RISK TAKING OVER GAINS AND LOSSES: A STUDY OF OIL EXECUTIVES

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Abstract

This paper examines the risk propensities of experienced executives in the oil and gas industry faced with a hypothetical risky business decision that involves significant gains and losses. The executives were asked to provide the minimum price their firm should accept before selling their share of a joint exploration venture whose future prospects were systematically varied to include gains only, losses only, and mixed gains and losses. In addition, they were asked to provide a single probability equivalence for a mixed gain/loss situation in lieu of breaking even for sure. The executives were more risk taking than risk averse over pure losses, consistent with the prediction of prospect theory. Over pure gains, however, there was as much risk taking as risk aversion, with more risk taking occurring when the chance of breaking even was higher. The relationship between risk propensity over pure gains and over pure losses was insignificant, indicating very different attitudes in these two domains. Although the reflection effect did occur in some cases, it was not pervasive. There was a tendency for certainty equivalences to show greater risk taking than probability equivalences in mixed gain/loss situations, which was consistent with a reframing effect. Risk propensity over mixed gains and losses was closer to that expressed in the losses only domain than to risk propensity over pure gains. More than half of the executives gave responses that were fully consistent with expected utility, and an additional quarter of executives were consistent within a 10% margin of error in their responses. However, one out of five executives did not satisfy the stochastic dominance relationships among the certainty equivalences. Systematic inconsistencies occurred most frequently in the mixed situations where the certainty equivalences for some subjects were biased toward the outcome that had the predominant chance of occurring.

1. Introduction

How do people deal with risky decisions that involve gains and losses? Several conjectures have been made regarding this question, based on different points of view. In their prospect theory, Kahneman and Tversky [14] have postulated that people tend to be risk taking over pure losses and risk averting over pure gains, which implies a reflection effect across one's reference point. Challenges to some of these claims have been made by Fishburn and Kochenberger [3], Hershey and Schoemaker [9,10], Hershey et al. [8], and Cohen et al. [2]. Hershey and Schoemaker [11] have taken a decision processing point of view to speculate how people might reframe gambles over pure losses (or gains) into mixed gambles by redefining the outcomes as "gains" and "losses" relative to some available sure alternative. Others have examined the use of expected utility theory as a descriptive theory and raised considerable doubt concerning its descriptive validity (see, for example, the summaries in Schoemaker [26] and Hogarth and Reder [12]).

Past studies of such conjectures have been limited by their use of student subjects, who are frequently inexperienced in making important risky decisions which can seriously affect their personal well-being, their careers, and their financial status. This limitation has further restricted attention primarily to personal risks where the decision maker bears all of the consequences of the decision. The research of Payne et al. [23,24] and Laughhunn et al. [17] is a notable exception for its use of experienced managers as subjects.

Experience in decision making can have an important effect on how people deal with risky situations (MacCrimmon and Wehrung [19]; March and Shapira [21]; Wallsten and Budescu [31]). Experienced decision makers may have different perceptions of the riskiness of situations and may make different evaluations of possible outcomes and their chances than inexperienced decision makers, which can result in different choices.

Similarly, decision makers who do not bear all of the consequences from their decisions may handle risky situations quite differently from those who do. For example, decision makers who are responsible for making decisions that involve important business risks, medical risks, or public policy risks may reveal significantly different risk propensities in these settings than those who bear all of the consequences from a personal financial decision (see, for example, Kunreuther et al. [16] and Weinstein [33]).

This paper will examine several conjectures regarding how experienced executives deal with risky business decisions that involve significant gains and losses. Do experienced executives faced with important business risks reveal risk taking over losses, risk aversion over gains, and a reflection effect across the two domains as predicted by prospect theory? Are their choices consistent with the reframing hypothesis suggested by Hershey and Schoemaker [11]? To what extent are their choices consistent with the principles of expected utility theory?

The outline for the remainder of the paper is as follows. Section 2 reviews prior empirical studies regarding risk taking over gains and losses. Section 3 describes the design of the study, including the subjects, instrument, procedures, summary of data, and preliminary consistency checks. The results are presented in sect. 4, and a discussion follows in sect. 5. An appendix contains details for the consistency checks made in the paper.

2. Review of previous studies

LOSS DOMAIN

Prospect theory predicts that people will be absolute risk takers over losses. Previous empirical studies of the personal risk propensities of students have shown that absolute risk taking in the domain of losses is quite prevalent (Slovic et al. [27]; Kahneman and Tversky [14]; Schoemaker and Kunreuther [25]; Hershey and Schoemaker [9,11]; Hershey et al. [8]). Risk taking over nonruinous losses has also been found in studies of the business risk propensities of experienced executives (Libby and Fishburn [18]; Laughhunn et al. [17]; MacCrimmon and Wehrung [19,20]). See also Fishburn and Kochenberger [3], who found a predominance of risk taking over losses in the business utility functions summarized from Grayson [5], Green [6], Swalm [29], Halter and Dean [7], and Barnes and Reinmuth [1]. On the other hand, Freifelder and Smith [4] found that casualty underwriters showed more risk aversion than risk taking in a series of pure loss situations.

Studies of the personal risk propensity of students have found on an across-subject basis that, when the possible downside loss was held fixed, risk taking increased as the chance of loss increased (Hershey and Schoemaker [9]; Hershey et al. [8]; Cohen et al. [2]). Some previous studies have found a degree of risk aversion over small losses in conjunction with the overall trend toward risk taking that is consistent with a utility function having an inflection point in the loss domain (Kahneman and Tversky [14]; Schoemaker and Kunreuther [25]; Hershey and Schoemaker [9,10]; Cohen et al. [2]).

GAIN DOMAIN

In the gain domain, prospect theory predicts that people will be absolute risk averters. Uniform risk aversion over gains (or above-target returns) has been found in some studies of both the personal risk propensities of students (Kahneman and Tversky [14]) and the business risk propensities of experienced executives (Spetzler [30]; Libby and Fishburn [18]; Fishburn and Kochenberger [3]). Other studies have discovered a substantial degree of risk taking in the pure gain domain (Hershey et al. [8]; Cohen et al. [2]; Hershey and Schoemaker [11]; MacCrimmon and Wehrung [19,20]). In the first two of these studies, the risk taking tended to occur over smaller gains with risk aversion for larger gains, consistent with a utility function having an inflection point in the gain domain.

