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MULTIPLE SCENARIO DEVELOPMENT: ITS CONCEPTUAL AND BEHAVIORAL FOUNDATION

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This paper examines the multiple scenario approach as an important corporate innovation in strategic planning. Using a participant/observer perspective, I examine how scenario planning tries to meet certain methodological, organizational and psychological challenges facing today's senior managers. Three prime characteristics are identified as setting the scenario approach apart from more traditional planning tools: (1) the script or narrative approach, (2) uncertainty across rather than within models, and (3) the decomposition of a complex future into discrete states. After exploring the intellectual roots of scenario planning, I examine such organizational aspects as the need for diversity of views and the importance of simplicity and manageability. Both benefits and obstacles to using scenarios in organizations are identified. Cognitive biases are examined as well, especially the well-known biases of overconfidence and the conjunction fallacy. Two experiments test the impact of scenarios on people's subjective confidence ranges. Another two experiments test the internal coherence of subjects' beliefs. The psychological benefit of scenario planning appears to lie in the exploitation of one set of biases (e.g., conjunction fallacies) to counteract another (such as overconfidence).

Numerous firms have incorporated scenario planning into their strategic decision making. This has been one response to increased uncertainty, interdependence and complexity—such as the 1973 and 1979 oil shocks, widespread deregulation, increased globalization, and the emergence of new technologies. According to a major survey (Linneman and Klein, 1983), over 50 percent of *Fortune* 500 industrial companies had turned to scenario planning by 1982. Royal Dutch/Shell has been one of the leading proponents and innovators of scenario thinking. This Anglo-Dutch oil and gas giant started the use of scenarios around 1970 in order to make its senior executives consider the possibility of an OPEC-induced price hike. When oil prices in fact quadrupled in 1973, Shell started to use scenario planning much more seriously in trying to anticipate and exploit subsequent oil shocks, such as the tripling of oil prices in 1979 (see Wack, 1985a,b for details) and the collapse of oil prices in 1986.

The goal of this paper is to explain how scenario planning differs from other planning approaches and to ask whether its corporate appeal is justified. The plan and primary contributions of this paper are as follows:

1. The scenario method is described and contrasted with other planning tools.
2. The value of this method to strategic planning is discussed.
3. Circumstances are identified that favor the use of this method.
4. Behavioral issues are identified that need further research.

Key words: Scenario method, planning under uncertainty, Royal Dutch/Shell, cognitive biases, probability calibration, consensus building

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5. Psychological hypotheses are formulated and tested experimentally.

The analysis of items 1–3 above is based on the author's experience with the scenario approach during a 2-year sabbatical with the Planning Group of Royal Dutch/Shell from 1982–84. Hence the first part of the paper employs a participant/observer methodology. This research method differs from other academic approaches in that it tries not to favor any particular disciplinary perspective (Leach, 1961; Partridge, 1987; Whyte, 1991). Items 4–5 are addressed using the more traditional research methods of conceptual analysis and psychological experimentation.

BACKGROUND

Various prior studies of scenario planning exist. Bell (1982) examined scenarios in decision theoretic terms (also see Merkhofer and Keeney, 1987); Kahneman and Tversky (1982) from a psychological viewpoint (see also Dawes, 1988 and Jungerman, 1985); Porter (1985) from an economic perspective; Raubitschek (1988) in business planning terms; and Huss (1988) from a forecasting angle. Each of these prior descriptions captures important aspects of the method, but none its full organizational essence. Specifically, scenarios are more than selected paths through a complex decision tree or some statistical boundaries of multidimensional confidence intervals.

Multiple scenario analysis is an important new tool to examine fundamental uncertainties and expand people's thinking. As summarized in Table 1, other techniques exist for this as well, but they are often more limited in scope and organizational friendliness. This paper presents a generic method for scenario construction, in which the focus is on learning and exploring interrelationships among trends and key uncertainties. Scenarios share with these other techniques the 'divide and conquer' strategy but little attempt is made to integrate all elements into an overarching super-model.

Just as physicists, in their quest to understand the behavior of say H_2O, first developed state-dependent theories (i.e., water as a liquid, gas or solid), scenarios likewise decompose complex phenomena into more analyzable subsystems. Unlike physics, however, these decoupled subsystems need not be reconcilable, but may present antithetical world views. In terms of inquiring systems (Churchman, 1971), scenarios are Hegelian in their underlying philosophical premise. The scenario method courts contradiction and paradox. In contrast, the traditional approaches of decision analysis and forecasting tend to be Leibnizian. They seek a single truth and representation of reality (see Mitroff and Kilmann, 1978).

The gist of the scenario method seems that it is many things: art and science, deduction and induction, structured and fluid, rational (in the unitary actor sense) and political. These multiple facets have caused it to remain elusive and fuzzy by academic standards. Nonetheless, the use of scenarios in strategic management is real, important and growing (see Mandel, 1982; Becker, 1983; Honton, Stacey and Millett, 1985; Godet, 1987). In the following sections, I try to understand why. The paper starts by placing the scenario method in a historical context and then compares it to other planning approaches. Thereafter, it addresses important organizational and psychological issues, followed by four experiments that test the psychological impact of scenarios on people's beliefs. The first two experiments examine how scenarios affect people's subjective confidence ranges (as one measure of perceived uncertainty). The last two experiments examine the coherence of subjects' beliefs and perceptions in relation to scenario construction. Hence, the paper especially focuses on the psychological basis of scenario planning. First, however, the method is placed in a larger historical and organizational context.

INTELLECTUAL ROOTS AND COMPARISONS

The term scenario has many meanings, ranging from movie scripts and loose projections to statistical combinations of uncertainties. In its broadest sense, scenario thinking is as old as prospective story telling. However, as a tool for disciplined thinking and problem solving, its formal roots trace back half a century, to the use of computer simulation in the Manhattan project. In 1942, atomic physicists such as Lawrence, Oppenheimer, Teller, and Compton were unsure whether a full scale explosion of the atom bomb might literally ignite the skies (Davis, 1968). The associated physics equations were too complex for closed form solution, since

Table 1. Techniques to enhance strategic thinking

	Systematic thinking tool?	Internal communication device?	Identifier of strategic issues?	Problem scope?	Uncertainty bounding?
1. Lateral thinking and brainstorming (Osborn, 1953; de Bono, 1973)	No	No	Somewhat	Broad	No
2. Synectics and morphological analysis (Gordon, 1961; Zwicky, 1969)	Medium	Perhaps	Perhaps	Limited	No
3. Delphi method (Linstone and Turoff, 1975; Wedley *et al.*, 1978)	High	Yes	No	Narrow	Yes
4. Dialectic reasoning (Mitroff and Emshoff, 1979; Schwenk and Cosier, 1980)	Perhaps	Perhaps	Yes	Broad	Perhaps
5. Multiple scenarios (Wack, 1985a, b; Huss, 1988)	Medium	Yes	Yes	Broad	Yes
6. Requisite decision modeling (Berkeley and Humphreys, 1982; Phillips, 1982)	High	Yes	Perhaps	Narrow	Perhaps
7. Dynamic systems analysis (Forrester, 1961; Sterman, 1988; Senge, 1990)	High	Yes	Perhaps	Medium	Perhaps

they involved complex chain reactions of heat build-up. Instead, computer simulations were used to estimate probabilities of the atmosphere and planet catching fire. The subsequent flourishing of scenarios and simulation in the study of social problems seems to reflect three relatively independent research strands.

