# Three Decades of Scenario Planning in Shell

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Investment risks and opportunities have to be assessed in full recognition of the external environment in which corporate strategies are elaborated. Environmental uncertainty is not easily encapsulated as a simple risk parameter, but rather interacts with corporate strategy in global, national, and industrial contexts.[1] An important risk companies face is that major shifts in the business environment (e.g., due to changes in the geopolitical landscape, government policies, and industry structure) can make whole investment strategies obsolete. These changes can occur very abruptly as the result of a single event. The terrorist attacks on September 11, 2001, for example, have fundamentally altered U.S. foreign policy, upending nearly all the basic assumptions about political, economic, and financial risks.[2] Given the irreversibility of most major capital investments, however, their sunk costs may be huge.

Changes in the business environment can also create important new opportunities. The end of the Cold War, the collapse of the former Soviet Union, and Russia's opening have allowed companies to invest in one of the world's most resource-rich countries. China's race to the market has produced spectacular economic growth and become a key driver for the world's commodity markets. New opportunities have arisen for renewable energy, thanks mostly to more stringent environmental regulations.

Unfortunately, forecasts—which are usually constructed on the assumption that tomorrow's world will be much like today's—provide an inappropriate tool to anticipate shifts in the business environment. In fact, forecasts may even

The authors would like to thank Albert Bressand, Tom Copeland, Ged Davis, Bruce Kogut, Adrian Loader, Thierry Malleret, and two anonymous referees for their comments. The views expressed in this article are those of the authors and do not necessarily reflect the views of the Royal Dutch/Shell Group of Companies nor those of the World Economic Forum.

be dangerous, as they are typically wrong when they are needed most.[3] There are numerous examples of individual strategic busts in virtually every industry.[4] Discontinuities in the business environment present the greatest challenge in the energy sector, given the average size of investment projects and their long lead times. To deal with this problem, the Royal Dutch/Shell Group uses scenario analysis, a method it introduced more than 30 years ago.[5] Since then, global scenarios have been developed every three years, with the latest set presented at the World Economic Forum in Davos in January 2005.

Scenarios are not projections, predictions, or preferences; rather, they are coherent and credible alternative stories about the future. They are designed to help companies challenge their assumptions, develop their strategies, and test their plans.[6] At Shell, scenarios have played a particularly important role in anticipating shifts in the global energy mix and hence in determining the Group's upstream and downstream investments. Combined with other tools such as market and competitive analyses, scenarios represent an integral part of the Group's strategy process at all decision levels.

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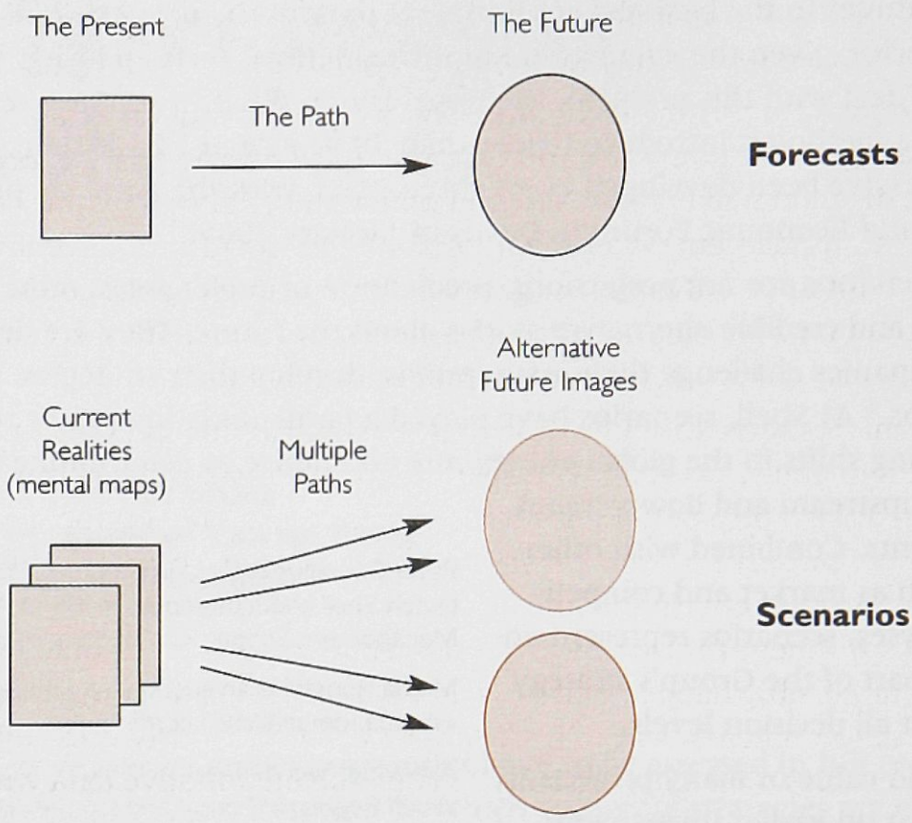
The value of many projects is contingent on earlier investments. Thus, once a company has decided to invest, it relinquishes the possibility of new information that might affect the desirability or timing of the expenditure.[7] Given the irreversible character of most investments, scenario planning can usefully be combined with real options analysis, an approach that emphasizes that many investments create important follow-on opportunities for a company. This approach is an extension of financial option pricing models to the valuation of options on real assets, and it is a way of thinking that helps managers formulate their strategic options.[8]

The real options approach is subject to important limitations. However, scenario planning may help overcome some of these limitations and assist managers in deciding when and how to exercise an option, capturing upside potential due to greater flexibility. Specifically, scenarios can contribute to real options at three fundamental levels. First, they can help identify options in the future. Second, they can help time the decision to exercise the real option. Third, they can provide an important input in the process of evaluating it.

## Scanning the Future with Scenarios

The choices firms make depend on their assumptions about what the future may bring. While they know that anticipating and shaping the future is critically important for their success, there is increasing uncertainty in the medium- to long-term horizon.[9] Significant efforts have been made to improve forecasting techniques. Econometric methods have become increasingly

**EXHIBIT 1.** Scenarios vs. Forecasts




sophisticated, new tools such as neural networks have been developed, and powerful computers and software make it possible to work with huge amounts of data. Despite the progress in all these areas, firm success has been limited, especially over longer forecast horizons.

While forecasts can be reasonably accurate, there is a fundamental problem. Pierre Wack, one of the founders of Shell scenario planning, observed almost 20 years ago that forecasts tend to be wrong when they are needed most—namely, "in anticipating major shifts in the business environment that make whole strategies obsolete."[10] Forecasts are usually constructed on the assumption that tomorrow's world will be much like today's. As long as this is the case and there are no critical discontinuities, forecasts perform reasonably well. However, sooner or later the world does change in a major way, which render forecasts wrong when it hurts most.