Studies of the personal risk propensities of students have found that, when the possible upside gain was held fixed, risk taking increased as the chance of breaking even (i.e. the less favorable outcome) increased (Hershey et al. [8]; Hershey and Schoemaker [11]; Cohen et al. [2]).

REFLECTION EFFECT

Kahneman and Tversky [14] postulated that risk taking over losses and risk aversion over gains would be revealed as opposite risk preferences for reflected pure gambles, and they provided evidence to that effect based on across-subject comparisons. This reflection effect has been critically examined by Hershey and Schoemaker [10] and Cohen et al. [2], who used within-subject comparisons of student subjects to conclude that, although the reflection did occur in some gambles, its occurrence was not pervasive and in many cases was well within a chance effect.

MIXED GAINS AND LOSSES

Prospect theory predicts that the convex value function for losses will be steeper than the concave value function for gains. Therefore, people will tend to be more risk averse for translated mixed gambles than for gambles over pure losses. This prediction has been supported in studies of students by Williams [34], Payne et al. [23,24], Hershey et al. [8], and Hershey and Schoemaker [11], and in studies of experienced managers by Payne et al. [23,24].

The shape of the value function predicted by prospect theory also suggests that people will tend to be more risk averse for gambles over pure gains than for translated mixed gambles. This prediction has been supported in studies of both students and experienced managers by Payne et al. [23,24]. Hershey and Schoemaker [11] interpret prospect theory to suggest the reverse prediction that there would be more risk aversion for mixed gambles than for gambles involving pure gains, and cite evidence from a pilot study of students to support their claim.

Wehrung et al. [32] and MacCrimmon and Wehrung [19] found strong risk aversion for business investment gambles that involved both gains and losses. They also found that executives who were willing to engage in a risky business investment gamble showed an increasing willingness to take risks as the chance of the unfavorable outcome increased. Close to 60% of these executives were risk averse for losses or low levels of rate of return, yet were risk taking for high rates of return. A risk taking segment was found in the utility functions of about 25% of the executives, with risk aversion at both ends.

RESPONSE MODE DIFFERENCES

The effect of response mode on risk propensity has been examined in a number of studies. Hershey et al. [8] found systematically greater risk taking in the personal risk attitudes of students when certainty equivalences were used than when probability equivalences were used. Hershey and Schoemaker [11] found similar results in their later extension of this study, where they investigated the relationship between this bias and one's risk propensity in the domains of gain and loss. They went on to postulate an explanation for this response mode effect as a reframing of the probability equivalence situation into "gains" and "losses" relative to the sure alternative. Johnson and Schkade [13] further extended this research by varying attributes of the gambles, such as expected value and probability levels, and they concluded that the observed pattern of bias was consistent with an anchor and adjustment heuristic.

In their investigation of the personal and business risk attitudes of executives, Wehrung et al. [32] found only weak positive associations between the risk propensities derived from gain equivalences and certainty equivalences. No trend toward greater risk taking was revealed from either equivalence method.

3. Design of the study

SUBJECTS

The upstream operations of the oil and gas industry were selected as the source of executives for this study because of the importance of risk taking in exploration and production decisions (Grayson [5]; Kaufman [15]) and the desire to have subjects who share a common basis of experience for making risky decisions. All firms that had their principal exploration and production activities headquartered in either Houston, Texas or Calgary, Alberta were considered. Both independents (having only exploration and production activities) and integrated oil companies (having refining and marketing activities as well) were included. Because small firms were rapidly being broken up or merged with larger ones at the time of the solicitation, only firms having assets of at least $100 million U.S. in their exploration and production activities were considered.

Fifty-eight firms were solicited to participate in the study, drawn equally from Houston and Calgary. The selection was based jointly on stratification by size (so that both very large and medium sized firms would be included) and the availability of business contacts in the firms held by deans of prominent local business schools. Firms were solicited by a letter of introduction from the local dean, followed by a written request for participation from the author. In firms that expressed an interest in participating, the author met with a senior executive who was asked to arrange participation of four or five executives at the vice presidential level and above who had decision-making authority over exploration, production, or financial activities. In return for each individual's time commitment of about four hours, the author promised to provide personalized feedback to both the individual and the firm regarding how their responses compared with those of key groups of executives and firms.

Twenty-nine firms agreed to participate in the study for a 50% response rate. About half the firms were headquartered in Houston and half in Calgary. All of the 127 executives who participated in the study had extensive managerial experience in the oil industry, which averaged fifteen years.

INSTRUMENT

Each participant was asked to consider a joint venture with several other oil firms in which his firm had committed a total of U.S.$60 million from its domestic capital and exploratory spending budgets over the past few years. No returns had yet been received from this joint venture, which involved extensive exploratory drilling at a number of sites in one of North America's frontier regions. The U.S.$60 million figure over a several year period and an unspecified percentage working interest was chosen so as to make this joint venture a reasonable size investment for both medium and large sized firms.

The subject was asked to respond in two ways. First, he was asked to recommend accepting or rejecting a specific offer for his firm's share of the joint venture from one of the other partners. If the subject recommended that his firm keep its share of the joint venture, the firm would receive an uncertain amount that depended upon which of two future scenarios occurred. These two scenarios were described to the subject, along with their monetary outcomes and chances of occurring (as estimated by staff personnel in the firm). If, instead, the subject chose to sell his firm's share for the specified amount, the firm received this sure amount and there was no uncertainty. The certain amount from selling the firm's share of the venture was always chosen to be equal to the expected value of keeping the firm's share, but this was not pointed out to the subjects. All returns were expressed in present value terms.

For example, in one situation the subject could recommend keeping his firm's share of the venture, resulting in a 25% chance of a net gain of U.S.$60 million (over and above recovering the initial investment) and a 75% chance of a net gain of zero (i.e. just recover the initial investment and receive no return). Alternatively, he could recommend selling his firm's share in return for a net gain of U.S.$15 million (i.e. recover the initial investment plus make a return of U.S.$15 million). This choice was explicitly framed for the subject, as shown in fig. 1.

