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An Experimental Study of Managerial Pay and Firm Hedging Decisions

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ABSTRACT

A manager's pay is often a function of a performance measure such as revenue, profit, or asset value. This study tests directly by experimentation the implications of pay function shape and managerial risk taking. Greater convexity of pay functions motivated greater risk taking, but not to the extent predicted and with great variability, individually and across managers. Decisions by managers about the level of firm risk were found to be significantly context dependent, in that simply referring to a hedging decision as "insuring" motivated greater risk avoidance. Managers were also more likely to take greater risks when pay was expected to fall.

Introduction

Managers face some decisions whose risk and return aspects are or seem to be closely intermingled and others where the two appear quite distinct by nature or by design. This study is concerned with decisions involving the risk aspect and how it is influenced by the way in which managers are paid.

The baseline theory is that there is no economic reason for firms or individuals to purposefully alter the riskiness of their activities in a perfect capital market that prices all risks that cannot be diversified away costlessly. One practical implication is that insuring is a matter of indifference in such a setting. We move away from the baseline, however, when managers are unable to fully diversify their personal portfolios because their human capital is specific to their jobs and to the firms for which they work. This may motivate hedging in the sense described by Donaldson (1963, p. 127): "Since the professional manager finds his own present and future intimately bound up with that of the corporation, any desire to reduce the riskiness of his own position must be accomplished by changing the specific corporate environment he works in."

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Economic theory also tells us that the risk-taking behavior of managers is determined jointly by attitudes toward risk and the way in which pay is tied to performance. There is little clear evidence, however, that pay contracts motivate risk taking as predicted. A lack of detail in and control over field data forces us to make many assumptions and results in composite hypotheses that are hard to disentangle. Managerial incentive questions resurface continually, with the financial press expounding regularly on both pay levels and the apparent incongruity between pay and performance in general. Baker, Jensen, and Murphy (1988, p. 593) have restated the significance of pay and performance issues: "A thorough understanding of internal incentive structures is critical to developing a viable theory of the firm, since these incentives determine to a large extent how individuals inside an organization behave."

This article investigates the riskiness of business decisions made by managers whose pay is tied to underlying firm value. Using a series of experiments, evidence is provided on the question of whether pay contracts motivate hedging or reverse-hedging of firm value. Evidence is also provided on whether the riskiness of managerial decisions is influenced by the context in which the decisions are made in the sense that the labeling of an activity as one that "insures" induces a state of mind conducive to risk avoidance. The next section describes the role of compensation in a firm's hedging policy. The following sections specify a model of managerial hedging and describe the experiment. The last two sections present and discuss the findings.

Firms' Hedging Policies and Hedging Determinants

Hedging at the firm level can be loosely defined as any activity intended to reduce the variability of firm value. A firm's hedging policy is the set of risk-altering activities that management undertakes and that shareholders condone either implicitly or explicitly.[1] Smith and Stulz (1985) have demonstrated how hedging may be valuable to firms facing certain market imperfections. Managers could be permitted or even encouraged in these cases to engage in hedging activities. But managers may otherwise engage in hedging that is simply self-serving because many of their activities are unobservable. This occurs, for instance, when high-risk, profitable projects are rejected because their riskiness cannot be hedged to the satisfaction of managers by "accepted" means. There has also been interest among the investment community in the connection between investment fund managers' compensation and risk taking. Modigliani and Pogue (1975) have argued that rewarding investment company managers according to a symmetric fee schedule does not

[1] Hedging may be accomplished by altering or maintaining certain characteristics of a firm's assets, equity, and debt. Choice of relatively liquid assets, lower debt-equity ratios, asset-liability duration matching, and purchasing insurance are examples of firm hedging. Some purely financial transactions are so closely associated with firm hedging that they are often referred to as hedging instruments; these include forward and futures contracting, swapping, and options trading.

guarantee that their portfolio choices will be aligned with the interests of fund holders. Fund managers are also sometimes rewarded with bonuses (incentive fees) if the fund's performance betters some index. A common concern about this type of compensation is the incentive to "game" the fund near the end of a period when performance during the period has been too low for a bonus. Similar agency concerns can be raised about the alignment under alternate compensation schemes of bankers' personal interests and their fiduciary responsibility to depositors.