Rather than looking for better forecast techniques or hiring more or better forecasters, Shell developed *scenario planning*. With its roots usually attributed to the pioneering work by Kahn and Wiener at the Hudson Institute,[11] several generations of Shell scenarios planners have refined this approach over the past 30 years.[12]

Scenario planning differs fundamentally from forecasting in that it accepts uncertainty, tries to understand it, and makes it part of the reasoning. Scenarios help prepare for a range of alternative and different futures. Scenarios are not projections, predictions, or preferences. Rather, they are coherent and credible

stories, describing different paths that lead to alternative futures (Exhibit 1). As such, they should not be confused with alternative forecasts under different assumptions (for example, the price of oil may be USD 20 or 40 per barrel in 2010—sometimes called "first-generation" scenarios).

Whereas forecasting techniques try to abandon any uncertainty by providing managers with only one forecast, multiple scenario analysis deliberately confronts decision makers with environmental uncertainties by presenting them with several, fundamentally different outlooks on the future.[13] Scenarios are generally built upon a dynamic sequence of interacting events, conditions, and changes that are necessary to reach a particular outcome. Thus, scenarios focus attention on causal processes and crucial decision points.

Scenarios serve multiple functions. First of all, they present a background for the design and selection of strategies. Since no single strategy can perform best in each scenario, special selection criteria, such as "bet on the most probable scenario" or "preserve flexibility" are needed.[14] Second, scenarios help make managers aware of environmental uncertainties by confronting them with fundamentally different future states. Third, scenarios provide a tool to identify what might possibly happen and how an organization can act upon or react to future developments. As such, scenarios can serve as early warning systems. Fourth, scenarios offer the possibility to combine quantitative data with qualitative input, enabling scenario planners to incorporate results from other forecasting techniques and allow for soft and fuzzy variables. Finally, scenarios can help stretch managers' mental models by explicitly confronting them with their own biased viewpoints.

## A Brief History of the Shell Scenarios

Although the scenarios at Shell have been made public only recently,[15] earlier scenarios are well documented in the literature, especially through contributions by former Shell scenario planners.[16] The first scenarios were developed in 1972, although a special "Survey of Energy in the World Political and Economic Environment for the Years 1985-2000" and some experimental scenarios had already been prepared in 1967 and 1971. The six scenarios produced in 1972 concentrated on economic growth, oil supply, and oil price options. While they included some description of the geo-political context, the scenarios' main focus was on the key variables of direct impact for the businesses. In a world characterized up until then by continuing and sustained expansion, the scenarios foresaw a disruption in oil supply and the subsequent rise in prices. By October 1974 this scenario had quickly materialized, with the Arab Oil Embargo following the Yom Kippur War pushing oil prices to unthinkable levels. The advent of the first oil price shock did much to cement the scenario tool in the planning process in the Group.

Later in the 1970s, in an attempt to make scenarios more suited to address medium-term concerns and assist tactical decision making, scenarios were produced both for medium- and for long-term purposes. In 1974, "the

Rapids" emerged as a framework onto which to build specific scenarios: it described a period of transition and new challenges in the wake of the oil crisis. Clearly what was needed at that specific time was a map to orientate the business in a very different and uncertain environment: *Belle Époque* and *World of Internal Contradictions (WIC)* were the first comprehensive scenarios—where the long-term economic and energy markets predictions were accompanied by an equally important geo-political and social analysis.

*Constrained Growth* was developed in 1975 as part of *WIC*, and was centered on the idea that recovery would be slower than in previous upswings. *WIC* described a world of low economic growth in stark contrast with the "miraculous" economic growth of the previous 25 years. This again was a voice out of the crowds, during a period in which quick and powerful recovery was expected. The 1976-1978 period was indeed a period of internal contradictions, with what had been the floor for economic growth expectations before 1973 now having become the ceiling. Many Shell managers recognized the structural change and adapted their business decisions, hedging the possible risk.

The late part of the 1970s saw an extension regarding the scope of the scenarios—in particular, in terms of analyzing societal change. Nevertheless, the scenarios maintained a focus on the key variables relevant to the business: energy demand and oil prices. The recession of the end of the decade made it difficult for the scenarios to attract managers' attention away from the troubled short-term conditions.

In the 1980s, the Shell scenarios elaborated the socio-political analysis further. High oil prices and a looming recession inherited from the late 1970s, represented the background for a series of rather pessimistic scenarios. First in 1982 and subsequently in 1984, the scenarios included the possibility of a sharp drop in oil prices in the medium-term: *Next Wave* suggested that by 1986/1987 the price for oil could drop to USD18/bbl. A key driver was seen in the tightening of the credit markets and the growing burden of the U.S. fiscal deficit.

The 1982 scenarios speculated about the longevity of the former Soviet Union. This was the result of a specific scenario for centrally planned economies, a first attempt at focused scenarios, which would become the norm by 1988. *Devolution* suggested a gradual opening-up of Central and Eastern Europe due to the need for technology and for consumer goods.

By 1987, the Shell scenarios had grown in size, comprising three separate volumes on oil, energy, and socio-economic trends. For the first time, the scenarios identified the possible tensions arising from globalization as a fundamental trend for the 1990s. Moreover, in these scenarios environmental issues gained increasing importance. It was only in 1989, however, that these two areas represented the gravity center of analysis. Specifically, the *Sustainable World* scenario contemplated the write-down of developing countries' debt and the signing of stringent environmental treaties.

In the book *The Roaring Nineties*,[17] the dismantling of economic borders, the liberalization of markets, and the relentless onrush of new technology became such powerful trends that they were widely perceived as something

to which "There Is No Alternative" (TINA). With these trends believed to continue to be the primary shapers of the future, the 1995 scenarios were built on *New Frontiers*, one of the 1992 scenarios, with the question being not "will the world embrace or resist TINA?" but rather "What form of embrace will be most successful"? With governments seen as neither quick enough nor competent enough to match the dynamic power of corporations, the world of *Just Do It!* stressed individualism and libertarianism. This scenario was contrasted with one—*Da Wo*—which was based on a more communitarian approach, emphasizing cohesion and the idea that "governments do matter."

As technological progress, market liberalization, and globalization continued unabatedly, and indeed gathered further steam in the second half of the 1990s, "the 1998 scenarios were built on *Just Do It!* as the only successful kind of response to TINA." *The New Game*, a "TINA above" scenario, represented a world where global governance was promoted through the development of new institutions to enhance the health of the global economy. *People Power*, a "TINA below" scenario, explored the effects of growing numbers of people becoming wealthier and better educated than ever before.

Shortly after *The New Game* and *People Power* were published, the world was shaken by the events in Seattle, which led to a breakdown in the WTO trade negotiations. These violent demonstrations against globalization represented a major branching point, which was difficult to reconcile with TINA as expressed in the 1998 scenarios. It was against this background that the 2001 scenario, *People and Connections*, asked whether TINA was overturned. The answer given was a no, albeit a qualified one. The forces of globalization, liberalization, and technology were anticipated to continue. However, it was recognized that people want not only the efficiencies that market liberalization brings, but also government regulations to assure uninterrupted supply of essential goods, including energy.