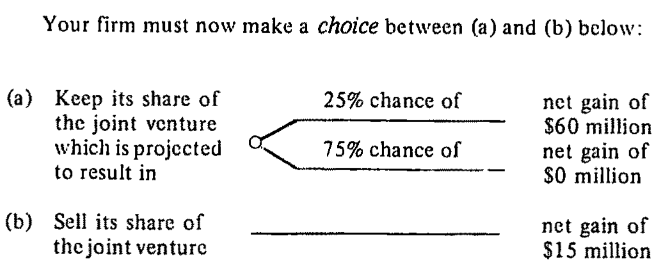

Fig. 1. Example of decision frame presented to executives.

After the recommendation was made, the subject was then told to suppose that his firm had not yet received an offer, but was expecting to receive an offer for its share of the joint venture. He was asked to give the *smallest* net amount (over and above recouping the initial investment of U.S.$60 million) that the firm should accept before he would recommend selling its share of the joint venture. This minimum selling price is the subject's *certainty equivalence* for the venture. For example, the subject might specify a minimum selling price of a net gain of U.S.$20 million.

The subjects were asked to provide the above recommendations (i.e. choices) and corresponding certainty equivalences for each of six situations that could face their firms, depending upon which events had occurred since the initial investment had been made. The situations were systematically varied to differ in their possible outcomes and chances of occurring. They are summarized in table 1. Two situations

Table 1

Description of risky ventures and risk propensities

	Chances of				Percentage			
Situation	$60 million net loss	$0 million net gain	$60 million net gain	Sure amount	Risk taking	Risk neutral	Risk averse	Risk premium mean
1 Gains	0	0.75	0.25	CE	38.9	34.5	26.5	– 3.7
2 only	0	0.25	0.75	CE	23.9	43.4	32.7	3.0
3 Losses	0.75	0.25	0	CE	54.0	37.2	8.8	– 9.7
4 only	0.25	0.75	0	CE	38.9	44.2	16.8	– 1.7
5 Gains	0.75	0	0.25	CE	56.6	34.5	8.8	– 13.0
6 and	0.25	0	0.75	CE	38.1	38.9	23.0	– 1.5
7 Losses	1-PE	sure amount	PE	0	32.7	28.3	38.9	1.3

involved favorable scenarios that could only result in net gains, two involved unfavorable scenarios that could only result in net losses, and two involved mixed scenarios that could result in either net gains or net losses.

Each pair of situations differed only in the chances given to the two possible outcomes – either 3 to 1 in favor of the more favorable outcome, or 3 to 1 in favor of the less favorable outcome. All outcomes were expressed on a net basis after consideration of the initial investment of U.S.$60 million. If the joint venture were sold, the fixed amount received was expressed net of the initial investment: Thus, if the selling amount covered the initial investment there would be a net gain, otherwise there would be a net loss. The sure selling amounts and the certainty equivalences for the net gain situations were necessarily net gains, those for the net loss situations were net losses, and those for the mixed situations could be either net gains or net losses. To account for the differences in domains, the wording for the certainty equivalence questions was modified appropriately (e.g. maximum amount of net loss you would accept). The subjects were instructed to respond to each situation independently as though the other situations had not occurred.

Finally, the subjects were asked to consider a choice between keeping their firm's share of the joint venture, resulting in either a net gain of U.S.$60 million or a net loss of U.S.$60 million or selling it for a net gain of zero (i.e. just recover the initial investment but no return). They were asked to respond to this last situation by providing a *probability equivalence*, namely, the *lowest* chance of obtaining the net gain of U.S.$60 million that they would require before recommending the firm keep its share of the venture. This last situation was included to allow the net gain and net loss situations to be linked using expected utility theory and to allow certainty equivalences to be compared with probability equivalences.

Even though all outcomes in the questionnaire were framed as either *net* gains or losses *after* the initial investment of U.S.$60 million had been subtracted, some subjects may have considered all outcomes as *gains* because they treated the initial investment as a *sunk cost*. In this case, the absolute risk propensities found in each domain would change, but the relative risk propensities would not. This interpretation will be addressed further in the discussion section of the paper.

Thus, a total of thirteen responses were requested from each subject – a choice and a certainty equivalence for each of the first six situations, plus a probability equivalence for the seventh situation. The situations were presented in a nine-page questionnaire.

PROCEDURES

The contact person in each firm distributed the materials described above to the participating executives, together with other questions that were part of a larger study of risk taking in the oil and gas industry. The executives mailed their responses directly to the author to provide confidentiality within the firm. Upon receipt, the author reviewed the responses for several types of consistency. Any detected inconsistencies were discussed at the end of an extensive interview held with most of the executives, which was also part of the study. These preliminary consistency checks will be discussed in the next section.

SUMMARY OF DATA AND PRELIMINARY CONSISTENCY CHECKS

A total of 117 executives responded to this instrument out of the 127 people who participated in at least one phase of the overall study. Only the 113 executives who answered all thirteen of the questions will be considered in the results below. All of these subjects were male, so the masculine form will be used throughout.

The preliminary consistency checks of the executive's responses were of two forms. The first check compared each certainty equivalence with its theoretical upper and lower bounds as determined by the best and worst possible outcomes in the risky option. All certainty equivalences were within these bounds, indicating the executive understood the certainty equivalence concept and the task being requested of them.

The second check compared the recommendation to sell or keep the firm's share of the joint venture with the certainty equivalence provided in the associated situation. For example, in order to be consistent in the first situation, a recommendation to keep the firm's share of the joint venture rather than sell it for a net gain of U.S.$15 million would have a certainty equivalence above U.S.$15 million. Similarly, a recommendation to sell the firm's share for a net gain of U.S.$15 million would have to have a certainty equivalence at or below U.S.$15 million. Certainty equivalences equal to the specified expected value amount (i.e. U.S.$15 million in this example) were not considered inconsistent with a recommendation to keep the firm's share because of possible indifference at this value.