Where managers would be inclined to hedge or reverse-hedge firm value to the detriment of claimholders, the structure of pay contracts, in theory, could be used to neutralize or reverse the inclination. An empirical question is whether a given pay contract motivates risk taking in the way we would expect. The lack of empirical evidence on the question is attributable to the complexity of field data. However, some provocative studies have been done. Amihud and Lev (1981) and Walking and Long (1984) investigated the self-serving management hypotheses of conglomerate mergers and take-over bid resistance. Agrawal and Mandelker (1987) studied the relationship between the stock and stock option holdings of managers in their firms and the riskiness of their financing and investment decisions. Titman and Wessels (1988) found a relationship between corporate leverage and a measure of the uniqueness of a firm's activities, which relates to the specificity of employee human capital to a firm. But any interpretation of these studies that ties compensation to managerial risk taking must be made cautiously because of the assumptions that must be made about uncontrolled variables, such as the composition of the personal wealth portfolios of managers and the nature of investments and financings. Smith and Stulz (1985, p. 403) note as well that "more detailed data are required than are available from sources such as *Compustat,* in which firms' hedging activities are aggregated with other contingent outcomes such as insurance contracts and outstanding lawsuits."

Financial decision experiments offer a complementary approach to field studies of such questions, because experiments typically permit control of more of the underlying assumptions of a model of interest. Individual hedging choices in experiments can be observed over time, and there is complete control over pay, the set of managerial actions, and the distribution of firm value. In this way, the incremental hedging or reverse-hedging behavior of managers facing different pay functions can be measured relative to what will be described as a risk-neutrality-inducing pay function as the benchmark.

Modeling Managerial Hedging

The Model

Suppose end-of-period pay is positively related to firm value. A manager's utility is then a composite function of pay and firm value, with the pay function transforming uncertain, end-of-period firm value into uncertain wealth. A risk-averse manager's utility is strictly concave over wealth, but, depending on the shape of the pay function, it may be convex, linear, or concave over firm value. Smith and Stulz (1985) show that if a manager can alter the riskiness of his or her wealth only by changing the riskiness of firm value, then the incentive to do so depends on the shape of utility as a direct function of *firm value*. A sufficiently convex pay function, for example, will cause utility to be convex in firm value and therefore motivate risk-seeking with respect to firm value despite risk aversion over personal wealth.

Let managers be single-period, expected utility of wealth (pay) maximizers with utility, U(W), strictly concave and twice differentiable in end-of-period wealth, W. W is uncertain because it is positively related to uncertain end-of-period firm value, A, by a pay function W(A). Suppose that managers may only select real productive or financial investments for the firm whose payoffs result in mean-preserving changes in the spread of firm value in the sense of Rothschild and Stiglitz (1970). We can think of A as the sum of two random variables: one is the uncertain firm value that will be realized in the absence of a manager's investment on behalf of the firm, and the other is the uncertain payoff of that investment which may alter the spread of A but not its mean.[2] Managers maximize E[U(W(A))], the expected utility of wealth, with respect to some risk characteristic of the available investments.

Define $U_A(A)$ as utility as a direct function of firm value. The distribution of A that maximizes E[U(W)] also maximizes $E[U_A(A)]$. Strictly convex utility in *firm value* implies pay functions that motivate risk-seeking in A, while strictly concave utility in firm value implies pay functions that motivate hedging, and a complete hedge if possible. A linear U_A implies risk neutrality in A. The second derivative of U_A with respect to A, $U''W'^2 + U'W''$, therefore provides the following relationship between the shape of pay functions and the shape of utility of wealth, which determines the risk incentive of pay.

$$U''_A \gtreqless 0 \text{ iff } \frac{W''}{W'^2} \gtreqless \frac{U''}{-U'} = R(W),$$

where primes and double primes denote first and second derivatives, and R is a manager's Arrow-Pratt coefficient of absolute risk aversion (see Arrow, 1971). If $\frac{W''}{W'^2} < \frac{U''}{-U'}$, for example, even though W may be convex, increases in expected wealth are never large enough to compensate for the disutility of

[2] It is not necessary to assume that the investment choices preserve mean firm value. It is a convenience that allows us to avoid having to deal with the additional questions of how managers might alter mean firm value, say, through superior talent or greater effort, and whether they are effort-averse. It is also assumed that other possible ways of changing the riskiness of W, such as buying income insurance, are prohibitively costly. Choosing the risk scale of an investment is a manager's only course of action.

increased spread of wealth, and the least risky firm investment is preferred by a manager.[3]