First, the development of computers enabled simulated solutions (e.g., using Monte Carlo methods) for otherwise intractable problems. Second, game theory (von Neumann and Morgenstern, 1947) provided a rich theoretical structure for the study of social interaction and conflict (see Dresher, 1961 or Shubik, 1964). Third, the post-war defense needs of the U.S.A. required war games in which humans and machines interacted. The Rand Corporation played a central role in bringing these three strands together for military purposes (see Kahn and Mann, 1957), especially in the Air Defense System Missile Command, a large scale early warning system. Later, some of these Rand researchers extended the simulation concept beyond defense applications, to companies and society in general (see Jones, 1980).[1]

Given this evolution, it is not surprising that the term scenario means different things to different people. To 'gamers' it refers to the contextual definition (or operating environment) within which the man/machine simulation is played out (Brown, 1968). In this paper, scenarios will be defined more broadly as *focused descriptions of fundamentally different futures presented in coherent script-like or narrative fashion.* In corporate planning, multiple scenarios are often used to characterize the range within which the future is likely to evolve (Huss, 1988). Sometimes a few scenarios are sufficient to bound the zone of possibilities; other times numerous scenarios may be needed depending on the number of issues examined. At Royal Dutch/Shell, scenarios present more than an end state description, but

[1] For instance, Herman Kahn left Rand to found the Hudson Institute, which published numerous futuristic scenarios, such as the controversial book *The Next 200 Years: A Scenario for America and the World* (Kahn *et al.*, 1976).

especially highlight dynamic interactions (i.e., how we might get from here to there). Furthermore, they aim to reflect a variety of viewpoints (within and outside the company), so as to cover a broad range of future possibilities (see Wack, 1985a and b; Schoemaker and van der Heijden, 1992).

Note that scenarios, in this sense, are not states of nature nor statistical predictions. The focus is not on single-line forecasting nor on fully estimating probability distributions, but rather on *bounding* and better understanding future uncertainties. Scenarios also aim to counter psychological biases (see Hogarth and Makridakis, 1981; Barnes, 1984; Russo and Schoemaker, 1989) as discussed later. Of course, there are multiple ways to interpret scenarios. To some they may be no more than a form of predecision analysis, useful to sort out one's mind before tackling specific problems. To others, they may constitute a form of *incomplete* decision analysis, which deemphasizes probabilities and explores in detail selected states of nature. In my view, they represent a fundamentally different approach to dealing with uncertainty and complexity, in that the method is focused on characteristic biases of the human mind such as overconfidence and anchoring.

People seem to relate best to concrete, causally coherent narratives. As shown by Pennington and Hastie (1986, 1988), comprehension of complex evidence relies on weaving intentional and causal accounts around strands of evidence that would otherwise seem disparate and hard to remember. This causal tapestry in turn provides a basis for further inquiry and integration of new evidence. Scenarios try to accommodate this mode of thought. Also, the scenario method caters to people's preference for certainty, by primarily specifying uncertainty *across* rather than within scenarios. This treatment of uncertainty is quite different from more traditional methods which usually present one model, with uncertainty nested within it. Scenarios instead present several models, which *bound* the uncertainty range but do not give it probabilistic prominence. The downplaying of probabilities is consistent with the focus on learning and understanding (de Geus, 1988; Senge, 1990), as opposed to problem solving and choice. Lastly, an important feature of scenarios is their decomposition of complexity into distinct states. This further reflects an adaptation to the human mind, which can only handle a limited amount of complexity (Schwenk, 1984).

THE SCENARIO METHOD

Table 2 describes 10 steps that in my view characterize the process in general terms. This list is not a recipe but a road map to steer along a complex and creative group process, often lasting well over a year. We shall refer to this table later when discussing methodological, organizational and psychological issues. First, however, we should briefly highlight the main elements of the scenario building process.

The first one is the identification of important *current* trends, as perceived by industry experts, managers, and knowledgeable outsiders. A crucial question to ask analysts is whether such perceived trends are mutually compatible (within the chosen time frame) and what evidence supports each. Following the trend analysis, key uncertainties should be identified, including their correlations. Such procedures as conditional probabilities assessment and cross-impact analyses can be useful here to assure internal consistency (see Kirkwood and Pollack, 1982). Once *coherent* trends and uncertainties have been identified, the main ingredients for scenario construction are available. As our experiments will show, however, people's beliefs may not be coherent.

A simple start is to construct extreme worlds, by putting all positive elements in one and all negatives in another scenario. Alternatively, the outcomes can be clustered around high vs. low continuity, or high vs. low surprise. However, such mechanically constructed worlds are not truly scenarios, since they are usually *internally inconsistent*. Three types of consistency should be checked for: (1) trend consistency, (2) outcome consistency, and (3) stakeholder consistency. Trend consistency concerns the compatibility of the trends within the chosen time frame. Outcome consistency involves the correlations referred to above, i.e., do the scenarios postulate outcomes for the key uncertainties that indeed fit together. Stakeholder consistency requires that the major actors in each scenario are not placed in positions they dislike and can change.[2]

In view of these main features of the scenario process, it is instructive to compare it with other

[2] This is especially relevant for macro scenarios involving governments, international organizations (e.g., IMF, World Bank, UN) or strong interest groups such as OPEC (see Godet, 1982).

Table 2. Steps in scenario construction

1. Define the issues you wish to understand better in terms of **time frame, scope** and **decision variables** (e.g., prices of natural gas over the next 5 years in the Far East). Review the past to get a feel for degrees of uncertainty and volatility.
2. Identify the major **stakeholders** or **actors** who whould have an interest in these issues, both those who may be affected by it and those who could influence matters appreciably. Identify their current roles, interests and **power** positions.
3. Make a list of current **trends** or **predetermined elements** that will affect the variable(s) of interest. Briefly explain each, including how and why it exerts an influence. Constructing a diagram may be helpful to show interlinkages and causal relationships.
4. Identify key **uncertainties** whose resolution will significantly affect the variables of interest to you. Briefly explain why these uncertain events matter, as well as how they interrelate.
5. Construct two **forced scenarios** by placing all positive outcomes of key uncertainties in one scenario and all negative outcomes in the other. Add selected trends and predetermined elements to these extreme scenarios.
6. Next assess the **internal consistency** and **plausibility** of these artificial scenarios. Identify where and why these forced scenarios may be internally inconsistent (in terms of trends and outcome combinations).
7. Eliminate combinations that are not credible or impossible, and **create** new scenarios (two or more) until you have achieved internal inconsistency. Make sure these new scenarios bracket a wide **range of outcomes**.
8. Assess the revised scenarios in terms of how the key **stakeholders** would behave in them. Where appropriate, identify topics for further study that would provide stronger support for your scenarios, or might lead to revisions of these **learning scenarios**.
9. After completing additional research, reexamine the internal consistencies of the learning scenarios and **assess** whether certain interactions should be formalized via a **quantitative model**. If so, use this model to run some Monte Carlo **simulations** after obtaining subjective uncertainty ranges (or entire distributions) for key independent variables.
10. Finally, reassess the ranges of uncertainty of the dependent (i.e., target) variables of interest, and retrace Steps 1 through 9 to arrive at **decision scenarios** that might be given to others to enhance their decision making under uncertainty.

methods. Figure 1 contrasts five major approaches to planning positioned along two key dimensions, uncertainty and complexity. Uncertainty here concerns the extent to which the causal structure of a strategically relevant variable is *unknown*. The complexity dimension captures the extent to which the causal structure is *unique* to that variable, i.e., independent of the causal structures of the other strategic variables.

Complexity in this sense does not refer to the intricacy of the underlying causal structure, but rather to the degree to which the underlying factors *overlap* with the causal structures of other strategic variables. Exchange rates or a patent approval, for instance, would be considered to be of low complexity if they are causally independent of such variables as market share, price levels, production costs, etc. The latter, in contrast, would exhibit high complexity in case they entail strongly interrelated causes. In the metaphor of a tapestry, complexity is high if pulling one thread causes many others to move as well.[3] Uncertainty, in contrast, only concerns the degree to which the mapping of causes onto effects is unknown.

