PART ONE

Understanding the Projects

CHAPTER 1

Megaprojects—Creators and Destroyers of Capital

If you have spent much time hiking in the woods, you have probably had that uncomfortable occasion when, after walking for several hours, perhaps chatting with a friend along the way, you suddenly realize you have absolutely no idea where you are or how long it has been since you knew where you were. Many a megaproject director has encountered that same feeling while trying to bring a large and complex project safely home. This book seeks to explain how and why we so often find ourselves lost when trying to develop and execute very large industrial projects. If we can understand how and why we tend to get lost, we will better recognize when we are leaving the trail, find our way back if we do get lost, or at least know when to plead for directions.

Industrial corporations create their capital assets primarily through projects. The first decade of the twenty-first century has seen more very large and complex projects executed by the process industries—oil, chemicals, minerals, and power—than any comparable period in human history. These projects satisfy the world's demand for energy, metals, chemicals, and other products. Without them, modern society as we know it could not exist.

Projects have increased in size and complexity for a number of reasons: easily accessed resources close to markets have largely been depleted; international oil companies must venture into deep water and other difficult environments because national resource holders control more easily developed oil and gas; and chemical companies seeking lower-cost feedstocks need to exploit economies of scale to

compete globally and often must go to the source of the feedstocks to make the project viable. The need for extensive infrastructure development means that many projects will have to be very large to spread the infrastructure costs over a wide enough base of beneficial production to be economic.

As the projects have increased in size and complexity, they have become much more difficult to manage. Cost overruns, serious slips in completion schedules, and operability problems have all become more common. Many of these very large projects end up being disappointing to their sponsors; a fair number turn out to be massive destroyers of shareholder wealth; and a few are horrendous with respect to anything and everything involved—the investing companies, the local population, and the environment. When megaproject disasters become public knowledge, which is rarely the case, they damage reputations and even jeopardize continued existence.*

The research program of Independent Project Analysis, Inc. (IPA) on megaprojects over the past five years shows clearly that virtually all of the poor results of these projects constitute self-inflicted wounds. The sponsors are creating the circumstances that lead inexorably to failure. *And that is profoundly good news!* Problems we cause ourselves, we can fix.

WHO SHOULD READ THIS BOOK?

Anyone with responsibility for large, complex, or difficult capital projects will find things of interest in the pages that follow. My particular goal is to help those who sponsor, direct, or work on large projects guide the projects to safe and successful outcomes. My special focus is on what I call "industrial megaprojects"—very large projects sponsored by the petroleum, chemicals, minerals, power, and related industries.

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*The failure of BHP's Hot Briquetted Iron Project in 1999 contributed to the company losing more than half of its market value. The $10-plus billion overrun of Shell Sakhalin-2 Project damaged Shell's reputation and created an excuse for the Kremlin to nationalize a large portion of the project. The structural failure of BP's Thunder Horse semi-submersible platform in 2005 in the U.S. Gulf of Mexico was an important element in a series of stunning setbacks for the company. Most megaproject disasters, however, remain carefully private—while sometimes wearing a very different and well-contrived public face.

Anyone interested in complex projects, even if they fall far short of megaproject status, will find the story of these projects informative to their situation. Most of the basic principles of doing megaprojects well are the basic principles of doing all projects well. Megaprojects display some attributes that are common to megaprojects and uncommon in smaller projects, and we will focus our attention on those. But if the reader is interested in projects, megaprojects will always be fascinating.

I very much hope that members of boards of directors of companies that sponsor megaprojects read this book. To be blunt, when it comes to the governance of large projects, most boards strike me as brain dead. They are not asking the right questions, and they are not asking questions early enough in the process to deter bad decisions.

Those who finance major projects should find a great deal of interest (forgive the pun) in the book. In many respects this book is all about large project risk, which is a key concern for banks and others involved in project finance. It is my observation that bank financing often increases cost while doing nothing whatsoever about project risk.