The watershed case of a linear U_A is of particular interest because, when the pay function does not provide a risk incentive, the hedging or reverse-hedging choices of managers may be attributable to noneconomic factors, that is, those not contemplated by the model. The decisions made by managers facing risk-neutrality-inducing pay functions implied by a linear U_A are therefore a natural benchmark against which to measure the riskiness of choices of managers facing other pay functions. The benchmark pay function that is central to the experiment reported here is one that induces risk neutrality in A when managers' tastes can be represented by a general logarithmic function, $U(W) = \ln(W+k)$, $k > 0$, and is given by

$$W(A) = \exp\left(\frac{\ln\frac{W_h + k}{W_l + k}(A) - A_h \ln(Wl + k) - A_l \ln(W_h + k)}{\Delta A}\right) - k,$$

where $\Delta A = A_h - A_l > 0$ is the range of A. This function is convex and monotonically increasing in A.[4]

It is interesting to investigate whether managers facing concave pay functions hedge firm value, and, if they behave optimally, whether they seek complete hedges. If they do, then concave pay functions might be mechanisms by which firms bond themselves to a hedging policy, reducing the agency costs of debt (Smith and Stulz, 1985).

Also, does an appropriately defined bonus pay function motivate hedging or reverse-hedging of firm value? A bonus pay function has the form

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[3] A note is in order at this point about my use of the expected utility model. A growing literature in experimental work on choice under uncertainty documents systematic departures from expected utility maximizing behavior, and a growing theoretical work attempts to patch up the .heory. This study is not aimed at testing the conditions necessary for the expected utility representation or at characterizing systematic departures from expected utility maximization. Those research programs, which are of greater theoretical interest, are left to future work. Here, the expected utility model is used simply as a reference because it allows us to determine fairly easily the degree of pay function convexity necessary to incite risk taking.

[4] For exponential utility, $U(W) = -e^{-\gamma W}$, where $\gamma > 0$ is a constant, the pay function resulting in linear U_A is

$$W(A) = W_h - \frac{1}{\gamma}\ln\left(\frac{(A_h - A)(e^{\gamma \Delta W} - 1)}{\Delta A} + 1\right);$$

and for power utility, $U(W) = \frac{1}{d}(W+k)^d$, $0 < d < 1$, $k > 0$, it is

$$W(A) = \left(\frac{((W_h + k)^d - (W_l + k)^d)(A) + A_h (W_l + k)^d - A_l (W_h + k)^d}{\Delta A}\right)^{\frac{1}{d}} -k$$

Details of the solutions and other cases are available from the author upon request.

$$W(A) = B + \max\left(\frac{(A - K)}{D}, 0\right),$$

where B is a riskless base salary if we assume no chance of bankruptcy, D > 1, and K is the target firm value that must be surpassed in order for a manager to receive a bonus. Bonus pay is of interest because many compensation plans have option-like characteristics. For example, to the extent that supervisors are reluctant to assign poor performance ratings, promotions are like call options because they reflect an "up or stay" policy (Baker, Jensen, and Murphy, 1988; Medoff and Abraham, 1980).

An Alternative View of Decision-Making Under Uncertainty

Descriptive choice models from psychology enjoy supporting evidence that risky choices are highly context dependent in that the guise or presentation of a risky prospect affects the ultimate choice. Prospect theory (Kahneman and Tversky, 1979) is one such model in which the framing of decisions affects whether choices will be ultimately risk-seeking or risk-averting. An intuitively plausible frame of reference is a salary that allows one to maintain a desired standard of living, which is influenced by standards or norms in the community. A prediction of prospect theory, contrary to expected utility theory, is that managers are more likely to reverse-hedge firm value when they face an expected drop in wages than when they face an expected increase in wages, regardless of the shape of the pay function. The frequency of increased risk taking will depend on the opportunities they face, that is, the investment climate, and how frequently individual reference points are adjusted.

An interesting framing effect may also occur when labeling the outcomes of a prospect causes a change in a decision-maker's perception of its payoffs. Hershey and Schoemaker (1980) and Schoemaker and Kunreuther (1979) report that the number of subjects preferring a sure loss over the risky prospect of a larger loss or no loss increases substantially when the sure loss is referred to as an insurance premium. Choice behavior that is so sensitive to economically inconsequential changes in the guise of prospects should spark doubts as to the descriptive robustness in different contexts of models based upon expected utility theory, and we can ask whether pay incentives or contexts dominate in managers' decisions with regard to risk.