When uncertainty and complexity are both low, many firms will use best guesses or point estimates (Georgoff and Murdick, 1986). This approach seems appropriate when actual deviations from the forecast are small (relative to firms' adaptive capabilities) and relatively

[3] To express this distinction more formally, let y_1 through y_n denote the strategically relevant variables for a particular decision, and x_{i1} through x_{im} (denoted as the set X_i) the m causes influencing y_i (where m will vary across y_i). A given variable y_1 will be deemed complex if its set of $x_{11} - x_{1m}$ intersects significantly with the causal sets of the remaining $(n - 1)$ y_i (i.e., if $X_1 \cap X_i \neq \emptyset$ for $i = 2, \ldots, n$).

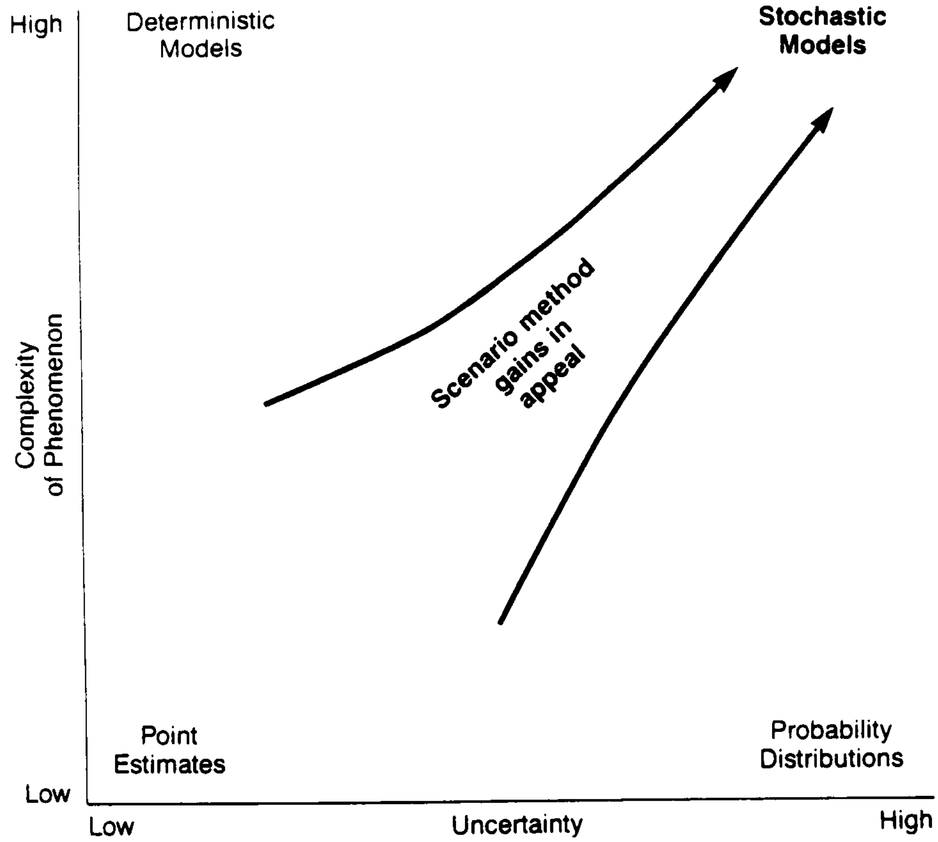

Figure 1. Approaches to planning

uncorrelated with other important variables. However, single point forecasting has not fared well during the past two decades. Even such an established organization as the OECD, employing more resources than most other forecasting units, regularly misses annual GNP growth by considerable amounts (Smyth, 1983). And, historically, many expert prognostications have failed miserably, in numerous walks of life (Cerf and Navasky, 1984; Schnaars, 1989).

When uncertainty is high, best estimates become relatively less important and measures of dispersion more relevant (Schnaars and Topol, 1987). A common approach is to accord each point estimate an upper and lower bound, so that one is highly confident the actual outcome will fall within that range. Although sound in principle, experience suggests that the intervals are typically too narrow. Numerous behavioral studies have demonstrated how poorly calibrated people's subjective probability judgments tend to be (Lichtenstein, Fischhoff, and Phillips, 1982). The reasons for such overconfidence can be several, ranging from general optimism to corporate or individual blind spots (Russo and Schoemaker, 1989). One intended benefit of scenarios is to instill greater realism, deeper understanding and consequently better calibration in case subjective confidence ranges are provided. We shall test this key presumption in the experiments.

In addition, to uncertainty, there is the problem of complexity, which may make it perilous to talk about the behavior of one variable in isolation of others. The danger of focusing on a single variable or trend was well expressed by Alvin Toffler (1985: 18–19):

> I mistrust isolated trends, whether mini or mega. In a period of rapid change, strategic planning based on straight-line trend extrapolation is inherently treacherous. What is needed for planning is not a set of isolated trends, but

> multidimensional *models* that interrelate *forces*—technological, social, political, even cultural, along with the economics.

When faced with high complexity, the challenge is to construct *models* that explicate the relationships among the variables (Polanyi, 1974). When uncertainty is low, deterministic models may be adequate, as in the case of linear programming, inventory/production models or econometric equations. However, deterministic models seem to perform less well at macro levels, as evidenced by the failures of econometrics (Leamer, 1983) and global models in general (Page, 1982).

When both uncertainty and complexity are high, we may have to employ stochastic models (in which some variables are treated as being random). Although an academic ideal, stochastic models likewise appear not to have worked well in practice in the field of strategy. Their use is usually limited to operational management (e.g., inventory-production models, queuing simulations, financial modeling and marketing), entailing well-structured problems. Scenarios offer a compromise between the theoretical ideal of completeness, formalism and objectivity on the one hand and most managers' desire to keep matters concrete, manageable and relatively simple on the other.

ORGANIZATIONAL ASPECTS

Most companies are designed to process one scenario only, the official corporate future. Risk analysis is permitted within the assumptions of this future, but not outside. Furthermore, budgets are normally based on single-point estimates of growth rates, exchange rates, costs, etc. Since budgets serve both a planning and control function, this deterministic approach is reasonable. Probabilistic budgets would invite gaming, ambiguity, arbitrariness and undue complexity. It is possible, however, to maintain the single-future machinery at the operational level, while injecting fundamental uncertainties (that question worldviews) in the strategic plans only.

For instance, Royal Dutch/Shell distinguishes clearly between business planning and strategic planning. They use scenarios to introduce fundamental uncertainty into the strategic thinking process only (see Schoemaker and van der Heijden, 1992). Once strategies have been formulated, their translation into 5-year budgets and operational plans is based on a single set of assumptions about the future. It is understood, however, that these assumptions are no more than a 'reference case', to assure comparability across divisions. Once all lower-level budgets have been specified, they are added up into a consolidated budget. This deterministic master budget is then re-examined by Shell's corporate planning group under alternative sets of assumptions (i.e., other reference cases) which cover the range of the original scenarios.

In smaller companies it may be actually feasible to go through the budgeting cycle more than once, to get a better feel for cashflows and expenditures under various scenarios. It is in this sense that the scenario method is a compromise between a completely stochastic approach at all levels, and the common tendency to have no systematic incorporation of deep uncertainty in the firm's strategies at all. Naturally, the extent to which epistemic uncertainty (Habermas, 1975) should be systematically incorporated depends on the firm's ability to adapt to unforeseen circumstances and its willingness to bet the company on one view of the future.