Those who are concerned about the management of the modern publicly owned industrial corporation and teach others about how it should be done will also find this book interesting, and perhaps very disturbing. The failure of these projects is symptomatic of the core problems of the modern firm: too much outsourcing of key competencies, poorly informed decision making, a woeful lack of accountability for results, and a pathological focus on the short term at the expense of the long-term health of the corporation and its shareholders.

WHAT IS AN INDUSTRIAL MEGAPROJECT?

The projects that are the subject of our research are a subset of all projects and even a subset of large projects. We focus on *industrial* megaprojects. By *industrial,* we mean projects that make a product for sale, for example, oil, natural gas, iron ore, nickel, gold ingot, diamonds, and high-volume chemicals. All of the projects under scrutiny were intended to make an economic profit, at least eventually,

for some if not always all of the sponsors.* By confining ourselves to industrial projects, we have excluded several classes of important projects: military developments, purely public works and transportation projects, monuments, works of art, and so forth. By excluding these sorts of projects we have excluded some megaprojects from our analysis. We have a couple of reasons for doing so:

- Confining ourselves to projects that are intended to make money simplifies the task of assessing outcomes, not necessarily simplifying the range and complexity of objectives in the projects. Although it is true for almost all of our projects that *someone* wanted and expected to make money on the result, it does not follow that *all* of the sponsors expected to make an economic profit. Some were motivated by jobs creation, political ambition, general economic development, and other "public" goals. These "mixed motive" projects as we call them are an interesting class and pose challenges for for-profit sponsors.
- Having some economic profit motive disciplines and constrains the objectives of the projects in important ways. Some public works projects have objectives that are hard to fathom by mere mortals. Some military acquisition programs appear to continue almost solely on the strength of political patronage long after the military rationale has become obsolete or discredited.† And some "prestige projects," such as the Concorde supersonic transport, have objectives that must forever be in the eye of the beholder. Who is to say whether prestige has actually been enhanced, and was it by an amount sufficient to justify the opportunity cost of the project? Industrial projects tend to have at least some nicely tangible objectives.

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*A few of our projects were undertaken with the explicit expectation that they would make little or no economic profit but would facilitate highly profitable projects later. These projects bear the dubious title "strategic," a subject to which we return in Chapter 4. The term *sponsor* is reserved for those organizations that claim formal ownership of a project by virtue of their economic investment in the project. Those investments could occasionally be in-kind or deferred but usually indicate monetary investment in the cost of the project.

†For example, long after a superior option had emerged, the U.S. Air Force B-1 Bomber program continued due entirely to political influence. "B-1 Problems, if reparable, could cost $3Billion," the *Boston Globe,* February 13, 1987. The V-22 Osprey aircraft program not only overran its budget colossally, but it also suffered repeated crashes . . . but continued anyway. "Assessments Needed to Address V-22 Aircraft Operational and Cost Concerns to Define Future Investments," GAO-09-482, May 2009.

What makes an industrial project an industrial *mega*project? Megaprojects, as the name implies, are very large. To provide a simple and simply applied definition, we are defining a megaproject as any project with a total capital* cost of more than $1 billion (U.S. dollars) as measured on January 1, 2003. In 2010 nominal dollar terms, that would amount to about $1.7 billion due to the effects of rapid escalation in project costs in the last decade. One can reasonably object that this definition is simplistic; it totally disregards the effects of complexity (however measured) and the project environment on whether the project is a megaproject. The objection is noted but must be dismissed. If we include consideration of aspects other than size in our definition, we forfeit the ability to examine the effects of those aspects on the outcomes and management of our projects. One can also most certainly object that the $1 billion criterion is completely arbitrary. Why not $500 million or $2 billion? Yes, the $1 billion figure is arbitrary, but it is somewhat less arbitrary than it may seem. In the neighborhood of a billion dollars is where we see project outcomes begin to deteriorate sharply.

WHY STUDY THESE PROJECTS?

There are four compelling reasons to study and understand megaprojects:

1. There are many more of them than in times past, and this will continue for decades to come.
2. These projects are important. They are important to the societies in which they are being done; they are important to the health of the global economy; they are important to the sponsors and others putting up huge amounts of money.

