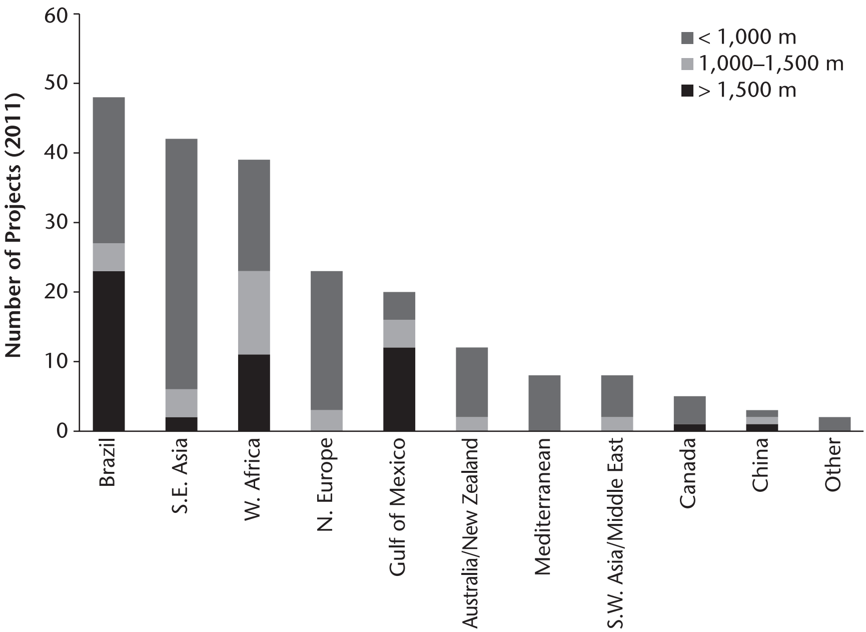

Fig. P–2. Number of FPSO projects by country or region (*Source:* Floating Production Systems: Assessment of the Outlook for FPSOs, Semis, TLPs, Spars and FSOs. International Maritime Associates, Inc., 2012.)

The globalization of the industry is forcing suppliers to respond with global service and more robust international logistics capabilities. Schlumberger now has 23 service centers around the world, many with field staff providing installation, troubleshooting, preventive maintenance, and repair. Baker Hughes has opened a service and operations base in Saudi Arabia.[13] Dresser-Rand plans to open 20 or more service and support centers to accelerate response to international opportunities.[14] Pump manufacturer Ruhrpumpen established service centers in Mexico, the United States, Germany, Egypt, Canada, and Argentina. As suppliers globalize, the cost of shipping internationally is forcing them to reevaluate their supply chains, sometimes replacing their raw material sources and reconfiguring their intermediate processing activities and locations. While this presents opportunities for local suppliers, it can also threaten them. In Saudi Arabia, local manufacturers like Saudi Cement Company and Saudi Yamama Cement have traditionally dominated the cement supply market. However, global leaders such as Lafarge and Cemex have set up plants to capture a share of the growing regional construction market in response to the Saudi Arabian government's $400 billion infrastructure plan.

Purpose and Organization of This Book

The book provides a toolbox for large-scale capital expenditure decision making and for transforming capital and operating expenditure to exert a visible financial impact at the enterprise level in oil, gas, and power companies. By using the supply chain risk management decision analysis tools in this book, operators can increase economic value added (EVA) by 3.8% (higher on greenfield capital projects, lower on existing infrastructures) while enhancing stewardship to safety and the environment. This is based on a 13% reduction in capital costs, a 9.8% increase in total annual sales revenue as a result of debottlenecking and increased throughput capacity, and an average 1.0% reduction in total operating costs.

The book is designed to be read in two passes. First, read the introduction and all of Part 1. This covers the overall concepts and principles that are relevant to the oil, gas, and power industries. Then, read the chapter in Part 2 that applies to your business—upstream, midstream, or downstream oil and gas or power generation.

Part 1

The initial chapter on capital expenditure and supply chain planning lays out concepts and principles for designing supply chains, architecting supplier relationships, managing contract risk, and engineering and constructing projects. It provides tools for managing the challenge of making commitments prior to final investment decision and describes the theory and application of options as they relate to project size, project life, and technology/product mix. This chapter also elaborates on multiple methods for hedging the risk of material and service unavailability and price volatility. Finally, it addresses the complex issue of how to define the buy when structuring project work—that is, whether to buy solutions or independent products and services, how to do a proper analysis of total cost of ownership, which project governance mode to select, which activities to insource and which to outsource, and how to determine the optimal contract term.