It is not surprising that the scenario method flourished first in industries with long lead-times, highly specific assets, and great external uncertainty. According to Malaska (1985), its most extensive use occurs in petroleum related industries (73% among respondents surveyed), transportation equipment (64%), and electricity supply (62%); see also Linneman and Klein (1985) or Millett and Randles (1986). In the oil industry it can take up to 10 years to bring a complex new refinery on stream; capital investments tend to be large and entail high asset specificity; further, the price of the primary raw material (oil) has been moving anywhere from $9 to $40 per barrel during the 1980s. It is hard to think of other industries that experienced comparable levels of uncertainty.

There may be considerable economies of scale in scenario construction. In a large company, hundreds of managers need continually to update their views about the future and their business in particular. These views in turn give rise to numerous mind-sets, problem perceptions, and solutions. If the world is uncertain and complex, it may pay to put together the best available minds (internally and externally) and ask them to anticipate possible futures for a particular *industry* (see Porter, 1985). However, the scenario building process should not be entirely entrusted to an intellectual elite. Its organizational power stems from drawing numerous players and viewpoints into the process. Ideally, it should serve as a consensus building and legitimation device concerning the key strategic issues that confront the organization.

It is precisely because scenarios do not aim to predict the future, but rather bound it, that a consensus building approach can work even if faced with starkly different viewpoints. A concerted, collective scenario building effort will give the firm's managers a head start, as well as a conceptual framework within which to scan, encode, update and understand the future as it unfolds. In our age of information overload, the ability to distinguish signal from noise is a critical skill. But, incisive pattern recognition can only occur if the right mental maps exist in a manager's mind. Scenarios can develop, align and focus such maps.

Paradoxically, building scenarios can make life simpler, in spite of introducing *multiple* futures. Good scenarios deepen the realization as to what is significant vs. ephemeral. If we view organizations as information processing systems, then sound scenarios change the *managerial software* used for this processing. Galbraith (1974) proposed four major strategies via which organizations can handle increased uncertainty or complexity given their information processing limits. These are (1) the use of slack (or buffers), (2) restructuring the organization along product lines or other self-contained units, (3) investment in vertical information systems, and (4) increased lateral contacts via teams, task forces, etc. There are two additional strategies we might add: (5) negotiating the environment to reduce its uncertainty (Cyert and March, 1963; Pfeffer and Salancik, 1978), and (6) changing managerial mindscapes so that they can cognitively and collectively handle more uncertainty. Scenarios are a powerful tool to accomplish the latter.

PSYCHOLOGICAL ISSUES

The intended benefit of scenarios is that they stretch as well as focus people's thinking. The presumption is that scenarios reduce overconfidence (Lichtenstein *et al.*, 1982) by making available to the mind futures not yet considered (Koriat, Lichtenstein, and Fischhoff, 1980) as well as by challenging those presumed likely (see Mason and Mitroff, 1981). Hence, one pertinent question is to what extent scenarios in fact stretch people's subjective confidence ranges and whether it matters if a person develops the scenarios personally or is simply presented with them. We examine this experimentally in the next section.

Although the precise psychological effects of scenarios remain unclear (and are probably difficult to generalize), they seem to entail (1) framing, (2) availability, and (3) anchoring effects. Good scenarios provide multiple intellectual windows on a complex phenomenon in order to challenge people's thinking. Russo and Schoemaker (1989) provide various managerial instances concerning the dangers of narrow thinking frames. For example, if British industry or U.S. automakers had more seriously examined the 'globalization' scenario a few decades ago, they might have switched their performance benchmarks earlier. For too long, they compared themselves against each other (domestically) or against their own past (e.g., last year's performance). Steps one through four of Table 2 aim to challenge people's mental boundaries, their implicit reference points, and their yardsticks of performance.

Scenarios (especially steps 5–8) can also help overcome the so-called availability bias (Tversky and Kahneman, 1974), according to which people undervalue that which is hard to imagine or recall from memory. When chemical managers in Shell, who had experienced decades of growth and expansion, developed scenarios highlighting causes of stagnation and overcapacity, their strategic visions changed. Usually, however, the negative scenarios are hard to envision and accept. Shoemaker (1992) provides a comparison of positive and negative scenarios constructed by MBA students for the industry they expected to be employed in upon graduation.

The negative scenarios were systematically given less weight and credence than the positive by the students who constructed them.

Third, scenarios can shift the anchor or basis from which people view the future. For most managers, the typical mental anchor is the past and usually they do not adjust their thinking very far from this starting point. However, the past may be a highly misleading guide to the future (Gilovich, 1981), especially after major discontinuities have occurred such as deregulation, tax changes, new technologies, etc. The financial community in London, for instance, may have been seriously hampered (cognitively) by its stable past in coping with the new deregulation after the 'Big Bang' (in 1987). Similarly, the new Bell Operating companies in the U.S. were significantly handicapped by having functioned for many decades as a regulated monopoly. One way to shift people's conceptual anchors is to provide powerful alternative scenarios that surplant the past as the dominant starting point.

To enhance the psychological impact of scenarios, it is important to understand better what determines their acceptance. The latter is influenced by source credibility (i.e., who developed them), content credibility (i.e., what they say), and channel credibility (i.e., by whom and how they are presented). In addition, various context effects are likely to operate, such as whether the scenarios are labeled as 'findings,' 'hypotheses,' or 'conjectures' (see Schoemaker, 1978).[4] If an event or scenario is presented as being certain, people will find it quite difficult to ignore this and return to their earlier state of doubt (Mitchell, Russo, and Pennington, 1989). To enhance the psychological impact of scenarios they might be presented in the *past* tense, as was done to great effect in the book *Seven Tomorrows* (Hawken, Ogilvy and Schwartz, 1982).

Another important topic, related to the above, concerns the determinants of plausibility and coherence in scenarios. Inasfar as causality is the psychological 'cement of the universe' (Hume, 1739; Mackie, 1980), the quality of causal reasoning (Einhorn and Hogarth, 1986) merits close attention in scenario development. Paradoxically, more cohesive and detailed scenarios are often perceived as more credible and believable. The more detail a scenario provides, the less probable it becomes statistically. However, people commonly fall prey to what Tversky and Kahneman (1983) termed the conjunction fallacy.[5] To what extent this error of inference is due to heuristic thinking (Tversky and Kahneman, 1974), causal reasoning (Einhorn and Hogarth, 1986) or other factors remains unclear (see Thüring and Jungermann, 1990). Likewise, the impact the weakest link in a conjunction or chain of arguments has on perceived credibility and plausibility, merits further research. Ironically, the conjunction fallacy may help people take seriously unlikely scenarios that normally would have been ignored. Thus, scenarios may utilize one bias (e.g., the conjunction fallacy) to counter another bias, such as overconfidence.

In sum, a variety of psychological issues impinge on both the theory and practice of scenarios. Foremost among these are the effects scenarios have on people's beliefs, degrees of confidence, and problem perceptions (as examined next). Secondly, the factors that determine scenario impact, especially causal strength, coherence and plausibility, need to be understood better. Third, such cognitive areas as text comprehension (Mandel, Stein, and Trabasso, 1982), metaphors (Lakoff and Johnson, 1980; Lakoff, 1987), scripts (Schank and Abelson, 1977) etc., may further explain why scenarios work well in practice. Lastly, it needs to be examined how scenarios can be made to have *emotional* impact (e.g., through drama or interactive video-disks) so that people will actually *feel* the future in addition to comprehending it cognitively (Deighton, Romer, and McQueen, 1989). We examine here only the first issue, concerning cognitive impact.