Before the interviews, 44 (6.5%) of the 678 choice/certainty equivalence comparisons (i.e. 6 situations times 113 subjects) were inconsistent. In each case where an inconsistency of this type was pointed out to the executive during the interview, he willingly changed either his recommendation or his certainty equivalence to make them consistent. About equal numbers of recommendations and certainty equivalences were changed. Not all of the inconsistencies could be checked because the author was unable to interview selected executives and because some of the responses were received after the interview was held. The remaining 17 inconsistent choice/certainty equivalence comparisons included nine subjects who had only one inconsistency and three subjects who had two or more. The high rate of consistency between the choices and certainty equivalences and the low rate of multiple inconsistencies for individuals indicate the responses were carefully considered by the executives. No systematic biases were evident in the few inconsistencies between choices and certainty equivalences that did occur.

Forms of consistency required by expected utility theory will be addressed in the next section. See the appendix for details of the additional types of consistency checked.

4. Results

PURE GAIN AND LOSS DOMAINS

An absolute measure of an executive's willingness to take business risks is the size of his certainty equivalence for a risky venture relative to its expected value. The difference in these two values is called a risk premium. In the situations considered here, executives whose minimum selling price for the joint venture exceeded its expected value were absolute risk takers. Those whose minimum selling price was lower than the expected value were absolute risk averters.

Table 1 shows the percentage of executives who were absolute risk takers and risk averters in each situation. In this section and the next, we will consider only situations 1–4, where there are no mixed outcomes. Within the pure gain and pure loss domains, between one-third and one-half of the executives were risk neutral (i.e. their minimum selling price was equal to the venture's expected value). Setting these executives aside, the two pure domains differed in the relative percentages who were risk takers and risk averters. In the gains only domain, about equal percentages were risk takers and risk averters, with more risk takers when the chance of the unfavorable outcome was higher than when it was lower. In the losses only domain, there were substantially more executives who were risk takers than who were risk averters, again with more risk takers when the chance of the unfavorable outcome was higher. This greater degree of risk taking when the chance of the unfavorable outcome was higher was confirmed using t-tests of the difference in risk premium means within each pure domain (1% significance level).

The joint responses within each of the pure domains provide some additional insights into the risk propensities of the executives. Within each domain, a check was first made whether the certainty equivalences were monotonic increasing with the chance of the more favorable outcome, as predicted by expected utility theory. In the gain domain, there was only a single inconsistency among the 113 pairs of responses. In the loss domain, there were three inconsistencies among the 113 pairs. This minor degree of inconsistency is easily within a normal tolerance for error.

Next, the coefficients of correlation between the certainty equivalences within the same domain were calculated to see if they were significantly positive as expected. For the gain domain, the correlation coefficient was 0.47 and for the loss domain it was 0.31. Both correlations were significantly different from zero at less than a 1% level.

Tables 2 and 3 summarize the distributions of risk propensities for the 113 executives in the gain and loss domains, respectively. The notation (p, X) is used in the tables to denote the risky venture with a p chance of ending up with a net gain (loss) of X million dollars and a $1 - p$ chance of ending up with a net gain of zero. In the gain domain, two out of three executives showed the same type of absolute risk propensity in the two situations, with 30% who were jointly risk neutral, 19% who were jointly risk taking, and 19% who were jointly risk averse. Excluding people who had equal risk premiums in the two gain situations left five times more executives who showed greater risk taking when the chance of the less favorable outcome was higher than executives who showed greater risk taking when this chance was lower. Even without excluding these people, a greater proportion of executives were risk taking when the chance of the less favorable outcome was higher than when it was lower (McNemar test, 1% level).

Table 2
Joint responses within pure gain domain (percentages)

		Situation no. 1 (0.25, 60) Risk taking	Risk neutral	Risk averse
Situation no. 2 (0.75, 60)	Risk taking	18.6	0	5.3
	Risk neutral	10.6	30.1	2.7
	Risk averse	9.7	4.4	18.8

100.0%

	%
Greater risk taking when chance of unfavorable outcome higher	51.3
Same degree of risk taking	38.9
Greater risk taking when chance of unfavorable outcome lower	9.7
Total	100.0

Table 3
Joint responses within pure loss domain (percentages)

		Situation no. 3 (0.75, −60) Risk taking	Risk neutral	Risk averse
Situation no. 4 (0.25, −60)	Risk taking	29.2	7.1	2.7
	Risk neutral	15.9	26.5	1.8
	Risk averse	8.8	3.5	4.4

100.0%

	%
Greater risk taking when chance of unfavorable outcome higher	51.3
Same degree of risk taking	37.1
Greater risk taking when chance of unfavorable outcome lower	11.5
Total	100.0

In the loss domain, three out of five executives showed the same type of absolute risk propensity in the two situations, with 27% who were jointly risk neutral, 29% who were jointly risk taking, and 4% who were jointly risk averse. Excluding executives who had equal risk premiums in the two loss situations left four times more executives who showed greater risk taking when the chance of the less favorable outcome was higher than executives who showed greater risk taking when this chance was lower. A McNemar test similar to the one performed above confirmed this result at a 2% significance level.

DOMAIN DEPENDENCE BETWEEN PURE GAIN AND LOSS DOMAINS

As indicated in table 1, when the probability of the less favorable outcome was held fixed, there were about 15% more absolute risk takers in situations involving only losses than in those involving only gains. This difference in risk propensity was reinforced by significantly smaller mean risk premiums for the loss situations than for the gain situations (t-test, 1% level).

Additional evidence supporting different attitudes toward risk in the gain and loss domains was provided by the absence of any correlations different from zero at a 1% significance level between risk premiums from the two domains and insignificant chi-square tests of independence.

Situations 1 and 4 were constructed to have the form of reflected gambles, as were situations 2 and 3. These gambles can be expressed, respectively, as (0.25, 60), (0.25, −60), (0.75, 60), and (0.75, −60), where outcomes are in millions of dollars. Therefore, the certainty equivalence data presented here provide additional evidence on the reflection effect based on a within-subject analysis of executives.

Table 4 presents the data for the pairs of reflected gambles, where reflections are indicated by a double line around the box. In both comparisons only about one-quarter of the executives exhibited reflections in risk propensity between gains and losses. Prospect theory predicts that the reflection will take the form of risk taking over losses and risk aversion over gains, namely, the reflection in the upper right box. When the chance of gain/loss is a relatively low 0.25 as in table 4(a), almost as many executives (10.6%) show the opposite reflection (i.e. risk aversion for losses and risk taking for gains) as the predicted reflection (12.4%). When the chance of gain/loss is a relatively high 0.75 as in table 4(b), the vast majority of reflections are in the predicted direction (23.0% to 2.7%).