These issues were explored in two scenarios, *Business Class* and *Prism*. Specifically, the scenarios emphasized that globalization was not just expanding economic opportunities, but was also pushing the boundaries of culture and family. They also stressed the enormous ethical dilemmas technology may bring about. In *Business Class*, the world was seen as one that was not run by business, but like a business with a focus on efficiency and individual freedom of choice. *Prism*, by contrast, was depicted as a world that had gone beyond the modernist emphasis on efficiency, functionality, and global homogeneity toward the realization of "multiple modernities" that incorporate diverse cultural values and practices.

Motivated by the dual crises of international security and trust in the market—which were triggered by the terrorist attacks of September 11$^{th}$ and the corporate governance debacles of Enron, WorldCom, and others—the most recent scenarios presented in early 2005 focus on the interplay of market incentives, aspirations to social cohesion, and the provision of security and oversight by the state. While these scenarios are built on past global scenarios, notably *People and Connections*, they emphasize to a considerably larger extent the

interaction between these forces and the trade-offs between objectives that they can plausibly foster. While societies often aspire to all three objectives—efficiency, equity, and security—the scenarios make clear that these objectives display elements of mutual exclusiveness: One cannot be at the same time freer, more conforming to one's group or faith, and more coerced.

Against this background, Shell's latest scenarios consider three different worlds. In *Low Trust Globalization*, the leading theme is "carrots and sticks." Governments use market incentives to promote economic efficiency within a stringent regulatory and security framework. However, institutional discontinuities persist, with rapid regulatory change, overlapping jurisdictions, and conflicting laws leading to intrusive checks and controls—which impede economic integration and hinder the movement of goods, people, and knowledge. Compliance and superior risk management are key challenges in this scenario.

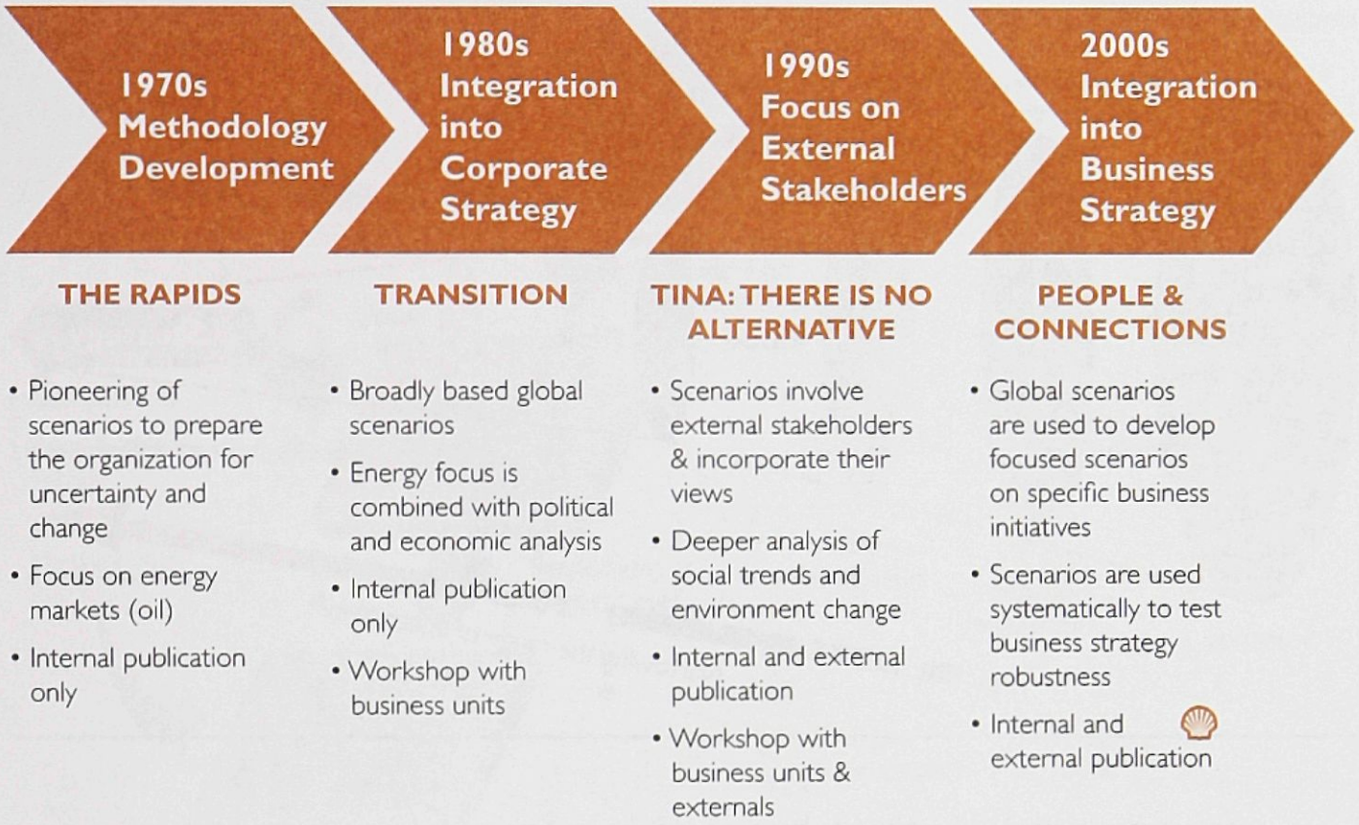
Driven by economic efficiency and the aspiration to social cohesion, *Open Doors* represents a world in which a trans-national society develops around market incentives. Compliance certification, regulatory harmonization, voluntary best-practice codes, and close links between investors and civil society encourage cross-border integration, international cooperation, and virtual value chains. Globalization continues unabated, and rapid technological progress and diffusion of knowledge supports strong productivity growth. In this world, networking skills and superior management are essential.

*Flags*, finally, is a world of nations and causes. Unlike in *Open Doors*, however, causes are pursued defensively, and as trust remains fragmented, the state resorts to the flag in an attempt to rally groups fighting under various political, social, and religious banners. Thus, the backlash against globalization is the result not so much of anti-globalization sentiment as of the absorbing nature of divisive domestic politics. Efficiency takes a back seat to security and solidarity. Governments resort to populist policies, with differing rules and standards, and to protectionist measures that inhibit the flows of trade and capital. Gated communities, patronage, and national standards exacerbate fragmentation and call for careful country-risk management.