EXPERIMENT I: EFFECT ON RANGES

This first of our four scenario experiments compares subjective confidence ranges before

[4] The notion that labels such as 'fact' vs. 'hypothesis' can affect the perceived credibility of a proposition (i.e., its subjective probability) is well-supported by the hindsight literature (Fischhoff, 1975; 1982).

[5] The conjunction fallacy occurs whenever people deem $P(A \cap B) > P(A)$ or $P(B)$.

and after scenario construction. Specifically, we test the following hypothesis:

> *H1: Asking subjects to construct multiple scenarios concerning the possible values of key uncertainties will widen their subjective confidence ranges.*

The ranges examined here concern 'strategic variables' i.e., issues of personal or professional interest to the subject involving significant stakes and complexity. A within-subject design was used involving the following distinct stages, which extended over a period of 6 weeks.

(i) Submission of best estimates, as well as 50 percent and 90 percent confidence ranges on the part of the subject and a colleague (see below) concerning selected strategic variables.

(ii) Construction of detailed scenarios and graded feedback from the instructor concerning their completeness, coherence and scope.

(iii) Repeat of stage (i) measures concerning the means, 50 percent and 90 percent confidence ranges of the initially selected key variables.

Subjects

University of Chicago MBA students ($N = 65$) taking a second year course in strategic planning. A second sample included friends or colleagues ($N = 63$) who were invited by the MBA subjects to participate (see below).

Design

Part (i) was administered during week 2 of a 10 week strategy course and returned by the subject in week 3, with the request not to keep copies of any estimates.[6] Weeks 4 and 5 were used to construct individual scenarios by the subject (Part ii). The scenarios were then evaluated for quality and completeness. Part (iii) was administered in week 6 and submitted in week 7. Each part was in the form of a take-home exercise.

[6] There is no independent verification that they obliged with this request, although no subject submitted identical estimates later. Also, if some kept their estimates, this would bias against the stretching hypothesis tested rather than favor it.

Procedures

Subjects first chose strategically important issues from work or home (entailing a time frame anywhere from 1–5 years). The issues generated included new product development, technological uncertainties, organizational design, divisional performance, competitor behavior, as well career options and personal finances. Subjects were asked to identify a few quantitative variables that would *measure* the important aspects of the particular issue they focused on. Sample target variables include profit margins, sales, market share, budget size, returns on investment, salary, personal wealth, etc. Each subject then provided a best estimate, as well as 50 percent and 90 percent confidence ranges for each of his or her target variables (anchored at some future date). Also, subjects asked a colleague at work or a friend, who would be familiar with the particular issue considered, for his or her point estimates as well as confidence ranges.

Instructions

Each exercise consisted of an instruction sheet, in-class discussion and answer sheet (to facilitate the data collection). The instructions for parts (i) and (ii) are shown verbatim in Appendix 1. Part (iii) then repeated the instructions used for part (i) to obtain *ex post* estimates and ranges.

RESULTS

Table 3 provides a summary of the mean point estimates and ranges *after* vs. *before* the scenario treatment. The data are aggregated over subjects and topics, and expressed in terms of after/before ratios. Estimates of *means* increased on average (but not significantly), possibly reflecting a temporal effect in general economic conditions (during the Spring of 1986). Systematic effects on *ranges*, however, were found on average for both subjects and colleagues. Specifically, the 50 percent ranges widened 56 percent and 67 percent for subjects and colleagues respectively after scenario construction. These stretch factors were 44 percent and 55 percent respectively for the 90 percent confidence ranges. To test the statistical significance of these widenings of ranges, each subject's ratios were log-transfor-

Table 3. Scenario effects on after/before ratios (Exp.I)

(a) Subjects themselves

	Mean	S.D.	Q1	Q3
Ratio of means (N = 63)	1.30	1.17	0.89	1.20
Ratio of widths of 50% ranges	1.56**	1.23	0.82	1.89
Ratio of widths of 90% ranges	1.44*	1.26	0.69	1.67

(b) Their colleagues/friends

	Mean	S.D.	Q1	Q3
Ratio of means (N = 55)	1.39	1.33	0.83	1.42
Ratio of widths of 50% ranges	1.67*	1.72	0.71	2.00
Ratio of widths of 90% ranges	1.55*	1.21	0.75	2.00

Note: All ratios are after/before; means are truncated (ratios below 0.01 or above 10 were eliminated); Q1 and Q3 are the bottom and top quartiles respectively. Asterisks denote mean ratios that significantly exceed unity at the 0.05(*) or 0.01(**) levels under a one-tailed test.

med. A ratio of one thus becomes zero, and ratios of $(1 + \Delta)$ and $(1 - \Delta)$ are equidistant from zero. All four log-transformed range ratios were Normally distributed ($p > 0.30$) over subjects according to Kolomogorov's D test. Using a standard t-test (with $H_o : \log(r) = 0$), all four ratios showed significant increases at the 0.05 level (see Table 2). Nonetheless, as shown in the Q1 column, for 25 percent of subjects the ranges *shrunk* by 18 percent or more. Conversely, ranges widened 67 percent or more for the top 25 percentile (Q3 column).[7]

DISCUSSION

Overall, Table 3 strongly supports the reason generation literature (Koriat *et al.*, 1980) and thus Hypothesis I. Ranges stretched on the order of 50 percent upon scenario construction. Interestingly, this effect was somewhat larger for colleagues, who received scenarios as prepared by the subjects. Scenarios developed by others may be less believable (than one's own) but can potentially add new information and new perspectives. The subject vs. colleague differences in Table 3, however, are not statistically significant ($p > 0.31$). Thus, active scenario generation vs. receiving a prepared set had comparable effects in this experiment on confidence ranges. Other relevant criteria, such as creativity, depth of understanding, or problem solving improvement were not compared.

The longitudinal nature of this within-subject study is one possible threat to its validity. As time elapses, the economic climate may change significantly. However, it is unlikely that this could explain the results. First, since the study was conducted during the Spring of 1986, it is now known that nothing drastic occurred. Second, temporal shifts in mean need not *per se* affect the ratio of ranges, since the latter are defined *relative* to the mean. Third, temporal effects, in the sense of uncertainty reduction, would actually work against the stretching hypothesis (H1). Lastly, temporal effects should be minor given the time lag of 1 month in the experiment itself and a planning horizon for the key uncertainties that ranged anywhere from 1 to 5 years.

EXPERIMENT II: IMPLAUSIBILITY

The possibility that ranges might shrink (see Q1 column in Table 3) is intriguing. Two scenario practitioners, Wack (1985a, b) and Sunter (1987), have argued that scenario analysis may highlight that particular combinations of outcomes are unlikely or implausible. Specifically, we test here:

> *H2: Forcing subjects to consider extreme values for key uncertainties will at some point reduce their subjective confidence ranges due to incredulity.*

Experiment II uses a *common* set of target variables about which subjects were asked to think in extremes. Instead of administering a detailed scenario process as in Table 2, subjects were merely asked to generate one page scenario scripts (i.e., as in the standard reason generation literature) that might bring about the requested level of extremity.

Subjects

New sample from the same general MBA population as in Experiment I.

[7] Since the questions involved were diverse, confidential and spread out in time, no data could be collected on accuracy or calibration (unlike Exp. II).

Design

A two-stage between-subject design was used. In stage I, 75 MBA students were assigned to one of the following three prediction tasks (at random). The study was conducted during the summer of 1988 and the target events would all be known by year-end.

1. Ratio of U.S.A. to USSR medals obtained during the summer Olympics of 1988 in Seoul, South Korea.
2. Level of the Dow Jones Industrial Average at the end of 1988.
3. The percentage of the popular vote for George Bush during the 1988 presidential election.