The extensive tests conducted by Hershey and Schoemaker [10] were performed for the data in table 4 after removing all cases of risk neutrality in either situation. Only one result was significant at a 1% level. This was for the type of reflectivity that they labelled SgR1, in which a majority (86.7%) of those who preferred the safe alternative on the gain side switched preference to the risky alternative on the loss side, and it only occurred when the chance of gain/loss was high.

Table 4

Joint response for reflected pure gambles (percentages)

(a)

Situation no. 4 (0.25, −60)	Situation no. 1 (0.25, 60): Risk taking	Risk neutral	Risk averse	
Risk taking	18.6	8.0	12.4	Low chance of gain/loss
Risk neutral	9.7	25.7	8.8	
Risk averse	10.6	0.9	5.3	
				100.0%

(b)

Situation no. 3 (0.75, −60)	Situation no. 2 (0.75, 60): Risk taking	Risk neutral	Risk averse	
Risk taking	15.9	15.0	23.0	High chance of gain/loss
Risk neutral	5.3	25.7	6.2	
Risk averse	2.7	2.7	3.5	
				100.0%

MIXED GAINS AND LOSSES

Unlike the situations discussed so far that involved either pure gains or pure losses, situations 5–7 involved both large gains and losses. Risk propensity for ventures involving mixed gains and losses was measured using both certainty and probability equivalences.

When a certainty equivalence was used to measure risk propensity in these mixed situations, there were substantially more executives who were risk taking than who were risk averse as shown in table 1. This preponderance of risk takers was greater when the chance of significant loss was higher (situation 5) than when it was lower (situation 6). This pattern of risk propensity is very similar to that for the loss only domain, and in fact the risk premiums for the mixed and pure loss situations show no significant differences (t-test, 1%) when chance of loss is held constant. No executive had a higher certainty equivalence for situation 5 than for situation 6, which would violate expected utility theory.

Although risk propensities over pure gains and over pure losses were not significantly correlated, the willingness to take risks in the mixed situations should be related to each of these because of the joint domain in the mixed situations. This premise was investigated using the risk premiums derived from the certainty equivalences for situations 1–6.

Using the notation $(p, X; 1-p, -X)$ to denote the risky venture with a p chance of ending up with a net gain of X million dollars and a $1-p$ chance of ending up with a net loss of $-X$ million dollars, mixed situations 5 and 6 can be expressed as (0.25, 60; 0.75, −60) and (0.75, 60; 0.25, −60), respectively. The risk premium for mixed situation (0.75, 60; 0.25, −60) was significantly positively correlated with the risk premiums in the pure gain situations (0.40 and 0.56, respectively) at a 1% significance level, but not significantly correlated with the pure loss situations. The risk premium for mixed situation (0.25, 60; 0.75, −60) was significantly positively correlated with the risk premiums in the pure loss situations (0.27 and 0.32, respectively) at a 1% level, but not significantly correlated with the pure gain situations.

These results suggest that a high chance of gain in a mixed situation might lead one to anchor on the gain amount in his judgment, so his risk propensity would be more like that in pure gain situations. Similarly, a high chance of loss in a mixed situation might lead one to anchor on the loss amount, so his risk propensity would be more like that in pure loss situations.

In mixed situation 7, a probability equivalence was used to measure risk propensity rather than a certainty equivalence. For this measure, there were about equal percentages of risk takers and risk averters as shown in table 1. The mean risk premium in this situation was not significantly different from zero, confirming that no trend toward either risk aversion or risk taking was apparent.

One would expect that the risk premium derived from the probability equivalence in situation 7 would be significantly correlated with those derived from the certainty equivalences in the other mixed situations because of their identical gain and loss amounts. This was indeed the case, with statistically significant correlations of 0.43 with situation 5 and 0.27 with situation 6.

In mixed situations, a certainty equivalence response mode has explicit probabilities attached to the gain and loss amounts, whereas a probability equivalence response mode does not. Consequently, subjects who might use an anchor and adjustment heuristic to guide their evaluation when a certainty equivalence response mode was used would not have explicit probabilities to help locate their anchor when a probability equivalence response mode was used. By this reasoning, one would expect that the risk premiums from the two pure gain situations would have substantially lower correlations with the risk premium from the mixed situation based on the probability equivalence than with the risk premium from mixed situation (0.75, 60;

0.25, −60) based on the certainty equivalence. Similarly, one would expect that the risk premiums from the two pure loss situations would have substantially lower correlations with the risk premium from the mixed situation based on the probability equivalence than with the risk premium from mixed situation (0.25, 60; 0.75, −60) based on the certainty equivalence. In three of these four comparisons, the correlation changed from significant at a 1% level to insignificant, and in the last comparison, the correlation dropped in half, from 0.56 to 0.28. These results support the hypothesis that an anchor and adjustment heuristic is being used when risk propensity over mixed gains and losses is assessed with certainty equivalences.

The use of both certainty and probability equivalences to assess risk propensity in the mixed gain/loss situations also provided an opportunity to test for both consistency with expected utility theory and response mode effects.

If the certainty equivalence in situation 5 is positive (negative) when the probability equivalence is greater than (less than) 0.25, then the responses are inconsistent with expected utility theory. Nine (8.0%) of the 113 executives were inconsistent in one of these senses, with the strong majority (8 to 1) showing certainty and probability equivalences that were jointly too high. Similarly, if the certainty equivalence in situation 6 is positive (negative) when the probability equivalence is greater than (less than) 0.75, then the responses are also inconsistent with expected utility theory. Ten (8.8%) of the executives were inconsistent in one of these senses, with only a statistically insignificant majority (6 to 4) showing certainty and probability equivalences that were jointly too high. The responses in the mixed situations for the remaining executives were consistent with expected utility theory.*

For the remaining executives, the risk premiums for the mixed situations were calculated based on the certainty and probability equivalences and then compared to see if there were systematic response mode effects. The results are summarized in table 5. Compared with an executive's probability equivalence, his certainty equivalence for the mixed situation with the dominant chance of net loss typically showed a significantly greater degree of risk taking (71 to 19), while his certainty equivalence for the mixed situation with the dominant chance of net gain typically showed about the same, or only slightly greater, risk taking (46 to 35). Excluding executives who showed equal risk propensity in the two response modes, a binomial test on the positive and negative differences in risk premiums confirmed that the former comparison was statistically different from a chance effect at a 1% level, while the latter comparison was not.