Experimental Design

Sixty managers individually played a risky choice game on personal computers, and their responses were recorded on floppy disks. Forty-four managers were executive MBA candidates at the University of Toronto at the time of the experiment, recruited by in-class solicitation, and the rest were recruited from large organizations in Toronto at which the author was given permission to recruit.[5] On average, the managers were 35 years old, had 15

[5] The organizations are the advertising firm Ogilvy and Mather, the electrical equipment

years of work experience, with three years experience in his or her current position, and were earning about \$60,000. Forty-five were men, and fifteen were women. Sixteen chose not to disclose their salaries. The participants held various jobs in finance, marketing, sales, manufacturing, general management, accounting, and consulting, to name a few. They represented fifteen industries, the most frequent being electrical and electronic products, communications, and the government.

Sessions were held on a number of days in the Faculty of Management's personal computer laboratory at the University of Toronto. Each participant was given a computer diskette, a one-page introduction to the experiment, and \$15. The diskettes were labeled with a randomly-chosen identification number that would determine pay type (convex, concave, or bonus) and scenario (reference, insurance) once a game was started. Assignment to the various treatments was random (no distinction was made between the executive MBA candidates and the others). Each player started the program and typed his or her identification number. More detailed instructions were given on the computer screen, followed by some questions about the player and a short quiz.[6] The experimenter was available to answer questions at all times.

On each of 14 trials, participants made an investment choice that could alter the spread of firm value but not its mean. Before doing so, a pay table such as the one in Figure 1 would appear on their screens. The pay table screen (in this case, the risk-neutrality-inducing benchmark or convex pay) provided examples of the relationship between investment payoff in state 1, H1, the value of the firm in two equally likely states, V1 + H1 and V2 + H2, and managerial pay in those states, W1 and W2. This screen could be redisplayed at any time during a trial and as frequently as desired. (The pay table gave examples of only some possible choices. Players' actual choices could be made to the nearest dollar.) By choosing a positive value of H1, firm value would increase by H1 dollars in state 1 and decrease by H1 dollars in state 2 (i.e., H2 = -H1, resulting in mean-preserving decreases in spread of A = V + H). Increasingly negative values of H1, on the other hand, would increase the spread of asset value and salary.

On the first trial, firm value was \$95 million or \$105 million in the absence of an investment choice (effectively, H1 = 0). Players could change this spread by choosing H1 anywhere in the range of -\$5 million to +\$5 million. The lower bound was the riskiest position, and the upper bound was a complete hedge. Reverse-hedging, therefore, could result in a firm value as low as \$90 million or as high as \$110 million, and, pay, consequently, could be as low as \$50,000 or as high as \$100,000 depending on the state realized. Referring to Figure 1, we see that a complete hedge on the first trial, on the other hand, would guarantee a salary of \$70,711 under convex pay. On subsequent trials, expected

manufacturer Federal Pioneer, the Canadian Bankers' Association, and the Ministry of Consumer and Corporate Affairs of Ontario.

[6] The instructions are available from the author upon request.

Figure 1
Pay Table Screen (Convex Pay)

FIRM VALUE AND SALARY FOR DIFFERENT CHOICES OF H1

H1	V1+H1	V2+H2	W1	W2
-5,000,000	90,000,000	110,000,000	50,000	100,000
-4,000,000	91,000,000	109,000,000	51,736	96,594
-3,000,000	92,000,000	108,000,000	53,589	93,303
-2,000,000	93,000,000	107,000,000	55,478	90,125
-1,000,000	94,000,000	106,000,000	57,435	87,055
0	95,000,000	105,000,000	59,460	84,090
1,000,000	96,000,000	104,000,000	61,557	81,225
2,000,000	97,000,000	103,000,000	63,728	78,458
3,000,000	98,000,000	102,000,000	65,975	75,786
4,000,000	99,000,000	101,000,000	68,302	73,204
5,000,000	100,000,000	100,000,000	70,711	70,711

This is your pay table for Year 1.

Press <ENTER> when ready.

firm value was set equal to the value realized on the previous trial. The lowest possible pay was increased by 10 percent if state 2 occurred and was reduced by 10 percent if state 1 occurred. In this way, pay functions moved about firm value-pay space but never changed their shape.