Procedure

Each subject was asked to develop both a 'high' and 'low' scenario for the assigned variable. The 'high' scenario had to be such that the target variable would be either 30 percent (one experimental condition) or 50 percent (a second experimental condition) *above* the subject's best guess. In the 'low' case, it would be 30 percent (or 50%) *below* expectation. Upon completing the two scenarios (high and low), the subject was asked to provide both a 50 percent and 90 percent confidence range. One week was allowed for the completion of this take-home exercise.

Stage II consisted of collecting from *all* subjects their 50 percent and 90 percent confidence ranges regarding all three questions. This was done after the single question scenarios, point estimates and ranges had already been submitted. Thus, the design permits a cross-sectional contrast between a scenario vs. control group as well as between a moderate (± 30%) vs. more extreme (± 50%) condition within the scenario group.

Instructions

Appendix 2 contains the verbatim instructions given to the subjects who received question 2 in the above list, for the less extreme scenario condition.

RESULTS

Table 4 summarizes the relevant statistics. The Olympic medals question shows significantly ($p < 0.05$) wider ranges for the scenario group ($N = 28$) than the control group ($N = 76$) which did not construct Olympic scenarios (but did develop scenarios for one of the other questions). This supports H1. But within the scenario group, the more extreme scenario condition (asking for ± 50% deviation from the initial best guess) failed to generate wider 50 percent confidence ranges (in support of H2). And the 90 percent ranges were not significantly wider in the ± 50 percent than in the ± 30 percent condition.

Guesses concerning the Dow Jones reveal a similar mixed pattern. The 90 percent range is noticeably wider ($p < 0.07$) for the scenario group but not for the 50 percent range. Within the scenario group, however, the more extreme scenario version (50% vs. 30% departure from the initial best guess) did not produce significantly wider 50 percent or 90 percent ranges. The third question, concerning George Bush, most strongly supports H2. The scenario group perceived *less* uncertainty in the election outcome than the control group. And within the scenario group, those contemplating ± 10 percent deviations from expectation perceived *less* uncertainty than those considering ± 5 percent deviation. The well-known historical fact that presidential elections are usually quite close may have made the ± 10 percent scenarios considerably less believable to subjects than the ± 5 percent scenarios, resulting in narrower rather than wider 50 percent and 90 percent subjective confidence ranges.

DISCUSSION

This second experiment also suggests that scenario construction alters beliefs, but not necessarily in the direction predicted by reason generation (H1). When subjects are forced to consider extreme scenarios, the availability effect may be countered by a believability concern. This lack of credibility may be due to the low perceived probabilities associated with any single cause (such as a terrorist strike against U.S. athletes in the Olympic camp) or with the unlikely conjunction of events necessary to produce an extreme outcome. The data of Experiment II

Table 4. Scenario impact on means and ranges (Exp.II)

Version	BG	(S.D.)	W50	(S.D.)	N	W90	(S.D.)	Key ratios (Treat/control) BG	W50	W90
Olympics										
Control	0.87	(0.5)	0.63	(0.78)	76	1.45	(2.6)	1.31	1.68*	1.75*
Treatment	1.14	(1.4)	1.06	(1.87)	28	2.54	(3.8)			
(1) ± 30%	1.45	(1.9)	1.46	(2.48)	15	2.44	(3.1)	0.56	0.41	1.09
(2) ± 50%	0.81	(0.14)	0.60	(0.43)	13	2.65	(4.6)			
Dow Jones										
Control	2186	(323)	673	(252)	70	1165	(748)	0.96	1.08	1.19
Treatment	2088	(175)	728	(422)	32	1392	(758)			
(3) ± 30%	2077	(230)	632	(344)	17	1189	(595)	1.01	1.32	1.36*
(4) ± 50%	2101	(148)	837	(485)	15	1622	(874)			
George Bush										
Control	49%	(10)	19%	(9)	75	36%	(19)	1.00	0.89	0.78
Treatment	49%	(5)	17%	(12)	27	28%	(18)			
(5) ± 5%	50%	(6)	19%	(15)	13	29%	(20)	0.98	0.79	0.90
(6) ± 10%	49%	(5)	15%	(9)	14	26%	(16)			

Legend: BG = best guess
(S.D.) = standard deviation
W50 = width of the 50% confidence range
W90 = width of the 90% confidence range
N = sample size
* = ratio differs from unity at 0.05 level

clearly suggest that extreme scenarios may reduce rather than stretch people's subjective confidence ranges. No significant differences were found in the accuracy of best guesses among conditions.[8]

The temporal confounding discussed in Experiment I could also be a concern in this experiment. The time delay of 2 weeks might especially have affected perceptions about the Presidential election, since Bush gained much strength later on in his race against the Democratic candidate (Michael Dukakis). However, the control group—which was polled 1–2 weeks after the treatment group—had the same mean guess. In general, shifts in expected values need not alter range widths nor vice versa, but of course may. Interactions between mean and range could be Bayesian or simply reflect floor and ceiling effects (especially for narrowly bounded percentage scales).

[8] The U.S.A. won 94 Olympic medals in South Korea in 1988 vs. 132 for the USSR, yielding a ratio of 0.712. The Dow Jones average closed at 1978 on December 31, 1988. George Bush won the 1988 election with 53.9 percent of the nearly 90.1 million popular votes cast.

EXPERIMENT III: CONJUNCTION FALLACIES

Scenario construction goes beyond reason generation in that it examines *combinations* of events. Statistical logic dictates that conjunctive events (such as both A and B occurring) are never deemed more likely than either the probability of A or B occurring alone. As noted earlier, psychological studies suggest that this statistical law may be systematically violated (Tversky and Kahneman, 1983). Researchers have yet to unravel the precise circumstances that favor or suppress conjunction fallacies (see Thüring and Jungermann, 1990). This experiment tests the following hypothesis:

H3: Conjunction fallacies also occur when well-educated and informed business students examine typical political and economic uncertainties.

Subjects

University of Chicago MBA students taking a second-year strategy course (*N* = 78).

Design

The ideal test of the conjunction fallacy is a within subject one, while controlling for carry-over effects. In the present setting, however, subjects would likely remember their probability estimates for the limited number of target events examined, thereby compromising any tests of the conjunction bias. Also, introducing a time delay was deemed undesirable given the time-dependent nature of the political and economic events examined. Instead, a between subject design was chosen in which each group received nonoverlapping questions. Specifically, the A group received the following question sequences: Q1, Q2 & Q3, Q4, Q5, Q6 & Q7, Q8, whereas the B group received: Q1 & Q4, Q2, Q3, Q5 & Q8, Q6 and Q7. Thus, each group serves as the other's control.

Procedure/Stimuli

The exercise was administered in-class by randomly assigning subjects to either the A or B group. Each subject received six outcomes (in the above order), two of which were conjunctive. Subjects were asked to assign a subjective probability from 0 percent to 100 percent to each outcome (either single or conjunctive) occurring sometime before the end of 1990. The experiment was conducted in the fall of 1986, with a time frame of 5 years. The elemental events (in brief) were as follows:

Q1. U.S. economic GNP growth of at least 4 percent per annum by end of 1990.
Q2. Short-term interest rates exceeding 13 percent in the U.S.A. sometime during the next 5 years.
Q3. Election of a Democrat as U.S. president by 1990.
Q4. Trade surplus of U.S. with Japan by 1990.
Q5. Direct U.S. military involvement in Central America by 1990.
Q6. Dow Jones Industrial average falling below 1500 mark by 1990.
Q7. Oil prices exceeding $30 per barrel by 1990.
Q8. Fall of the South African apartheid regime by 1990.