Chapter 2 includes a section on developing bid slates and explains the concept of category management. Methods are illustrated to determine the optimal number of suppliers and qualify suppliers once they are identified. A section on structuring partner relationships explains how to structure alliances, including whether to establish a joint venture and whether to take equity in a partner. Next, a section on build-own-operate choices defines a mutually exclusive and collectively exhaustive set of alternatives for how much to risk to bear and how much to shift to other parties. Finally, a section on managing tendering procedures provides guidance and tools for tendering products under development but not yet commercialized, tendering combined purchase and operating/maintenance agreements, tendering to local sources where local content regulations apply, and using auctions.

Chapter 3 is divided into three sections. The first section, on maintaining complex systems, provides frameworks and proven processes and measurements for managing asset productivity, total cost of ownership/life-cycle cost, the cost of quality, throughput and debottlenecking, preventive and predictive maintenance, and standardization of equipment, services, and processes. The second section, on achieving continuous cost reduction, explains the concepts of lean as they relate to inventory management, transportation management, outsourcing logistics, and total supply chain activities (third- and fourth-party logistics service providers), and how to engage suppliers in performance improvement initiatives. The third section, on logistics, inventory, and materials management, explains how to manage capital spare parts differently from maintenance, repair, and operating supplies and how to establish consignment, vendor-managed inventory, and other inventory programs.

Chapter 4 lays out risk management standards, enterprise risk management frameworks and methods, and operational risk-mitigation processes and methods. It also clarifies supply chain's role in reducing environmental footprint, and it includes an explanation of the key elements of the Carbon Disclosure Project.

Part 2

Part 2 is divided into four chapters providing examples relating to a particular industry segment: upstream oil and gas; midstream oil and gas; downstream oil and gas; and power generation. Each chapter follows a common structure but treats a variety of different subtopics to the extent that they are important in each segment. Each chapter consists of at least four common topics:

- Introduction, describing unique supply chain characteristics
- Project risk mitigation, including best practices and contingency planning
- Engineering and procurement of equipment and services at minimum cost and risk
- Operations and maintenance cost reduction

A conclusion lays out key success factors for achieving the benefits articulated in the book, and suggests areas for future research.

The book is designed as a reference resource, so abundant endnotes allow for follow-up research or investigation into specific topics. Many of the referenced documents are previous publications of mine. They are all available at www.bostonstrategies.com. Furthermore, the book has four appendixes:

- Appendix A is a study showing how the lack of effective supply chain coordination results in higher costs for upstream and downstream producers and their suppliers (i.e., bullwhip).
- Appendix B gives a useful reference list for categorizing purchased equipment and services.
- Appendix C is a glossary defining acronyms and abbreviations and explaining frequently used terms as they

apply to oil, gas, and power generation companies. The definitions are intentionally focused on the applications described in this book, so they are specific to the context of supply chain management; thus, they may differ from the standard definitions in more generic sources. They are also intended to be short, to the point, and practical, rather than comprehensive and academic.

- Appendix D provides a list of additional resources, for readers who want to dive further into specific topics.

Finally, readers are invited to send any suggestions for improvements to future editions to me at djacoby@bostonstrategies.com.

Notes

1 Boston Strategies International analysis based on HPI Market Data 2010, HPI Construction Boxscore, and Economist Intelligence Unit Data Tool.

2 HPI Market Data Book 2010. Hydrocarbon Processing. Houston: Gulf Publishing Company, p. 6. Data from Economist Intelligence Unit, London, www.eiu.com.

3 Jacoby, David. 2010. Balancing economic risks: tips for a well-structured deal. *Middle East Energy* (September): 5.

4 Jacoby, David. 2009. *Guide to Supply Chain Management: How Getting It Right Boosts Corporate Performance*. Economist Books. New York: Bloomberg.

5 Dobbs, Richard, Jeremy Oppenheim, and Fraser Thompson. 2012. Mobilizing for a resource revolution. McKinsey Global Institute, Sustainability and Resource Productivity Practice, in *McKinsey Quarterly—Energy, Resources, Material*, January, p. 1.