The functions for the other two pay treatments, concave pay and bonus pay, are shown alongside that for convex pay for comparison in Table 1. The concave function is a square root function. The convex pay function, described algebraically above, motivates risk neutrality in firm value conditional on subject risk preferences being represented by logarithmic utility. The bonus pay function was chosen to motivate risk seeking conditional on logarithmic preferences.[7]

Next, a choice screen appeared (Figure 2). Participants would now make tentative choices of H1, and possible outcomes for firm value and salary would be computed for them and displayed. Players could change their choice any number of times, refer back to the pay table screen or to a summary of results of previous trials like the one shown in Figure 3.

Because of the dependence of some of the hypotheses on risk preferences, the lottery technique developed by Berg et al. (1986) was used to induce the

[7] A sufficient condition for bonus pay to motivate risk seeking is for expected firm value to be less than or equal to the bonus hurdle, that is, $E(A) \leq K$. The intuition is that one has nothing to lose by going for broke because a salary of *at least* B is guaranteed *and* expected. However, when firm value is expected to be greater than the bonus hurdle, a salary of B is guaranteed but a bonus is expected. Hedging locks in that expected bonus; reverse-hedging increases the bonus that will be obtained if the favorable state occurs, but reduces or eliminates the bonus entirely if the unfavorable state occurs. The choice between hedging and reverse-hedging will then depend on tastes, which is how the bonus pay function was formulated in this experiment.

Table 1
Possible Pay Outcome as a Function of Investment Payoff

H1	*Convex*		*Concave*		*Bonus*	
	W1	*W2*	*W1*	*W2*	*W1*	*W2*
-5,000,000	50,000	100,000	50,000	100,000	50,000	100,000
-4,000,000	51,736	96,594	53,619	98,107	50,000	95,833
-3,000,000	53,589	93,303	57,009	96,177	50,000	91,667
-2,000,000	55,478	90,125	60,208	94,207	50,000	87,500
-1,000,000	57,435	87,055	63,246	92,195	50,000	83,333
0	59,460	84,090	66,144	90,139	50,000	79,167
1,000,000	61,557	81,225	68,920	88,034	50,000	75,000
2,000,000	63,728	78,458	71,589	85,878	50,000	70,833
3,000,000	65,975	75,786	74,162	83,666	50,000	66,667
4,000,000	68,302	73,204	76,649	81,394	54,167	62,500
5,000,000	70,711	70,711	79,057	79,057	58,333	58,333

Note: W1 and W2 = pay outcomes in states 1 and 2, respectively. H1 and H2 = investment payoffs in states 1 and 2, respectively. Each state is equally likely (H2 = -H1).

players to behave *as if* they possess logarithmic tastes.[8] Having made a tentative choice, the risk-taste inducement technique requires that players understand the relationship between the probability of winning or losing a dollar in a lottery and notional managerial pay, W. This was done by arranging equal increments of values of W on the circumference of a circle, the distance between each obtained by converting prob(win $1|W) to degrees. This circle was called a prize clock. In order to commit to a choice, a player first had to look at two prize clocks, each corresponding to one that would be used in the lottery depending on the state realized (Figure 4). A generic prize clock such as the one in Figure 5 could be recalled even if a tentative choice had not been made.

[8] The technique relies on the fact that expected utility functions are linear in the probability of winning some preferred prize and that they are unique up to a positive linear transformation. A player can be introduced to an intermediate choice whose outcome has value in terms of units which are exchanged for some probability of winning that preferred prize in a subsequent lottery. In our case, the intermediate choice was the hedging decision, H1, whose outcome was W (the units). Each possible W outcome can be transformed into the probability of actually winning $1 or losing $1 in a lottery which followed each trial. The unobservable utility of winning $1 and losing $1 can be arbitrarily set equal to one and zero. Logarithmic utility is induced (controlled for) by taking the natural logarithm of possible Ws to generate the conditional probabilities of winning $1 for different choices of H1. The reason for inducing a utility function characterized by constant relative risk aversion is that it implies that decisions will be made myopically; in other words, there should not be wealth effects as rewards change from trial to trial. By inducing logarithmic utility, therefore, a rejection of the null hypotheses is not explained by wealth effects or players having adopted a long-term strategy of the Markowitz (1976) type. Simply assuming myopia is also justified by invoking the cognitive limitations of human information processing documented in the psychology decision literature and by reference to the results of other multistage portfolio selection games (Kroll, Levy, and Rapoport, 1988b, p. 404).