The identical trends shown by the response mode effects and the inconsistencies with expected utility theory can be partially explained by framing effects induced by

*Other cases involving certainty equivalences equal to zero or probability equivalences equal to 0.25 (or 0.75) also may violate expected utility theory. These cases have not been considered as inconsistencies because they may result from minor errors in the equivalences and they disappear with even infinitesimal changes in the responses.

Table 5

Comparison of risk premiums in mixed gain/loss situations
Certainty versus probability equivalences

	Situation no. 5 (0.25, 60; 0.75, −60) versus Situation no. 7	Situation no. 6 (0.75, 60; 0.25, −60) versus Situation no. 7
More risk taking shown in certainty equivalence	71	46
Equal	14	22
More risk taking shown in probability equivalence	19	35
Total	104	103

the different equivalence methods used. Situations 5–7 all have the same gain and loss amounts, and they differ only in their probabilities and the presence or absence of a sure alternative. The certainty equivalence mode provides probabilities of gain and loss which serve to frame the situation. As discussed above, the dominant chance of loss in situation 5 suggests that it will tend to be seen primarily as a "loss situation", whereas the dominant chance of gain in situation 6 suggests that it will tend to be seen primarily as a "gain situation". The probability equivalence mode does not provide probabilities of gain or loss, so it will tend to be seen as a mixed situation.

The greater risk taking over losses than over gains predicted by prospect theory suggests that people will show greater risk taking over similar situations when they are framed as loss situations than when framed as mixed situations. This explanation is consistent with the greater risk propensity found using the certainty equivalence in situation 5 than with the probability equivalence in situation 7. Similar reasoning might suggest that people will show greater risk taking over similar situations when they are framed as mixed situations than when framed as gain situations. However, the insignificant difference in risk propensity between the certainty equivalence in situation 6 and the probability equivalence in situation 7 does not support this explanation.

UTILITY FUNCTIONS DERIVED FROM THE RESPONSES

Expected utility theory requires that the six certainty equivalences satisfy a number of consistency relationships, both among themselves and with the probability equivalence. These relationships are described in detail in the appendix.

Fifty-nine (52.2%) of the 113 executives satisfied all of the consistency relationships among the certainty and probability equivalences required by expected utility theory. Among the remaining executives, thirty gave certainty equivalences that satisfied expected utility theory but were inconsistent with the probability equivalence response. In the vast majority of these cases (22 to 8), the probability equivalences were too high, that is, higher than the range implied by the certainty equivalences and the properties of expected utility theory. For these executives, a sufficiently greater degree of risk aversion was found in the probability equivalences than in the certainty equivalences. Such a finding is consistent with the results in the previous section on response mode effects.

The last twenty-four executives had certainty equivalences that alone did not jointly satisfy expected utility theory. All but three of these cases were consistent with the certainty equivalences for one or both of the mixed situations being either systematically too high or too low. In fifteen out of sixteen cases, the certainty equivalence for the mixed situation with the predominant chance of net gain was too high relative to the certainty equivalences for one or both of the pure gain situations. In nine out of fourteen cases, the certainty equivalence for the mixed situation with the predominant chance of net loss was too low relative to the certainty equivalences for one or both of the pure loss situations. These executives apparently had difficulty providing certainty equivalences that were consistent with expected utility theory across pure and mixed domains.

A utility function can be derived for each executive by first defining two fixed points as $U(60) = 1.0$ and $U(-60) = -1.0$. The responses to situations 1–7 can then be used to locate seven points on the utility function, as described in the appendix. This was done for each of the fifty-nine executives who fully satisfied expected utility theory. The utility functions were then examined visually to determine their risk propensities in the gain and loss domains separately. The results are summarized in table 6.*

Most of the utility functions could be easily classified, either by a common risk propensity across both the gain and loss domains or by two segments that differed in these two domains. In addition, there were eleven executives whose utility functions showed risk taking at both ends, with a risk averse segment in between that occurred about equally often within the gain domain and near zero net gain. These executives are included with those who showed risk taking throughout the gain and loss domains. The utility functions of two executives could not be easily classified, so they were removed from the analysis. Overall, the results in table 6 show that a significantly

*The responses for executives who were not fully consistent with expected utility theory were also graphed, and smooth curves were used to approximate each (partially inconsistent) utility function. The analysis was then repeated, which resulted in a distribution of utility functions similar to the one shown in table 6.

Table 6

Risk propensities over gains and losses derived from utility functions of executives consistent with expected utility theory

		Gains		
		Risk taking	Risk neutral	Risk averse
Losses	Risk taking	18*	7	9
	Risk neutral	2	16	2
	Risk averse	3	0	0
				57**

*Includes eleven executives whose utility functions had a risk averse segment between the two risk taking segments.

**Two executives whose responses were fully consistent with expected utility theory were not included because their utility functions could not be easily classified.

greater proportion of executives were risk taking over losses than over gains (McNemar test, 5% level).

In the loss domain the executives were most commonly risk taking, where about 60% of them exhibited a willingness to take risks. The less common occurrence of risk neutrality over losses was due primarily to sixteen executives who gave exact or approximate risk neutral responses throughout both domains. Risk aversion over losses was rare and occurred in only about 5% of the executives.

In the gain domain the executives were not typically risk averse as predicted by prospect theory, but instead showed a substantial willingness to take risks or to play the long run odds by being risk neutral. Even when the eleven executives who showed a degree of risk aversion over small or moderate gains between their risk taking segments were moved to the "risk averse" classification, risk aversion over gains was not more common than risk neutrality. Risk taking over at least part of the gain domain was observed in the utility functions of 40% of the executives.