*By capital we mean the costs for materials, engineering, and construction labor associated with completing a project. We exclude venture costs associated with setting up the permanent operating organization at the site or in some cases for the new company. In frontier environments, these venture costs can be quite substantial, in some cases more than 20 percent of the capital costs of the venture. We also do not explicitly evaluate operating costs, although we do keep track of when operating costs end up substantially higher than expected in these projects. The sponsors should, of course, be looking at total costs of the venture and should do so on a life-cycle basis to the extent that the data permit.

3. These projects are very problematic. They are failing at an alarming and unsustainable rate.
4. There is not much published that speaks directly to the types of projects considered here.

I will discuss each of these reasons to worry about megaprojects in turn.

Increasing Numbers

Industrial megaprojects have become much more common. For much of the 1980s and virtually all of the 1990s, there were few very large projects, even in the petroleum industry. The Norwegian and UK North Sea had been home to a number of megaprojects in the 1970s. These projects had a very difficult go, and without the rapid rise in crude oil prices in the wake of the overthrow of the Shah of Iran, almost none of the megaprojects in the North Sea would have been profitable ventures.[1] Most of the megaprojects that had been in planning stages in the late 1970s died abruptly when commodity prices fell in the early 1980s.

However, a number of factors have converged to make megaprojects much more common in the first decades of the twenty-first century, and these factors give every indication of being enduring drivers of very large projects. The first factor driving the current wave of megaprojects has been the rapid rise in the demand for almost all major commodities; iron ore, coal, copper, and petroleum have all experienced very rapid increases in demand (and therefore price) since 2003. Previously, most prior commodity price fluctuations had not been synchronized; prices might rise for one or two metals, oil and gold prices might rise for political reasons, but not all at the same time. The underlying common driver this time was the rapid industrialization of China and India in the context of reasonable overall global growth. None of the major commodities are actually facing imminent global depletion; however, most are facing upward sloping long-run marginal costs.

The different commodities have had somewhat different drivers for large projects:

- Opening up a new major mineral ore body has long been expensive. Most major new mines today are in places that require major

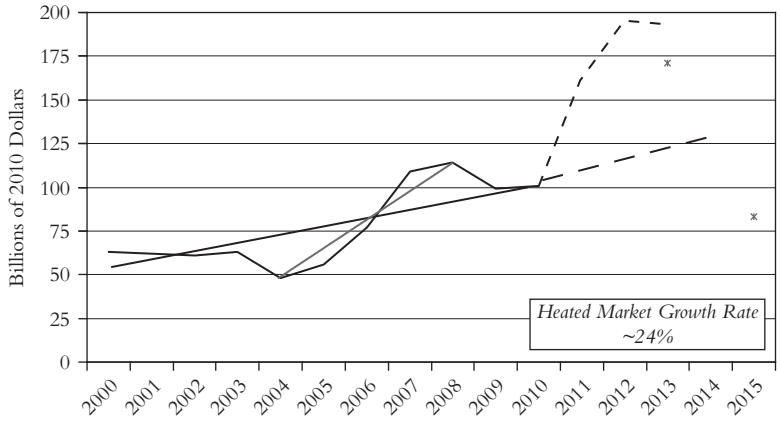
infrastructure development to be practicable. When a good deal of infrastructure is needed, the production volume must be very large to spread those infrastructure costs across a broad enough base for the venture to be profitable. This makes large size the only avenue to development.

- Crude oil is a special case, at least partially. A large portion of oil that remains relatively inexpensive to produce is held by state companies.[2] To stay in the oil business, international companies have been pushed quickly into places where oil is difficult and costly to develop, usually deep water. International companies also have gained access when reservoirs are difficult to produce, for example, offshore heavy oil production in Brazil, very heavy oil onshore in Venezuela, the very sour oil and gas reservoirs in the Caspian area, the very harsh climate off western Russia, or in inaccessible areas such as central Africa. As a consequence, the marginal capital costs of production have increased very rapidly for these companies. This translates into a dramatic increase in the number of international oil company megaprojects.
- Finally, rapid changes in the global economy have driven basic chemical companies to shift more of their manufacturing to fast-growing Asian economies. They have also sought to gain feedstock cost advantage by moving manufacturing to countries offering feedstock below world open market average prices to attract production facilities, mostly in the Middle East.*