Figure 2
Choice Screen (Concave Pay)
for a Hypothetical Choice of H1=$3,456,000

Year 1			
Range of H1: -$5,000,000 to +$5,000,000			
Basic Asset Value:	V1	$ 95,000,000	
	V2	$ 105,000,000	
	Average	$ 100,000,000	
Your choice of H1 (no commas):		$3,456,000	
------- POSSIBLE OUTCOMES -------			
V1+H1		V2+H2	
95,000,000+3,456,000=98,456,000		105,000,000-3,456,000=101,544,000	
W1		W2	
75,306		82,638	
You may change your choice at any time (F2).			
You must look at the prize clock (F1) before committing to a choice.			

F1-Prize Clock F2-Choose H1 F3-Summary F4-Pay Table F10-Quit

Figure 3
Summary Screen (Concave Pay)

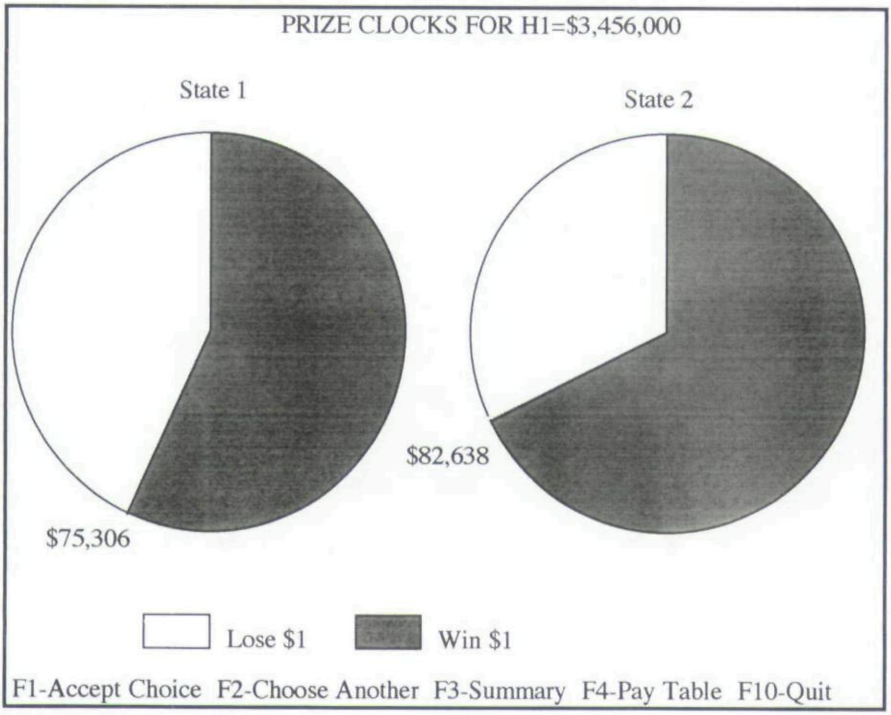
-----SUMMARY-----

	---POSSIBLE----		------ACTUAL------				
Year	W1	W2	H1	State	Salary	Firm Value	Prize
1	75,306	82,638	3,456,000	2	82,638	101,544,000	yes
2	86,963	86,963	5,000,000	1	86,963	101,544,000	no
3	53,839	96,709	-3,780,000	1	53,839	92,764,000	no

Press <ENTER> when ready.

Once a commitment was made, one of the two equally probable states was randomly generated, and firm value and pay for the period were announced. A prize clock would appear, its hand would begin to tick, and a player would win one dollar if its hand stopped at or before W, and lose one dollar otherwise (Figure 6). The game continued for 14 trials, the total being unknown to participants, and taking on average 40 minutes to complete. At the end of the experiment, players were paid or would have to repay the net amount won or lost in the 14 lotteries. They would earn as little as $1 or as much as $29 given the $15 allocated to them at the beginning of the game.