## Scenarios as an Integral Part of Strategic Planning

Shell's track record in anticipating major structural changes in the global energy markets has substantially enhanced the credibility of scenario analysis within the Group. The most legendary example is probably the first oil price shock that was anticipated in Shell's first global scenario. Other examples include the impact of higher oil prices on economic growth in the 1970s, the substantial decline in oil prices in the mid-1980s, European integration, and the collapse of the former Soviet Union. Of course, not everything was detected by the scenario team's radar screen, and some important developments have been underestimated in terms of their importance for the Group. Recent examples includes China's rise as a global economic powerhouse, the backlash against

**EXHIBIT 2.** Capitalising on Uncertainties: Scenarios at Shell

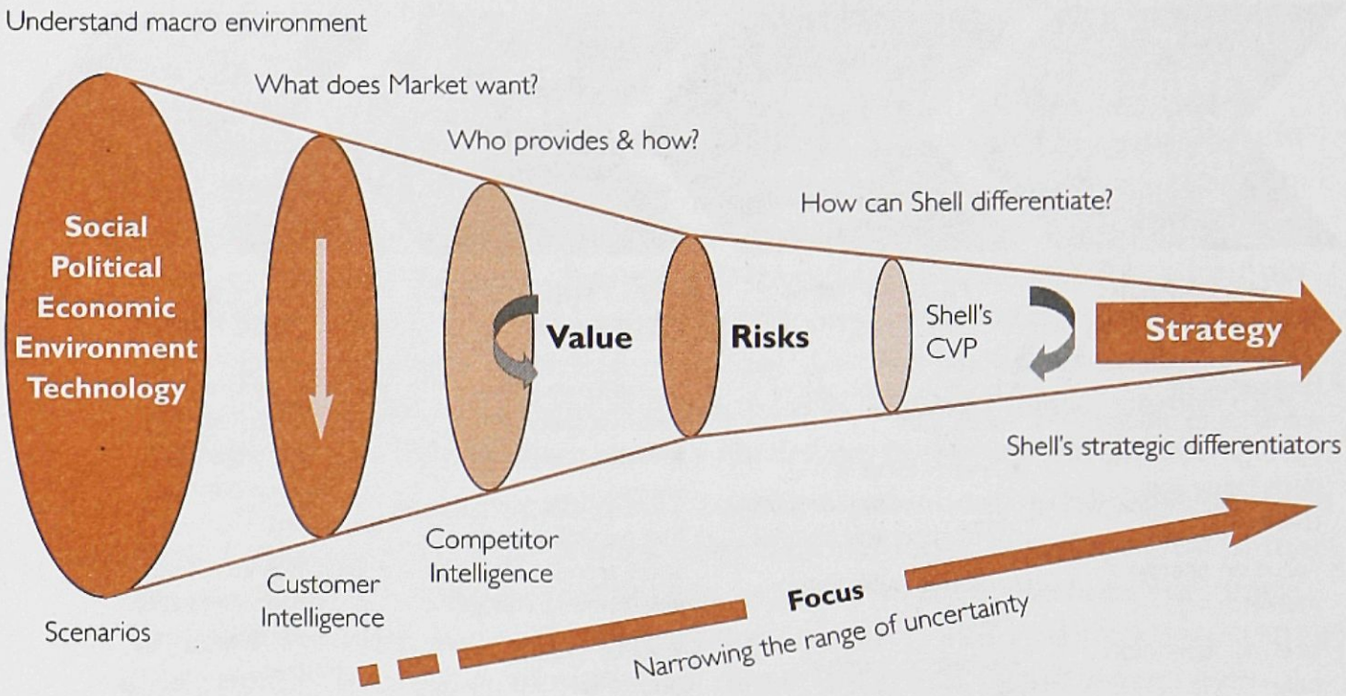



globalization, and the new scale of global terrorism. However, it appears doubtful whether traditional forecasting techniques would have performed better.

Arguably, however, the accuracy of the scenarios with regard to the prediction of events and the assessment of economic, energy, and price trends is only of secondary importance. What matters most is the ability to identify the driving forces, explain how these work, and ensure that the client understands them. Only then can scenarios be expected to influence and help improve strategic planning.

Reflecting this fundamental insight, scenario planning in Shell has been subject to important changes over the last three decades, not just in terms of the focus of the global scenarios, but also with regard to the underlying approach and how scenarios are incorporated into the strategic planning process (Exhibit 2).[18] The global scenarios remain at the center of this process, providing a comprehensive assessment of how the future business environment could develop. They are combined with a range of applications that provide a broad framework of ideas influencing strategy at the corporate level and assisting the businesses in identifying risks and opportunities. With the global scenarios setting the macroeconomic framework, the strategic funnel is then narrowed further by analyzing demand trends in individual energy markets and the strategic behavior of Shell's competitors. This analysis is followed by a comprehensive risk analysis. At this stage, the degree of uncertainty is sufficiently reduced to define the Group's customer value proposition and its strategic differentiators, which then leads

**EXHIBIT 3.** Using Scenarios in Strategic Planning

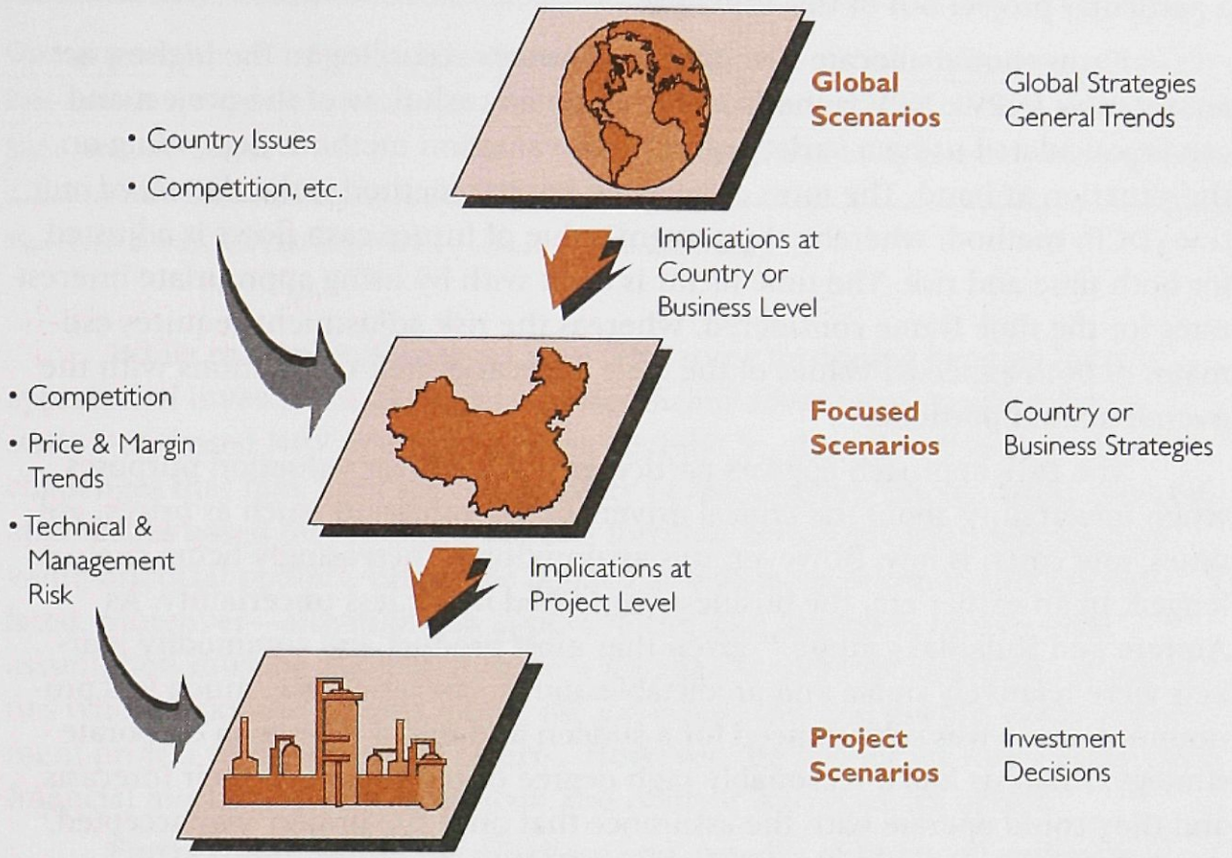



to strategic decisions about the aspired upstream and downstream portfolios (Exhibit 3).