RESULTS

Table 5 summarizes the mean perceptions. For only the first of the four comparison is the conjunction rule conclusively violated. Even if U.S. economic growth (Q1) and the trade surplus with Japan were to be perfectly correlated, P(Q1 $\cap$ Q4) should not exceed 18 percent. Under complete independence, the conjunction should have a probability of around 8 percent (as shown in parentheses below the observed 20 percent).[9] The remaining comparisons imply either significant dependence or conjunction fallacies. For Q5 and Q8, it is not plausible that strong correlations would exist between U.S. combat in

Table 5. Mean probabilities of single and conjunctive events

Group	Question type (abbreviated)	Mean probability	(S.D.)
A	Q1: Economic growth >4%	47%	(22%)
A	Q4: Trade surplus with Japan	*18%*	(18%)
B	Conjunction of Q1 *and* Q4	20% (8%)	(19%)
A	Q5: U.S. combat in Central America	47%	(28%)
A	Q8: Fall of apartheid regime	*50%*	(23%)
B	Conjunction of Q5 *and* Q8	35% (24%)	(25%)
B	Q2: Interest rate >13%	48%	(6%)
B	Q3: Democrat as U.S. President	*45%*	(4%)
A	Conjunction of Q2 *and* Q3	31% (22%)	(21%)
B	Q6: Dow Jones <1500	40%	(28%)
B	Q7: Oil price >$30/barrel	*39%*	(21%)
A	Conjunction of Q6 *and* Q7	31% (16%)	(21%)

Note: Sample sizes are 38 and 40 for the A and B group respectively.

[9] Our analysis uses an aggregate comparison of means, which is approximate. That is, if p_i and q_i are the perceived probabilities of two events P and Q for i = 1 to N subjects respectively, then $(\Sigma p_i/N)(\Sigma q_i/N) \neq (\Sigma p_i q_i)/N$. The between-subject design used, however, precludes the calculation of such individual joint probabilities.

Central America and the fall of S. Africa's apartheid regime. Thus, the observed probability of 35 percent seems rather high compared to the 24 percent benchmark representing zero correlation. For the remaining pairs, correlations seem plausible. High interest rates could unseat an incumbent president and the stock market tends to react adversely to high oil prices. Hence the conjunction fallacy is harder to assess for these items.

DISCUSSION

Strong violations were found in only one out of four cases tested. This conclusion is based, however, on an aggregate comparison of means using a between-subject design. How serious conjunction fallacies are in scenario construction in general is hard to assess. In an ideal world, subjects should exhibit no biases and hence scenario analysis may not even be necessary. Given that subjects in fact do suffer from overconfidence, availability biases, etc., the conjunction fallacy is perhaps beneficial in that it makes unlikely scenarios more believable. Our consistency tests so far have been restricted to pairwise correlations or contingencies. The following experiment examines the frequency of intransitivities across pairs of correlations.

EXPERIMENT IV: CORRELATIONAL CONSISTENCY

Jennings, Amabile, and Ross (1982) argued that subjects tend to underestimate the magnitude of correlations (when data rather than theory-based). Tversky and Kahneman (1983) highlighted the prevelance of conjunction fallacies. Naylor and Clark (1968) found that subjects less easily detect inverse than positive relations. All three of these factors could lead to inconsistencies in subjects' perceived covariances or conjunctive probabilities. Whereas the previous experiment established this in the aggregate, using pairwise events, the present experiment focuses on an entire matrix of subjective correlations.

> *H4: Inconsistencies in subjects' belief systems transcend pairwise events and produce systematic intransitivities (over pairs of events).*

To control for context differences, a common example was used concerning the future of Apple Computer Co. Students were familiarized with this company through an extensive case write-up. Each subject was asked to identify five strategic uncertainties facing Apple and complete a subjective correlation matrix.

Subjects

University of Chicago MBA students taking a second year policy course ($N = 109$).

Design

Subjects first read a Stanford case on Apple Computer (by Swanger and Maidique, 1988) and a paper on scenario construction (by Schoemaker, 1991). A week thereafter, they received a take-home exercise consisting of an analysis of trends and key uncertainties (see below). They were told the exercise would be graded.

Procedure/instructions

The specific instructions were as follows.

To gain more experience in scenario thinking and building, this individual exercise asks you to answer the following questions about Apple Computer, based on the case material in the reading packet and other knowledge you may have concerning the PC industry.

1. Identify the five most significant *changes*, discontinuities, or surprises that Apple experienced in this young industry.
2. Looking forward about five years, identify the most important *trends* you see for this industry (from a strategic perspective).
3. Also, within this 5 year time frame, identify what you deem to be the five most important strategic *uncertainties* faced by Apple, and assess their interrelationships (using subjective correlations ranging from -1 to $+1$).

Use the separate ANSWER SHEET to summarize your conclusions, and hand-in an additional type-written justification for your answers (not exceeding two double-spaced pages). Make sure your rationale covers the past surprises, important trends, key uncertainties, and their interrelationships. Since this is an individual take-home that will be graded, do not discuss the specifics of this assignment with others.

RESULTS

The raw data in this study consist of subjects' five dimensional correlation matrices. Each subject's 5 by 5 matrix was sliced up into six triplets, consisting of the following subsets: $[r_{12}, r_{13}, r_{23}]$, $[r_{12}, r_{14}, r_{24}]$, $[r_{12}, r_{15}, r_{25}]$, $[r_{23}, r_{24}, r_{34}]$, $[r_{23}, r_{25}, r_{35}]$ and $[r_{34}, r_{35}, r_{45}]$, where r_{ij} refers to the subjective correlation in row i and column j of the matrix. Each triplet in turn was subjected to an upper and lower bound test derived from the statistical requirement that absolute partial correlations do not exceed unity.[10] This way a total of 12 (2×6) inequalities can be tested per matrix. Whenever subjects left matrix elements blank or put down a question mark, the tests assumed either a missing value (in one run) or a zero correlation (in a second run). When using missing values, 13 percent fewer tests were possible per 5×5 matrix than when substituting zeros for blank entries.

For each matrix, the following consistency index was computed: percent of inequality tests past out of total permissible tests. When missing values were allowed, the mean consistency score was 87 percent with a range of 50 percent to 100 percent. About 60 percent of subjects failed at least 1 of the 12 consistency tests, implying that they provided correlation matrices which are mathematically impossible (i.e., not positive-definite). When the missing entries were coded as zeros, the mean consistency score was 88 percent across all tests, with a range of 58 percent to 100 percent. This time, 59 percent of subjects exhibited at least one inconsistency.

It was also examined how often subjects provided positive vs. negative correlations, which revealed an interesting asymmetry. Of the $n(n-1)/2$ or 10 correlations provided per subject, 5.2 were positive, 2.1 negative and the remainder missing or zero. Thus, subjects perceived positive correlations more than twice as frequently as negative ones ($p < 0.001$). In addition, the absolute magnitude of positive correlations was 0.63 compared to 0.58 for negative ones ($p < 0.05$). This difference is even more significant ($p < 0.02$) when excluding correlations of ± 1, or when applying Fisher z-transformations.

DISCUSSION

Although the upper and lower bound tests conducted are not very strict (deriving from minimal partial correlation constraints), almost two-thirds of subjects failed to generate internally consistent (i.e., positive definite) correlation matrices under this test.[11] The correlation assessment phase is especially important in the scenario process as it constrains the kind of scenario elements that can be plausibly combined. In essence, it provides the grist for the informal clustering analysis that underlies scenario construction. For this reason, the bias toward positive correlations, as also found by Naylor and Clark (1968), is likewise disconcerting. In sum, the scenario process may be beneficial in reducing overconfidence but is likely to be based on subjective inputs that fail simple tests of statistical coherence. Whether amelioration of these flawed inputs enhances the power of scenarios as a cure for overconfidence remains an open question.