6 McKinsey. Dependencies and regulatory risks.

7 Based on an extrapolation of data from the U.S. Geological Survey, Mineral Commodity Summaries, January 2006.

8 Wahbi, Salah Hassan. 2010. Sudan's growing exploration and development. Paper presented at the National Oil Conference, London, June.

9 Burdis, Ian. 2010. Strategies and practices to realize the maximum potential of NOC's and IOC's. Paper presented to NOC Congress, June 23, p. 5.

10 Jacoby, David. 2011. Uncovering economic and supply chain success in the new emerging economies. Paper presented to APICS International Conference, Pittsburgh, October 24.

11 Floating Production Systems: Assessment of the Outlook for FPSOs, Semis, TLPs, Spars and FSOs. International Maritime Associates, Inc., 2012.

INTRODUCTION

How Supply Chain Management in Oil, Gas, and Power is Different

Most people's understanding of supply chain management stems from the consumer products industry, in which thousands of stock-keeping units (SKUs) of fast-moving consumer goods flow through distribution centers and move from pallets onto retail shelves. While this characterizes *some* logistics flows that occur in oil, gas, and power, supply chain management in these industries is different in several important ways.

Supply chain management in oil, gas, and power more closely resembles supply chain management in the process industries (i.e., those with continuous production operations). Even so, it is much more complex than in low-value process industries such as paper and cement. While it more closely resembles supply chain management in high-value process industries such as petrochemicals and pharmaceuticals, it is different enough from those industries to have its own body of knowledge.

Technology, and often chemistry, affects every decision, from network design to procurement, installation, and logistics. In the offshore segment, logistics draw heavily on the experiences of the maritime industry, with purpose-built vessels to tap hydrocarbon reserves farther offshore and in deeper waters. This complexity manifests itself in most segments of the business—for example,

- In upstream oil and gas, replacing a worn part on a subsea wellhead is more complex than stocking an item

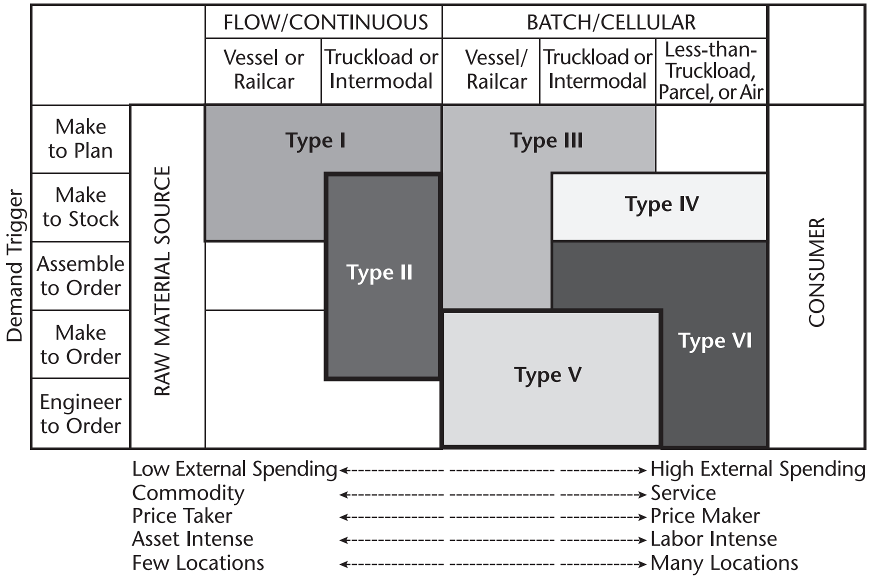

Fig. I–2. Supply chain types (*Source:* Jacoby, 2009, p. 105.)

Table I–1. Correlation between value chain role and supply chain strategy (*Source:* Jacoby, 2009, p. 53.)

Type of Business	Rationalization	Synchronization	Customization	Innovation
Extraction	Positive	Negative	Negative	Negative
Process (continuous) manufacturing	Positive	Negative	Negative	Negative
Batch manufacturing	Negative	Positive	Negative	Negative
Make-to-order manufacturing	Negative	Positive	Positive	Positive
Distribution	Negative	Negative	Positive	Positive
Reselling	Negative	Negative	Negative	Positive

resells them to the oil producer or service company. This allows it to avoid tying up capital in facilities and gives it the flexibility to choose the best supplier for a given type of chemical without developing the chemistry itself.