The global scenarios have helped the Group gain competitive advantage in the past and continue to drive Shell's upstream and downstream portfolio decisions.[19] In its Group Strategy Review in late 2004,[20] the Executive Committee outlined several key decisions regarding Shell "aspired" portfolio that are based on scenario planning. Against the background of a higher price outlook, these decisions include more capital spending on exploration and production of oil and gas; a rising share of natural gas, with integrated gas reaching 40-45% of total production by 2014; and a rising share of unconventional oil especially from Canadian oil sands. On the downstream side, capital deployment is envisaged to shift to new growth markets, with Asia's share in oil products forecast to rise by around 15 percentage points to around 40% by 2010.

While the global scenarios are designed to help the company formulate its overall tactical and strategic policies and permit management to explore new ideas by shifting the company away from "group-think," over time focused scenarios have gained in importance. Typically, these scenarios deal with country-specific issues or individual projects (Exhibit 4). While the different levels of analysis are closely intertwined, the process that links them is flexible. As Shell's experience suggests, a mechanistic planning process that forces managers to produce a strategic response to global scenarios at the same point in time does not necessarily produce uniformly high-quality responses from the business units. Indeed, it appears that business units invest more energy and creativity in strategy development only occasionally when there is a formal planning process.

**EXHIBIT 4.** Bringing Scenarios to the Business




Focused scenarios tend to be more closely aligned to improving the judgment of individual managers on specific investment decisions. At the project level, it must be demonstrated that a particular investment is sufficiently robust against both the global scenarios and the supporting focused scenario. For instance, could abrupt changes in the regulatory framework make a project obsolete? To what extent could changes in the geopolitical landscape affect production and transportation? To what extent could demand shifts affect the economics of a project?

## Selecting Projects Using Real Options

The belief in a single outcome can lock us into a narrow set of options, a risk that scenarios can help to mitigate by discovering the full range of pathways. Suppose we know that scenario A is going to happen. All the uncertainty is gone and we can actively think about options. If we know, for example, like Noah, that it will rain for forty days and forty nights, we would need to creatively generate options for a flood scenario. In this "take-a-phone-call-from-God" example, we might just come up with the idea of building an ark,[21] an option we might never have conceived if we had seen the flood only as a very remote possibility. By going through all the scenarios and turning them into 100 percent certainties, we can identify options that we may overlook if we limit ourselves

to predict probable futures. Thus, scenarios can help us determine the universe of possible options. The question remains, however, as to how we should select a particular project out of this universe.

Firms should allocate investment resources according to the highest *net present value* (NPV). NPV is the future discounted cash flow of the project and can be calculated using a variety of intrinsic valuation methods depending on the situation at hand. The most commonly known method is the *discounted cash flow* (DCF) method, whereby the present value of future cash flows is adjusted for both time and risk. The time factor is dealt with by using appropriate interest rates for the time frame considered, whereas the risk adjustment requires estimates of both expected values of the cash flows and their correlations with the overall market portfolio.

The DCF approach appears particularly suitable for valuation purposes when uncertainty about the critical drivers of the valuation (such as prices, volumes, and costs) is low. However, this assumption is increasingly being challenged. In an earlier era, the business world had much less uncertainty. As Amram and Kulatilaka argue,[22] given that most product and commodity markets were relatively stable and predictable and globalization was much less pronounced, there was seldom need for a sudden and major change in corporate strategy. Analysts had a reasonably high degree of confidence in their forecasts, and they could operate with the assurance that once the project was accepted, the firm would attempt to run it pretty much according to plan.

This is where real options analysis comes in. Representing the right—but not the obligation—to invest, real options are a tool that may have important advantages where uncertainty is high. Their roots lie in the financial option pricing models developed by Black and Scholes and by Merton in the early 1970s.[23] As an extension of such models to the valuation of options on real (i.e., nonfinancial) assets,[24] the real options approach is a way of thinking that helps managers formulate their strategic options, i.e., the future opportunities that are created by today's investments. The real options approach focuses on the potential value embedded in exercising the option once the uncertainty has been resolved—that is, it values strategic initiatives by recognizing all the downstream choices that may be encountered over an investment's life.[25]

Real options and DCF analysis are not necessarily mutually exclusive. In fact, as van Putten and MacMillan show, real options may actually enhance DCF analysis. Where future cash flows are subject to substantial uncertainty, DCF analysis requires them to be discounted at a high rate. While the possibility that actual cash flows may be lower than forecast is captured in the valuation, the possibility that they may be higher is not. Therefore, there is an inherent bias in the DCF approach in the sense that managers may be led to reject highly promising, if uncertain projects. This is exactly where real options come in: They provide a way to recapture some of the value lost through the conservative DCF valuation while still protecting against the considerable risk of pursuing highly uncertain projects: "The DCF valuation captures a base estimate of value; the option value valuation adds in the impact of positive potential uncertainty."[26]

**EXHIBIT 5.** DCF versus Real Options*

| DCF—Traditional | Real Options |
|---|---|
| Operating decisions will not change in the future | Directional changes pending arrival of new information |
| Base case set of expected cash flows | Cash flows contingent on future uncertain conditions |
| Static sensitivity analysis | Managerial flexibility to react to changing conditions |

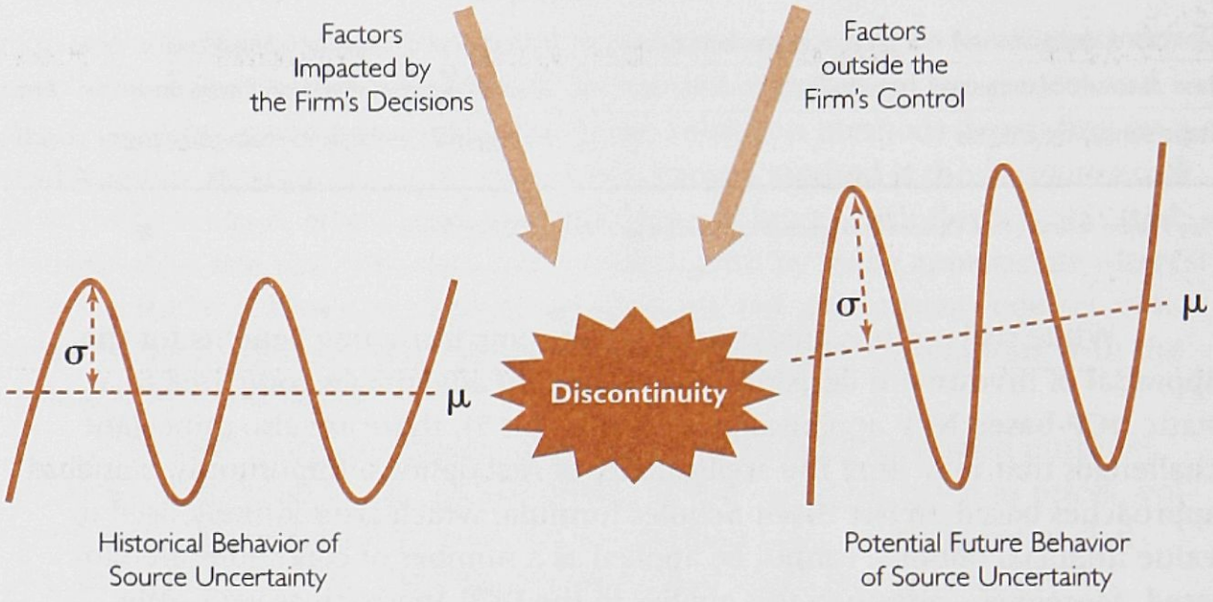
*See Marion A. Brach, Real Options in Practice (Hoboken, NJ: John Wiley, 2003), p. 331.