CONCLUDING REMARKS

Business is about taking calculated risks. Nonetheless, many companies feel uncomfortable with risk and uncertainty, especially the types that cannot be modeled or quantified easily. Traditional risk analyses (e.g., decision trees, expected utility, etc.) work best in environments that are themselves stable. Risks that do not fit people's conceptual frameworks—what Habermas (1975) called epistemic risks—are more problematic. For instance, most oil companies master risk analysis in the area of exploration and production, where decision trees, Bayesian models, etc., are commonly used. However, those same companies often struggle with how to analyze political risks, or uncertainties concerning the economy and the structure of their industry. These latter risks are more fundamental (since they stem from limited worldviews), less amenable to actuarial risk analysis, and potentially

[10] In general, for any three interlinked correlations r_{ij}, r_{ik} and r_{jk} it must be that $r_{ij} \geq r_{ik}r_{jk} - \sqrt{(1 - r_{ik}^2)(1 - r_{jk}^2)}$ *and* $r_{ij} \leq r_{ik} + \sqrt{(1 - r_{ik}^2)(1 - r_{jk}^2)}$.

[11] Even if we permit random noise, violations will only occur if extreme correlations are perceived. For example, if $r_{12} = 0.3$ and $r_{13} = 0.5$, then r_{23} can range anywhere from -0.67 to 1. The permissable r_{23} range narrows as the other r_{ij} increases in magnitude. For instance, if $r_{12} = 0.7$ and $r_{13} = 0.9$ then $r_{23} \geq 0.32$. Still, however, room is left for random noise in this more extreme case.

more damaging in their consequences. They are ones for which expectation rules or traditional decision analyses appear less appropriate (although see Thomas, 1984).

This paper especially explored the psychological basis of scenario planning, an increasingly popular approach to overcoming corporate blindspots and myopic thinking frames. Building multiple scenarios, with broad organizational input, appears a practical way to stretch people's thinking collectively and individually. If the scenarios are presented as possibilities, rather than firm predictions, they become psychologically less threatening to those holding different worldviews. Regarding their impact on individual beliefs, the experiments suggest that scenario building can expand people's thinking (stretching subjective confidence ranges as much as 50%).[12] However, forcing people to consider extreme values or outliers may cause the opposite, due to lack of believability. Also, asking subjects to consider conjunctions of events (as opposed to isolated ones), can enhance a scenario's credibility due to the conjunction bias. Scenarios thus exploit one set of biases (such as the conjunction fallacy and intransitivities of beliefs) to overcome another set, namely overconfidence, anchoring and availability biases. The efficacy of scenario planning seems to hinge on examining a confluence of factors (instead of just single contingencies). This conjunctive focus appears to produce wider subjective confidence ranges up to a point, after which incredulity causes these ranges to shrink.

The multiple scenario method thus differs from traditional planning and risk analysis in its psychological basis. In addition, key differences exist in intent (i.e., problem defining vs. problem solving), organizational implementation (fluid vs. structured), and philosophical premise (Hegelian vs. Leibnitzian) when compared to such methods as decision analysis and quantitative forecasting. Having analyzed and tested some of the salient features of the multiple scenario method as practiced by Royal/Dutch Shell and other companies, the next challenge is to subject it to critical *comparative* experiments (as suggested by Table 1). The positive aspects of the scenario approach must be weighted against its negatives such as a relatively steep learning curve, broad organizational ramifications (including culture shock) and a new set of challenges concerning how to move from scenarios to stategies, plans and budgets.

[12] Readers concerned about the use of student subjects and/or the hypothetical nature of the experimental tasks are referred to Hogarth and Reder (1986: S194–196) for a balanced and incisive comparison of the economic and psychological research paradigms and methodologies.

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APPENDIX 1: VERBATIM INSTRUCTIONS FOR EXPERIMENT 1

Part (i): This assignment is aimed at linking the scenario methodology to an issue you find of personal or professional interest. This exercise can do no more than convey the flavor of this methodology, which normally requires considerable time and multiple experts. However, by treating this assignment seriously, a basic understanding of the limitations and potential of scenario thinking can be obtained.

1. Select an issue of personal or professional interest that is complex (i.e., influenced by many factors) and partly measurable. Examples would be future sales of a new product, return on an investment, future salary, response of a competitor, outcome of a committee's decision, price of a commodity, etc. Take a time-perspective of at least a year into the future and clearly define at least two uncertain quantities.
2. Based on your current knowledge, without much further thought, provide for the above uncertain variables a best estimate, as well as a 50% and 90% confidence intervals. Make sure you complete this *before* doing any of the readings on scenarios. Ask a friend or colleague to do the same for the variables you selected, after explaining them.

Part (ii): Now that you have selected some complex issue, and provided uncertainty ranges without much systematic analysis, the next step is to examine this issue using scenarios. To a large extent, scenarios require creativity and intuition that are difficult to systematize. However, going through the steps outlined (see Table 2) should help get you on the right track.

As a first cut, you may want to use the blank work sheets attached to identify some of the major variables, trends and stakeholders of interest. This should provide you with some ideas about possible scenario structures. However, to arrive at truly useful scenarios, you will have to iterate through this process a few times. Remember, scenarios should be viewed as a thinking tool; the *process* is as important as the end result.

Once you have settled on a few scenarios you are happy with, you should write them up in a crisp, concrete way that would be understandable to another person. The aim of scenarios is to reflect a realistic range of uncertainty and provide a backdrop against which to make decisions. It is not necessary, for purposes of this exercise, that you include some formal model as part of your scenarios, although you are welcome to do so. Also, there is no need to provide probabilities or uncertainty ranges (unless you wish to). At this point, the exercise should be *qualitative* in nature. In addition to handing in typed vesions of your scenarios (to be limited to one page each), you should also submit a background report on the underlying logic of your scenarios, how easy or difficult you found the process, type of internal inconsistencies you had to cope with, and what you learned about the issue that you had not appreciated initially.

APPENDIX 2: ILLUSTRATIVE VERBATIM INSTRUCTIONS FOR EXPERIMENT II

In class we used various business trivia questions to demonstrate overconfidence. In most business situations, the relevant questions will concern future uncertainties which people would think about carefully prior to providing numerical estimates. This exercise is aimed at simulating this process, in order to evaluate the quality of your own thinking. Rather than provide off the cuff estimates, you are asked to construct different scenarios first, as follows.

Step. 1. Provide your initial best estimate for the following variable: Level of the Dow Jones Industrial Average at the end of 1988.

Step 2. Construct a reasonable scenario under which the value of this variable would be low, say 30% *below* your best guess.

Step 3. Construct a reasonable scenario under which the value of this variable would be high, say 30% *above* your best guess.

Step 4. Type each of these two scenarios on a separate piece of paper (double-spaced), without exceeding one page (per scenario).

Step 5. Upon completing the scenarios, write down your subjective estimates below for the following:

Your Best Guess:______________(if changed at all)

A 50% Confidence Range:_________ to_________

A 90% Confidence Range:_________ to_________

(Note: Make your confidence ranges as symmetric as possible around your best guess).

Step 6. On a separate sheet, type a commentary on what insights you feel your scenarios generated (if any), and what you found easy or difficult in constructing these low and high scenarios for this particular variable.

You will be graded on how well you complete each step, especially the quality of your scenarios. Important criteria include whether your scenarios are plausible, coherent, and persuasive. Also, they must be well-explained, since your scenarios will be compared with those of other students and rated accordingly. Lastly, do not discuss your scenario topic with other students, nor consult outside sources. Just try to utilize whatever you currently know about the variable in question to come up with sound scenarios.