- ***A more global network, including enhanced access to foreign markets.*** For example, one supplier of drilling and completion fluids outsources production of most component chemicals to local suppliers, to reduce shipping time and cost. Instead of investing in capacity in each region, it has developed a network of local suppliers. As most of the lead time for chemicals is related to shipping, outsourcing allows this supplier to deliver faster than competitors that produce in another region. In one instance, it arranged next-day delivery of a drilling-fluid additive, sourced from a local partner, when the supplier with the next shortest lead time quoted a week.
- ***More sophisticated and updated information technology platforms that provide higher accuracy and reliability compared to in-house systems.*** Many companies outsource logistics primarily because the electronic manifests and other supply chain visibility systems cost too much to create and update in-house. Third-party logistics providers continually invest in new information technology because they are serving a multitude of customers and can pass on a fraction of the cost to each one.
- ***Value-added services that would be challenging or expensive for the operator to do in-house.*** Often, the cost of in-house staff makes value-added logistics tasks more expensive than using outsourced providers' equivalent services—for example, kitting, light assembly, mixing, blending, and similar customization operations that are performed on a finished or semifinished product. Outsourcing these activities can often take advantage of the lower cost structure of an operation that is set up with non-union, part-time, or offshored labor to perform them at a lower cost than would be possible with in-house personnel.

embedded procurement practices favor domestically incorporated companies, such as China. Weir Pumps and Mitsubishi Heavy Industries (MHI) formed joint ventures in China in 2010 and 2011 to gain access to Chinese buyers. Weir formed a joint venture with Shengli Oilfield Highland Petroleum Equipment to sell high-pressure oil field pumps in China. The firms will leverage Highland's relationships with CNPC and Sinopec to sell Weir's fracturing pump technology to Chinese shale gas operators.[24] MHI created a compressor manufacturing joint venture with Hangzhou Steam Turbine & Power Group Company, a Chinese firm that makes compressors for petrochemical plants, in early 2011. The joint venture gives MHI a stronger sales presence in mainland China, and access to a lower-cost manufacturing base than its Japanese facilities. However, MHI supplies key components such as bearings from Japan to ensure quality and maintain control of the intellectual property.[25]

In the offshore wind power business, Dong (the Swedish utility) and Bladt Industries (the Danish offshore foundation fabricator) formed a joint venture to ensure adequate capacity for its growing demand. Dong agreed to buy 600 foundations from Bladt's Aalborg plant. The two organizations cooperated on design and manufacturing.[26] Also, SSE, the U.K. utility, took a 15% stake in BiFab, a supplier of foundations. In exchange for the equity infusion, BiFab agreed to provide SSE the option to order up to 50 foundations per year from 2014 for 10–12 years. Both the Dong joint venture and the SSE equity stake clearly offer these operators increased supply chain flexibility in a market that may get overheated.[27]

If management decides to form a joint venture, potential joint venture partners should discuss operating models while forming their mission and governance structures. Within joint ventures, the operating paradigm can favor dominance by one of the partners, or alternatively it can be operated as a truly independent entity exercising control over its own destiny in the model of WellDynamics, a smart-completion supplier owned jointly by Halliburton and Shell. The degree to which each partner manages operations in a joint venture should reflect its experience and success in operating similar businesses, its strategic assets, and its access to customers of joint interest.

process capacity will be underutilized. Moreover, in the latter case there will be a bottleneck.

Debottlenecking is the process of successively identifying the binding constraint, eliminating that constraint, aligning other processes to the new throughput levels, and pursuing the next constraint. Debottlenecking efforts should consider the entire supply chain as a system. This is challenging because, to identify bottlenecks, supply chain partners would need to share information about their processes and many companies hesitate to share such information as it could be considered as confidential business information.

As demand levels change over time, capacity must flex up and down. Given that capacity takes a long time to build and remove in oil, gas, and power, there have historically been two basic strategies for matching supply to demand: *chasing* and *leading*. Chasing means adjusting capacity in *response* to changing demand, while leading means adjusting capacity in *anticipation* of changing demand. Both approaches assume some risk—in the case of chasing, the risk that capacity will not be available when needed and, in the case of leading, the risk that capacity will sit idle until demand catches up. These risks can be minimized through *flexible capacity management*. Flexible capacity management lowers the breakeven point, thereby increasing profit potential without increasing the asset base.