The wide diversity of individual risk propensities in table 6 shows that none of the joint patterns across gains and losses describe the majority of the executives. With such wide diversity, it is especially noteworthy that the uniform risk aversion over gains and losses assumed in most theories of economics and finance was not observed even once among the oil executives.

The results of this study have already shown that slightly more than half of senior oil executives were fully consistent with expected utility theory. The utility functions for many others, however, showed that the degree of inconsistency was quite small. Such inconsistency can be due to random error or systematic bias in responses. In either case, it seems useful to have a measure of the extent to which experienced executives are inconsistent with expected utility theory.

To investigate this issue, the inconsistent utility functions were further examined to determine whether a change in a *single* response could make all seven responses consistent. Ten of the inconsistent utility functions could not be made consistent in this fashion and were not considered further. The response that required the smallest percentage change in the equivalence was then identified for each remaining inconsistent utility function. Percentage changes were determined using the range for the equivalence as a base (i.e. U.S.$60 million for situations 1–4, U.S.$120 million for situations 5–6, and 100 probability points for situation 7).

The percentage changes that were required to bring complete consistency to the utility functions ranged from 1.7% to 40%, with a median of 8.3%. Consider a 5% change in a response, for example, a change of U.S.$6 million (0.05 x 120) in the certainty equivalence for a mixed situation or a change of 0.05 in the probability equivalence for the mixed situation. If this relatively small amount of change is considered a tolerable degree of error in the elicitation process, then the percentage of executives who were consistent with expected utility theory within this degree of tolerance increased from 52% to 65%. Increasing the degree of tolerance to a 10% change in the range of a single equivalence increased the degree of consistency to 74% of the executives.

As pointed out in earlier parts of this paper, several systematic biases appear to be at work in the responses of some executives. The inconsistent utility functions examined above provide a mechanism to further identify these biases. The single response changes were classified according to which equivalence was changed to make the utility function consistent, as well as the direction of the change. For all but three of the forty-four executives whose utility functions were changed, the change occurred in the certainty or probability equivalences for the mixed situations. Approximately equal numbers of executives required changes in each of these three equivalences. For the probability equivalence and the certainty equivalence in the mixed situation having the predominant chance of net loss, the typical required change was a reduction (12 to 3 and 11 to 3, respectively). For the certainty equivalence in the mixed situation having the predominant chance of net gain, there was no significant trend in either direction (7 to 5). These results reinforce the observation that the probability equivalence may be revealing greater risk aversion and the certainty equivalence in the mixed situation having the predominant chance of net loss may be revealing greater risk taking than is consistent with the other responses.

5. Discussion

RISK TAKING OVER LOSSES

The predominance of risk taking over pure losses found in this study strongly supports the prediction of prospect theory. Such risk taking over losses was very clearly indicated by the responses of the pure loss situations and the convexity of the utility functions in the loss domain for the vast majority of executives.

Prospect theory also predicts that the value function for losses will be much steeper than for gains. Such a steep function for losses is consistent with the finding of prior studies cited earlier that, when the possible downside loss was held fixed, risk taking increased as the chance of loss increased. This study extends this result from the personal risk propensities of students on an across-subject basis to the business risk propensities of experienced executives both within and across subjects.

Studies by Hershey and Schoemaker [9] and others have found a degree of risk aversion over small losses in conjunction with the overall trend toward risk taking that is consistent with a utility function having an inflection point, as suggested initially by Markowitz [22]. Our results did not find such a risk averse segment in the loss domain.

RISK AVERSION OVER GAINS?

Executives exhibited both risk taking and risk aversion in the gain domain. This finding is consistent with a number of other studies cited earlier that discovered a substantial degree of risk taking in the pure gain domain and is contrary to prospect theory's prediction of the predominance of absolute risk aversion. Executives who treated the initial investment as a sunk cost would have considered the outcomes in "pure loss" situations 1 and 2 as "gains". As a result, the extensive risk taking over "pure losses" reported above can be interpreted as risk taking for "gains" for these executives.

The evidence for an inflection point in the utility functions over gains for a number of executives was widespread, although the emerging picture was not entirely clear. When the possible upside gain was held fixed in the pure gain situations, risk taking increased significantly as the chance of breaking even increased. The typical executive was risk taking over smaller pure gains and risk averse over larger ones. This result extends a similar finding by Hershey et al. [8] and Cohen et al. [2] in their studies of the personal risk propensities of students on an across-subject basis to the business risk propensities of experienced executives both within and across subjects.

On the other hand, the utility functions for about 20% of the executives revealed inflections in the gain domain of a different sort, with risk aversion for smaller gains and risk taking for larger gains. Similar results were found by MacCrimmon and Wehrung [19] in the business utility functions of a large percentage of the executives in their study. These findings suggest that the search for a common model of risk propensity over gains may have to give way to a model that permits widespread individual differences in risk attitude over gains.

None of the utility functions derived in this study were uniformly risk averse throughout the entire domain of gains and losses. Thus, the uniform risk aversion assumption frequently made in the economics and finance literature clearly does not hold for senior oil executives.

One possible explanation for the lack of predominant risk aversion over gains in this study might be that oil executives tend to be more risk taking than other people. Such a tendency would also be consistent with the absence of a risk-averse segment in the utility function over losses, which has been found in several other studies. The effects of such possible selection biases might be tested by examining the risk propensities of people believed to be predominantly risk averse, such as bankers. Such an explanation, of course, would also tend to overstate the degree of risk taking over losses.

REFLECTION EFFECT AND RELATIONSHIPS AMONG RISK PROPENSITIES ACROSS DOMAINS

The results of this study support the finding by Hershey and Schoemaker [10] and Cohen et al. [2] that the reflection effect postulated by Kahneman and Tversky [14] is not uniformly prevalent. No more than a quarter of the executives exhibited any reflection effect, those who did indicate a reflection did not always do so in the predicted direction, and no significant relationships between risk propensities in the gain and loss domains were found. The accumulating evidence in studies of both the personal risk propensities of students and the business risk propensities of executives seems to suggest that although individuals may exhibit both risk taking and risk aversion, these risk propensities are not as systematically linked to the loss and gain domains as prospect theory predicts. The significant variations in risk propensity between gain and loss domains that do exist for some people mean that predictions of risk behavior in one domain based on observations of behavior in the other domain must be seriously questioned. Further research on the role of targets as investigated by Payne et al. [23,24] may shed further light on the relationship between risk propensity and the domain of risky outcomes, especially if targets other than nominal break-even amounts are considered.