While real options analysis may offer some intriguing benefits for the appraisal of investment decisions and significant advantages compared to a static DCF-based NPV appraisal process (Exhibit 5), there are also important challenges that may limit the applicability of real options. Importantly, standard approaches based on the Black-Scholes formula, which are routinely used to value financial options, cannot be applied as a number of conditions are violated. Moreover—although this applies to the DCF approach as well—the assumption must be made that there is a traded security or a portfolio of securities whose risks and payoffs mimic the expected risks and payoffs of the investment project to model future returns. However, the farther we move away from financial markets, the more difficult and costly it is to track an option.

Furthermore, while the purchase and exercise of financial options is unlikely to alter the payoff dynamics of the replicating portfolio consisting of financial assets (stocks and bonds), the same might not be true for real options. Steps taken or not taken by any individual firm may have an immediate impact on the action of its competitors and hence the market equilibrium. An oil company, for example, that relies on the volatility of oil stocks, futures, or oil prices to replicate its real option on exploring a new oil field becomes immediately part of the dynamics that govern the twin security when acquiring the option. Its decision to explore the oil field will already send a signal to its competitors and alter their investment decisions.

While these challenges in applying real options to oil energy investments are important but not insurmountable, the most important problem lies in the limited guidance that history can provide for the future. Specifically, the search for twin securities whose past stock volatilities could serve as a proxy for the future volatility of a corporate investment project appears of limited value in rapidly changing environments. To be sure, there have been several paradigm shifts over the last three decades—most importantly, the two oil prices shocks in the early and late 1970s, the subsequent collapse of oil prices in 1986, and the recent increase in prices since 1999. If stochastic processes assumed in financial option pricing to estimate future values of the underlying asset do not seem appropriate for real options, what are our alternatives to quantify the uncertain value drivers of the project (the source uncertainties), notably the forward-looking mean annual volatility and the mean reverting coefficients?

**EXHIBIT 6.** History as a Predictor of the Future

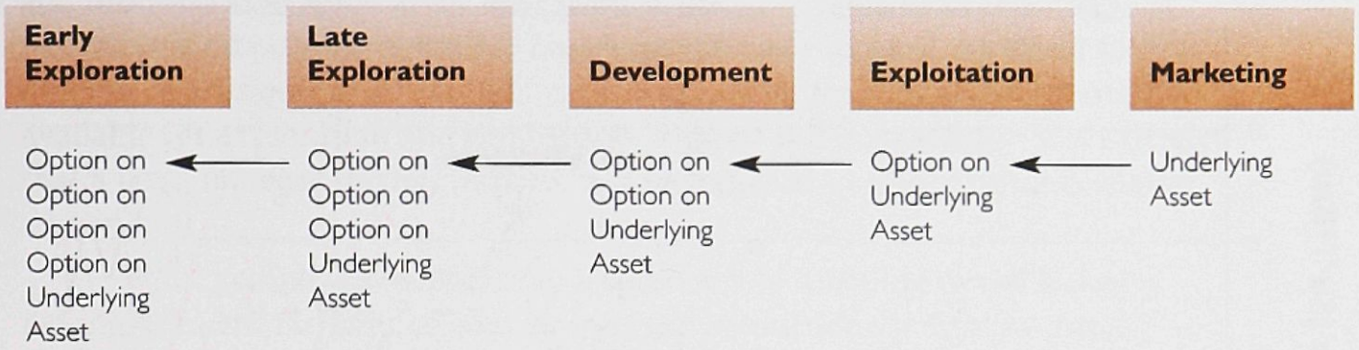



Starting from an analysis of historical price and quantity data, it is important to understand the factors that may affect them. These factors explain why future payoffs may differ from past payoffs (Exhibit 6):

- Factors affected by the firm's decisions are usually project- or sector-related and are generally easy to identify. Technological breakthroughs are examples of factors influencing the volatility of source uncertainties. These factors are typically not correlated with the general movements of the economy and require deep sector knowledge to identify them and assess their potential impact.
- Other factors may be outside the firm's control, however. Often, they depend on the social, economic, and political environment and may affect an entire sector or region and even the global economy. Deregulation of the telecommunication sector in Europe during the 1990s is a factor outside the firm's control that turned the telecommunication sector upside down, as most incumbent players were not ready to effectively compete in a deregulated market. Not surprisingly, deregulation of markets usually leads to an increase in uncertainty. Conversely, regulation leads to a decrease in uncertainty as the future becomes more predictable and stable.

In analyzing the potential future behavior of source uncertainty on the basis of factors that are within and outside the firm's control, scenario planning may provide a useful tool. As Brach argued, "for real option analysis scenario planning approximates what volatility is for financial option pricing. It builds on existing knowledge and past experience to create a range of plausible scenarios for the future, just as financial options rely on past volatilities when predicting

**EXHIBIT 7.** The Five Phases of Oil and Gas Exploration




future volatilities."[27] In this context, scenarios can provide key information that helps evaluate the option and time the decision to exercise it.