IPA's projection of industrial megaproject activity excluding power is shown in Figure 1.1. The graph shows the number of dollars spent each year from 2000–2009 on megaprojects in the oil, chemicals, and minerals industries outside China. The pace of megaproject activity in the middle of the first decade of the twenty-first century was so brisk

*High natural gas prices have pushed a good deal of basic chemical manufacture out of Europe and the United States. Natural gas prices control the prices of ethane and propane, which are feedstocks for building block commodity chemicals such as ethylene and propylene. The situation in the United States may be stabilized by the advent of shale gas, which has substantially lowered natural gas prices. It is even possible that we will see some reversal of the decline in commodity chemicals in the United States if prices remain low. The situation in Western Europe shows no signs of reversal anytime soon, as natural gas is largely imported and relatively expensive.

Figure 1.1
IPA Forecast of Industrial Megaproject Activity, 2000–2013



that it triggered rapid global escalation in EPC* services and equipment markets. From 2004 until the boom ended in 2008 with the global financial crisis, the megaprojects market expanded at a rate of 24 percent per year. IPA's forecast for the next four years exceeds that growth rate even in constant U.S. dollar terms.† By 2012, we expect to be spending at a rate of nearly $200 billion per year on industrial megaprojects outside China and excluding the electric power generation sector.

Megaprojects Are Important

Without the industrial megaprojects in the extractive and manufacturing sectors, global competition for resources, which is already very intense, would become unmanageable. Although one can reasonably question whether extractive projects have been a net boon for less developed economies that hold large supplies, one cannot doubt

*EPC is shorthand for engineering, procurement, and construction. It refers both to the activities and to the industry that supplies these services to the megaprojects marketplace.

†IPA's forecast is based on projects in development by our clients that we are highly confident will be authorized for execution. This is then extrapolated to nonclient companies based on 2009 capital spend. This forecast was completed in May 2010; major economic changes between then and publication may perturb the forecast in either direction.

that the overall megaproject effect on global economic growth has been substantial. Megaprojects are responsible directly and indirectly for millions of jobs around the world, and without the many megaprojects we have seen over the past decade, global prices for virtually all major commodities would be much higher with all the attendant economic dislocation.

For the sponsors of megaprojects, success or failure of the project can mean the success or failure of the company. For all except the largest oil companies, a serious failure of a megaproject puts the company's future in jeopardy. Megaprojects are increasingly seen as essential to being competitive, but in many cases the skills needed to effectively develop and control these projects have not developed in tandem with the need.

It is also important to remember that the success or failure of these projects is often critical to the societies in which they are developed. Megaprojects place a good deal of stress on local communities. When they fail, and especially when they fail completely, the local communities suffer irreparable damage.

Megaprojects Fail Too Often

Megaproject results are frequently seriously short of the expectations of the sponsor-investors. Their cost overruns are often so significant that the whole project becomes NPV negative.* Their schedules often slip, and early-year operability, which has a disproportionate effect on profitability, is frequently very poor. Occasionally, the projects produce environmental disasters as well. As we will show, these results are not inherent in the nature of the activities. They are instead, caused by human decisions, ignorance, and uncontrolled, but controllable, human failings. These projects can be fixed.

The Literature Is Sparse

This book is needed because, despite the many thousands of pages written on the management of projects, very little of the literature addresses the peculiar nature of very large and complex projects as a class.

*NPV, of course, refers to net present value, which is a measure of the economic returns from an investment with future profits discounted for the effects of time.