Risk propensity in mixed gain/loss situations was more closely related to risk attitude in pure gain situations when the mixed situation had a dominant chance of gain, whereas the relationship was closer to risk attitude in pure loss situations when there was a dominant chance of loss in the mixed situation. Such a finding reinforces the possible role of an anchor and adjustment heuristic (Slovic and Lichtenstein [28], and highlights the difficulty of accurately assessing one's risk attitude by eliciting responses from both pure and mixed gain/loss domains.

CONSISTENCY WITH THE PRINCIPLES OF EXPECTED UTILITY THEORY

The extent to which experienced oil executives satisfy the principles of expected utility theory is mixed. On the positive side, about half of the executives gave responses that were fully consistent with the theory. An additional quarter of the executives would have been consistent with expected utility if they had changed a single equivalence response by no more than 10% of its possible range.

On the negative side, one out of five executives did not satisfy the stochastic dominance relationships among the certainty equivalences. The most problematic inconsistencies were, of course, the systematic ones. These inconsistencies occurred most frequently in the mixed situations, where the certainty equivalences for some subjects were biased toward the outcome that had the predominant chance of occurring. These executives may have had difficulty integrating their answers for mixed gain/loss situations with those for situations involving pure gains or pure losses.

PROBABILITY VERSUS CERTAINTY EQUIVALENCES IN MIXED SITUATIONS

Another systematic inconsistency found in the mixed situations was the greater risk taking revealed in an individual's certainty equivalence than in his probability equivalence, substantiating the findings of previous studies cited earlier. Hershey and Schoemaker [11] postulated the existence of a probability equivalence mode reframing effect to explain this result. Their premise is that people reframe gambles over pure domains that appear in a probability equivalence format into mixed gambles by redefining the outcomes as "gains" and "losses" relative to the sure alternative. The response mode effect is then the result of different risk propensities over "gains" and "losses".

Because the probability equivalence situation used in the current study was already framed in terms of gains and losses relative to the sure alternative of breaking even, it was a natural setting for examining this conjecture. Although the associated setting for the certainty equivalences was a mixed situation rather than a pure situation, we have already seen that these mixed situations tended to be seen as mostly gain or loss situations, depending on whether the chance of gain or loss was dominant. According to the reframing effect of Hershey and Schoemaker [11], there would be a trend toward greater risk aversion when moving from a certainty equivalence in a predominant loss situation to a probability equivalence in a (reframed) mixed situation. This result was confirmed in this study, where both the probability equivalence and the certainty equivalence for the mixed situation with the predominant chance of loss tended to be too high relative to the other responses. This reframing effect would also predict greater risk aversion when moving from a certainty equivalence in a predominant gain situation to a probability equivalence in a mixed situation. This latter prediction was not confirmed with a statistically significant difference, although the trend was in the predicted direction. These results are also consistent with the finding by Johnson and Schkade [13] that the greatest response mode effect occurred when the chance of losing was the highest. The reframing effect, therefore, is at least partially substantiated by the responses from the executives.

Overall, then, the results of this study have shown that experienced executives tend to behave in conformance with both the principles of expected utility theory and the predictions of prospect theory about as well as students do. Although half of the executives fully conformed to expected utility theory, many others revealed systematic violations of the theory. Likewise, some of the predictions of prospect theory such as a propensity to take risks over losses were strongly substantiated, whereas others were at least partially rejected, as found in other studies with student subjects.

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Appendix

Define the two fixed points on the utility function as $U(60) = 1.0$ and $U(-60) = -1.0$, where all domain values are in millions of dollars, and let $U(0) = k$, where $-1.0 <= k <= 1.0$ is specific for each individual. By expected utility, the utility values corresponding to the certainty equivalences for situations 1–6 are, respectively, $0.25 + 0.75k$, $0.75 + 0.25k$, $-0.75 + 0.25k$, $-0.25 + 0.75k$, -0.50, and 0.50. The probability equivalence (PE) in situation 7 must therefore satisfy the equation $k = 2.0\text{PE} - 1.0$ or $\text{PE} = 0.5(k + 1.0)$.

Expected utility theory requires the certainty equivalences over pure gains to be nonnegative and over pure losses to be nonpositive (assuming we allow horizontal and vertical sections of utility functions). Defining CEi as the certainty equivalence for situation i, the following relationships are inconsistent with expected utility: $\text{CE1} < 0$, $\text{CE2} < 0$, $\text{CE3} > 0$, and $\text{CE4} > 0$.

Expected utility theory also constrains 13 of the 15 pairs of relationships among the 6 certainty equivalences. The following relationships are inconsistent with expected utility: CE1 < CE3, CE1 < CE4, CE1 < CE5, CE2 < CE1, CE2 < CE3, CE2 < CE4, CE2 < CE5, CE2 < CE6, CE4 < CE3, CE5 < CE3, CE6 < CE3, CE6 < CE4, and CE6 < CE5. The two remaining pairs can only lead to an immediate inconsistency if both CE6 < CE1 and CE4 < CE5. Other relationships involving these two pairs constrain the value of k (and hence PE) as follows: CE6 < CE1 and CE5 <= CE4 (0.67 <= PE), CE4 < CE5 and CE1 <= CE6 (PE <= 0.33), CE1 = CE6 and CE5 < CE4 (0.33 <= PE), CE1 < CE6 and CE4 = CE5 (PE <= 0.67), CE1 < CE6 and CE5 < CE4 (0.33 <= PE <= 0.67).

Lastly, expected utility theory constrains the relationships between the probability equivalence and both CE5 and CE6 as follows: CE5 <= 0 and CE6 < 0 (0.75 < = PE), CE5 > 0 and CE6 < 0 (inconsistent), CE5 < 0 and CE6 = 0 (0.25 <= PE), CE5 < 0 and CE6 > 0 (0.25 <= PE <= 0.75), CE5 = 0 and CE6 > 0 (PE <= 0.75), CE5 > 0 and CE6 >= 0 (PE <= 0.25).

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