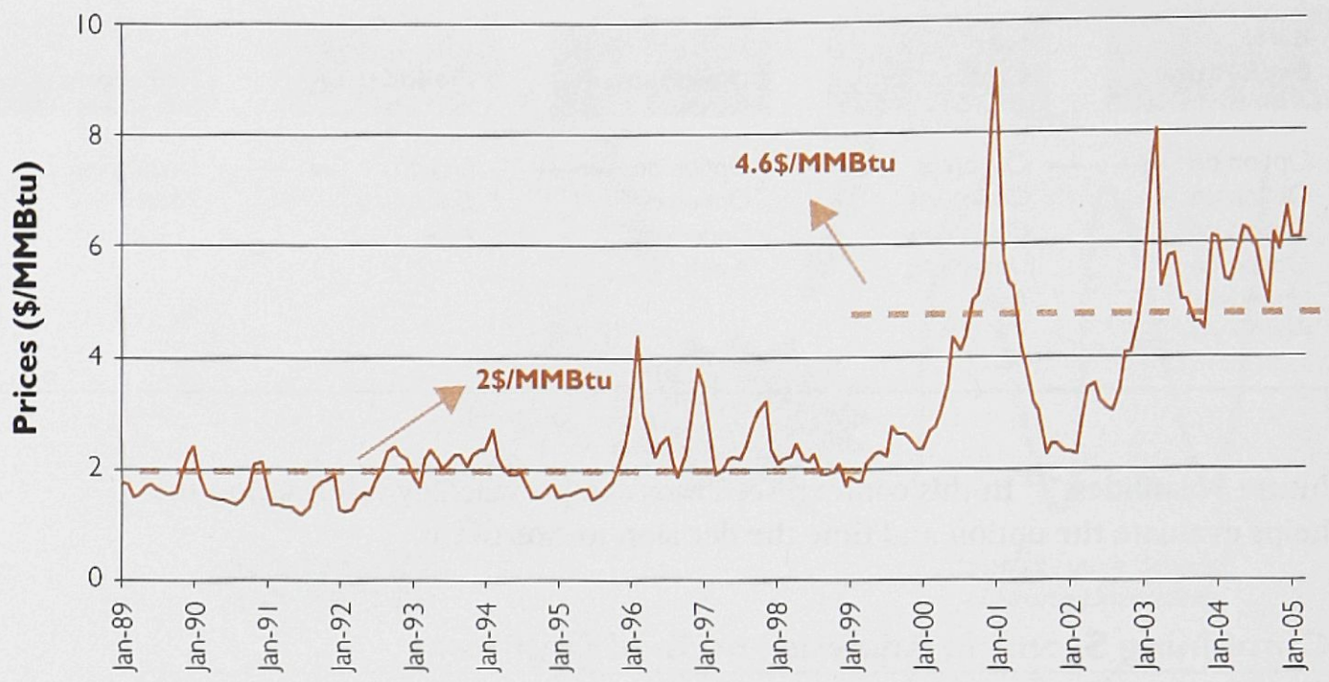
## Combining Scenario Analysis and Real Options: An Illustrative Example

Taking into account that a project's value may change over time due to the introduction of new information and the ability to act on that information, real options analysis is especially suitable for staged investment decisions in highly uncertain environments.[28] Exhibit 7 shows the stages of an oil or gas field investment from exploration to extraction, a sequence that might cover several decades. Each box indicates a stage of activity, and a decision whether to continue or not is made at the beginning of each stage. Each stage can be seen as a call option on the value of continuing with the exploration, a value that includes the value of all future options. As Amram and Kulatilaka argue,[29] exploration decisions are strongly affected by market-priced risk and exploration options can be valued with reasonable accuracy by tracking portfolios composed of oil/gas securities.

For example, consider an oil and gas company in the mid-1990s that had just discovered significant amounts of natural gas in West Africa. Bringing this natural gas to the market requires either piping or liquefying and then shipping it overseas to Europe and North America. However, shipping natural gas adds significant costs associated with liquefaction, storage, transportation, and regasification.

In the 1990s, the natural gas market in the United States was very much business as usual with few changes. With the gas market having become largely decontrolled in the 1980s,[30] few expected new discontinuities going forward. Thus, the mean gas price between 1991 and 1999 was $2.0/MMBtu, with an annual volatility of 57.2 percent (Exhibit 8). Under these conditions, an energy company would not have considered developing the overseas field in West Africa to supply North America, since the high costs associated with liquefaction, transportation, and regasification would have yielded a negative NPV.

**EXHIBIT 8.** Historical Henry Hub Prices




Source: Bloomberg Professional.

However, natural gas prices in the United States more than doubled in the first few years of this decade. Specifically, between January 2000 and January 2005 the Henry Hub price (the benchmark price for the U.S. gas market) averaged $ 4.6/MMBtu. At the same time, price volatility increased substantially, to more than 100 percent. Several demand and supply factors have caused this fundamental shift in what is the world's largest integrated gas market. On the demand side, concerns about air pollution have become increasingly important, and with people becoming more health conscious, natural gas is increasingly favored for domestic heating.[31] It is estimated that 75 percent of all homes built in the last fifteen years use natural gas, bringing the current level of all U.S. homes to 50 percent. At the same time, environmental regulations have been tightened, favoring natural gas to fire power plants.

Greater demand for cleaner energies and more stringent environmental regulations has fostered technological progress. Combined Cycle Gas Turbine (CCGT) technology is both simple and efficient (a premium of around 50 percent compared with coal). In addition, output can more easily be matched to demand, resulting in less wastage of energy. Over the last decade, this resulted in massive investments in CCGT plants for electricity generation, dramatically increasing the demand for natural gas.

The impact of higher demand for natural gas has been compounded by supply-side factors. According to the U.S. Department of Energy (DOE), technically recoverable natural gas reserves amount to around 36,200 tcf (trillion cubic feet), which is equivalent to around 67 years of current U.S. production. However, as the DOE points out, most of the increase in U.S. natural gas production

will come from unconventional sources (tight sands, shale, and coalbed methane) whose costs are considerably higher. Moreover, restrictions on exploration and production in some areas have limited the development of resources. In fact, almost 40 percent of the gas found on U.S. federal lands is subject to production restrictions. Furthermore, no acreage along the east and west coast is available for exploration and production. Against this background, it is expected that a large increase in LNG imports will be required to satisfy rising domestic demand.

This example emphasizes the importance of mapping causal linkages among different factors that may or may not be outside the firm's control. Focusing on the complex interplay of technological, regulatory, environmental, and supply factors, scenario planning could have helped to anticipate the emerging discontinuity in the U.S. natural gas market. Of course, scenarios, as stressed earlier, are not forecasts, and they can be used in the strategic planning process only in conjunction with specific tools to select individual projects. Traditional DCF analysis would have rejected the investment in the development of the West African gas field and the LNG chain to ship the natural gas to the United States. However, real options analysis combined with scenarios could have come to a different conclusion. Instead, scenarios would have signaled that the firm's option to develop the gas field could come to maturity. Capturing the upside of price risk, a combined real options/scenario analysis could have induced investment in the entire LNG chain between the gas field and the U.S. consumer market, with the option to expand the investment later depending on market conditions.

## Conclusions

While scenario planning represent an important tool to understand the critical uncertainties and their interrelationships, this tool is not designed to choose particular investment projects and allocate capital efficiently in the best interest of shareholders. Scenarios should usefully be combined with a real options approach, as a project's value may change over time due to the introduction of new information. Scenarios can contribute to real options at three fundamental levels. First, they can help identify future options. Second, they can help time the decision to exercise an option. And finally, scenarios can provide important input in the process of evaluating real options.

### Notes

1. Withold J. Henisz and Jonathan Story, "Corporate Risk Management and Business Strategy: A Prime Task for Senior Management," in Peter K. Cornelius and Bruce Kogut, eds., *Corporate Governance and Capital Flows in a Global Economy* (New York, NY: Oxford University Press, 2003), pp. 217-238.
2. Nicolas Checa, John Maguire, and Jonathan Barney, "The New World Disorder," *Harvard Business Review*, 81/8 (August 2003): 70-79.
3. Pierre Wack, "Scenarios: Uncharted Waters Ahead," *Harvard Business Review*, 63/5 (September/October 1985): 72-89.