There are some notable exceptions. Morris and Hough explored a set of eight very large public and private projects in 1987.[3] Like us, they concluded that the success rate is quite disappointing. We build on their path-breaking work. Miller and Lessard[4] and their colleagues explore what they call "large engineering projects," focusing on the development of new institutional arrangements. Their discussion of the process by which turbulent project environments might be settled is a key starting point for our own discussion of the shaping process in Chapter 4. We focus much less on the creation of new contractual forms, such as build-own-transfer (BOT), simply because we have seen very few of these "new institutional arrangements" actually function as advertised. Our data, which are considerably deeper than that found in Miller and Lessard, flatly contradict the effectiveness of certain arrangements, such as incentivized contracts, which they tout as successful.

Flyvbjerg, Bruzelius, and Rothengatter make the most recent major contribution to the megaprojects literature, focusing primarily on very large infrastructure projects executed by the public sector around the world.[5] Although we share some of the same conclusions about these projects, public infrastructure projects are in many respects quite different than the projects explored in this research. Public infrastructure projects share many of the pathologies common in other publicly funded projects, such as military acquisition. They are frequently beset by a phenomenon known as "buy-in and hook," in which low costs are promised early, knowing full well that the eventual costs will be much higher. Although this sort of deception is not unknown in private sector ventures, it is not very common, simply because there is usually no taxpayer available to foot the bill later.

THE ORGANIZATION OF THIS BOOK

I have organized this book in three parts. Part One introduces the IPA megaprojects database and describes the research process that underpins this book. I seek to provide enough about methodology to satisfy the methodologically oriented reader without boring others to a stupor. I then present the track record of industrial megaprojects, summarizing the 300-plus large and complex projects we have studied to date.

Part Two deals with corporate decisions that relate to megaprojects and the behavior of senior management as it affects megaproject outcomes. This section deals extensively with what Miller and Lessard[6] call the "shaping" of megaprojects. It focuses on some brilliant examples of business leaders making an inherently unstable environment strong enough to permit a successful megaproject to be executed. But it also focuses on the decisions that corporate managers make that have devastating consequences for their projects without their ever fully understanding what went wrong. Business professionals who touch capital projects need to read Part Two to avoid being the root cause of trouble and to see what has worked well in situations similar to those they face. Project professionals need to read Part Two to understand how they got into this mess and what they might do in the future to elevate problems when mischief is being created by their bosses. Part Two will also be of interest to those concerned with how industrial corporations are being managed and mismanaged.

Part Three is written more for the project professional. It focuses not just on what needs to be done to make these big projects successful but on *why* those things are crucial. Many of the practices required to generate successful megaprojects are resisted by business management because they are apparently expensive and time-consuming. When the project team understands why certain practices are critical based on the actual history of megaprojects, they are better able to persuade reluctant managements to do the right things. The first chapter of Part Three addresses one of the most common root causes of megaproject failure: inaccurate or incomplete Basic (technical) Data. As I was tallying up the causes of failure in these projects, I was surprised to see the number of times that Basic Data problems occurred. Because the Basic Data development often needs to start long before the project gets fully going, the Basic Data chapter should be read by the business professionals, who often control the funding for Basic Data development, and by the research and development (R&D) and technical specialist community that often do not consider themselves part of "project management" but who usually do the Basic Data development.

RESPECTING CONFIDENTIALITY

Some of the readers (I sincerely hope) will have been directly involved in the megaprojects that underpin the conclusions of this research. When I have offered examples, I have tried to select cases that are not unique and in some cases I have masked the cases enough to ensure that no individual project for which we have conducted a closeout evaluation can be identified conclusively. This is necessary to meet our obligations of confidentiality to the people and companies involved. When any project is mentioned by name, it is based solely on publicly available information.

If you are certain that I am discussing your project in a particular example, let me offer this caveat: several years ago, I wrote a volume of 20 case studies of new technology projects for the DuPont Company. Many of the projects had disastrous outcomes, but some were brilliant successes. In the introduction, I carefully explained that *none* of the projects summarized in the volume were DuPont projects, because the DuPont new technology projects would be covered in a separate volume. Nonetheless, for the next six months I had DuPont business and project professionals stop me in the hall while I was visiting the company and comment something like this: "You did a pretty good job summarizing my project, but you got a couple of the details wrong. . . ." This reflects a well-known fact: We humans have been making a hash of projects for a long, long time.