During ongoing operations (post-capex), five tactics can be used to make capacity flexible:

- Increase temporary employees as a proportion of staff. This reduces the fixed labor cost base and therefore lowers the breakeven point. Temporary employees are easier to hire and let go when demand shifts and if managed carefully can eliminate expensive overtime.
- Implement *lean* concepts—such as just-in-time, one-piece flow, level loading, cycle-time compression, and make-to-order—to avoid building unnecessary inventory.
- Postpone disposition, dispatching, or finishing operations to as late as possible in the value chain in order to reduce capacity requirements and inventory obsolescence.

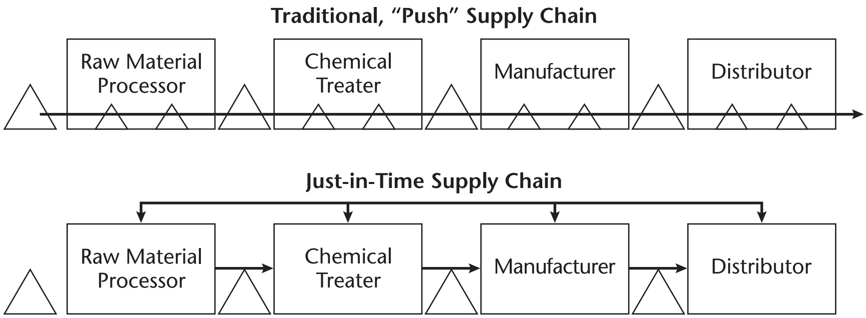

Fig. 3–2. Traditional push versus just-in-time supply chain (*Source:* Jacoby, David and Michael Gourd. 2005. "Lean Distribution: How Distribution is Changing, and Tools You Will Need for the New Environment." Seminar given to Boston APICS, May 5. P. 21).

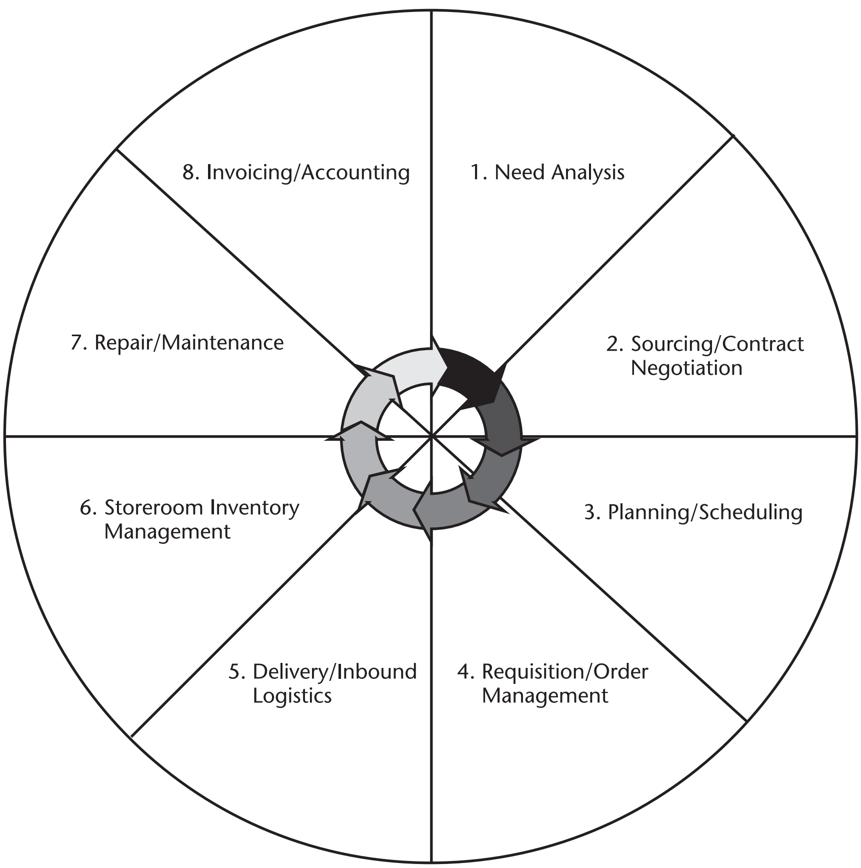

Fig. 3–3. Maintenance, repair, and operating (MRO) order management processes