4. Peter Schwartz, "The Official Future, Self-Delusion and the Value of Scenarios," in James Pickford, *Mastering Risk, Volume 1: Concepts* (London: Financial Times and Prentice, 2001), pp. 42-46.
5. On July 20, 2005 the shareholders of Royal Dutch and Shell Transport and Trading voted in favor of the unification of the Royal Dutch and Shell Group of Companies under a single parent company, Royal Dutch Shell plc. In this article, we refer to the "Royal Dutch/Shell Group of Companies," or simply "the Group" or "Shell."
6. Ged Davis, "Scenarios as a Tool for the 21st Century," paper presented at the Probing the Future Conference, Strathclycde University, July 12, 2002, <www.shell.com/static/royal-en/downloads/gd_scenarios_as_a_tool_12072002.pdf>.
7. For most firms, a substantial part of their market value is attributable to their options to invest and grow in the future, rather than the capital they already have in place. See Avinash K. Dixit and Robert S. Pindyck, *Investment Under Uncertainty* (Princeton, NJ: Princeton University Press, 1994).
8. Martha Amram and Nalin Kulatilaka, "Strategy and Shareholder Value Creation: The Real Options Frontier," *Journal of Applied Corporate Finance*, 13 (Summer 2000): 8-21. Myers, who coined the term in 1977, argues that by recognizing that standard discounted cash flow techniques tend to understate the option value attached to growing profitable lines of businesses, the real options approach has the potential of closing the wide gap between strategic planning and finance. See Stewart Myers, "Determinants of Corporate Borrowing," *Journal of Financial Economics*, 5/2 (November 1977): 147-175.
9. C.S. Galbraith and G.B. Merrill, "The Politics of Forecasting: Managing the Truth," *California Management Review*, 38/2 (Winter 1996): 29-43.
10. Wack, op. cit.
11. Helmut Kahn and A. Wiener, *The Year 2000* (New York, NY: McMillan, 1967).
12. Peter Schwartz, *The Art of the Long View: Planning for the Future in an Uncertain World* (New York, NY: Doubleday Currency, 1991); Kees Van der Heijden, *Scenarios: The Art of Strategic Conversation* (New York, NY: John Wiley, 1996); Kees Van der Heijden (with Ron Bradfield, George Burt, George Cairns, and George Wright), *The Sixth Sense: Accelerating Organizational Learning with Scenarios* (New York, NY: John Wiley, 2002); Pierre Wack, "Scenarios: Shooting the Rapids," *Harvard Business Review*, 63/6 (November/December 1985): 139-150.
13. Robert Bood and Theo Postma, "Strategic Learning with Scenarios," *European Management Journal*, 15/6 (December 1997): 633-646.
14. Michael E. Porter, *Competitive Advantage* (New York, NY: The Free Press, 1985).
15. Shell International, *People and Connections: Global Scenarios to 2020*, Public Summary (London: Shell International, 2002).
16. Schwartz, op. cit.; Van der Heijden, op. cit.; Wack, op. cit.; Davis, op. cit.
17. Joseph Stiglitz, *The Roaring Nineties* (London: Penguin Books, 2003).
18. Paul Schoemaker and Kees Van der Heijden, "Integrating Scenarios into Strategic Planning at Royal Dutch/Shell," *Planning Review*, 20 (1992): 41-48; Arie De Geus, *The Living Company* (Boston, MA: Harvard Business School Press, 1997).
19. For instance, the scenario that anticipated the first oil price shock enabled the Group to respond quickly to the oil embargo, boosting its margins to the top of its peer group. In the years that followed Shell's advantage among the international oil companies widened further, and while in 1970 the Group had 35 percent less market capitalization than Exxon, it led Exxon with 25 percent by the end of 1994.
20. Available on Shell's website at <www.shell.com/home/Framework?siteId=media-en&FC3=/media-en/html/iwgen/news_and_library/press_releases/2004/strategy_pres_stock_22092004.html&FC2=/media-en/html/iwgen/news_and_library/press_releases/2004/zzz_lhn.html>, downloaded on April 29, 2005.
21. Paul Schoemaker, *Profiting from Uncertainty* (New York, NY: The Free Press, 2002).
22. Amram and Kulatilaka, op. cit.
23. Fischer Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy*, 81/3 (May/June 1973): 637-654; Robert C. Merton, "Theory of Rational Option Pricing," *Bell Journal of Economics and Management Science*," 4/1 (Spring 1973): 141-183.
24. Although the term "real options" was already coined in 1977, the new approach gathered considerable momentum only in the second half of the 1990s thanks to important contributions by Dixit and Pindyck, Trigeorgis, and Amran and Kulatilaka. See Dixit and Pindyck, op. cit.; Lenos Trigeorgis, *Real Options. Managerial Flexibility and Strategy in Resource Allocation*

(Cambridge, MA: MIT Press, 1996); Martha Amram and Nalin Kulatilaka, *Real Options: Managing Strategic Investment in an Uncertain World* (Boston, MA: Harvard Business School Press, 1999); Jeffrey J. Reuer and Michael J. Leiblein, "Real Options: Let the Buyer Beware," in James Pickford, ed., *Mastering Risk. Volume 1: Concepts* (London: Financial Times and Prentice, 2001), pp. 79-85.

25. Real options analysis may also be applied to country risk assessments. One example concerns alternative modes of market access through exports as opposed to foreign investment. For example, if the investor is uncertain as to whether the introduction of a more investment-friendly tax rate is permanent, he may attach a (subjective) probability to the potential reintroduction of the tax at the original level at a later stage, which could make his investment obsolete. Clearly, the investor will only commit his capital if the expected profits from investing now (net of investment costs) exceed the present discounted value of all future profits from exporting; he will continue to export otherwise. However, if the investment can be delayed, the investor will gain information about the eventual state of policy and take the optimal decision once all uncertainty is resolved. By committing his capital in the initial period, he kills the option and thus foregoes this opportunity. He incurs an additional cost that is equal to the value of the option to invest. See Alexander Lehmann, "Country Risks and the Investment Activity of U.S. Multinationals in Developing Countries," IMF Working Paper, Washington, D.C., International Monetary Fund, 1999.
26. Alexander B. van Putten and Ian C. MacMillan, "Making Real Options Really Work," *Harvard Business Review*, 82/12 (December 2004): 134-141.
27. Marion A. Brach, *Real Options in Practice* (Hoboken, NJ: John Wiley, 2003), p. 333.
28. Schoemaker, op. cit.
29. Amram and Kulatilaka, op. cit.
30. For details, see Franklin Tugwell, *The Energy Crisis and the American Political Economy* (Stanford, CA: Stanford University Press, 1988).
31. According to the World Energy Council, a natural gas powered power plant emits about 0.64 carbon per ton of oil equivalent (TOE), compared to 1.08 for coal-fired and 0.84 oil-fired plants.