Figure 4
Prize Clock Screen



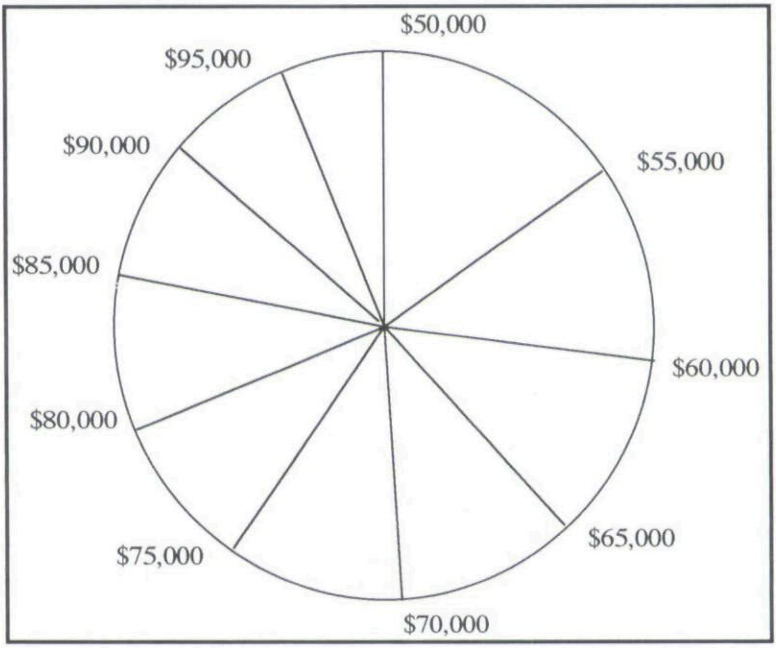
Context was manipulated by giving different sets of instructions to each half of the subject pool. In the reference scenario, the choice of H1 was described to half of the participants as a generic business decision that could change the spread of possible firm value and of possible pay. The words hedging or reverse-hedging were never used. The instructions for the other half of the players, in the insurance scenario, described choosing positive H1 as "buying insurance" and choosing negative H1 as "reducing coverage" or "selling insurance." The instructions differed only in the presence or absence of the word insurance.

Findings

Distribution of Hedging Choices

The histograms shown in Figure 7 suggest qualified support for the model based on aggregate responses. Recall that concave pay should motivate hedging, and, optimally, H1 should equal $5,000,000 on each trial. Bonus pay should motivate reverse-hedging, with H1 equal to -$5,000,000 being optimal. Choices under convex pay are the benchmark. There also should be no difference between the distributions of H1 under the reference and insurance scenarios if context is irrelevant.

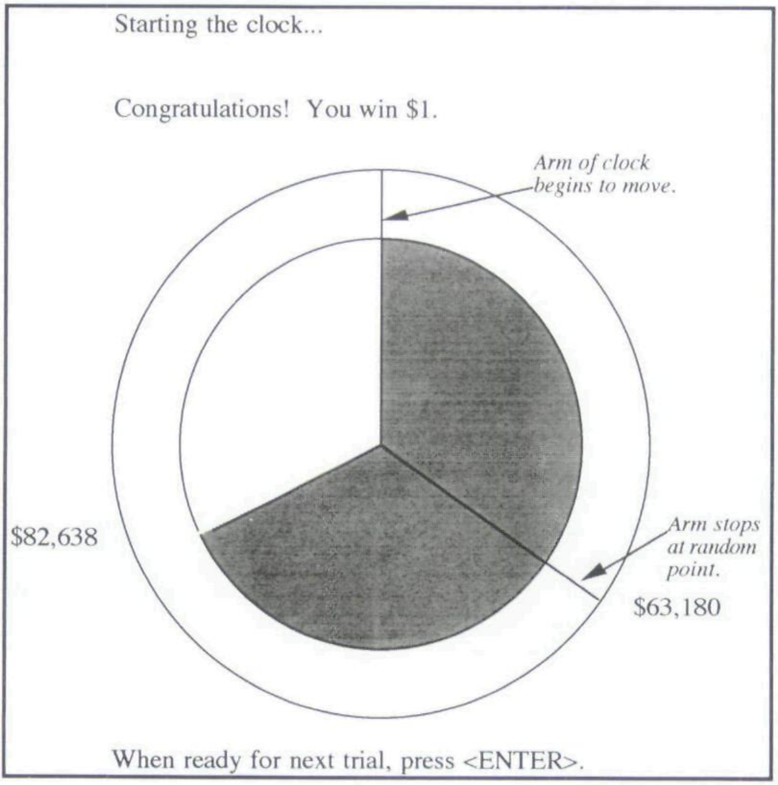
Figure 5
Generic Prize Clock



Concave pay motivated more hedging than convex pay, and bonus pay motivated less hedging than convex pay. Sixty-one percent of the choices were hedges under concave pay, while only 34 percent were risk-increasing. Sixty-eight percent of the choices were reverse-hedges under bonus pay, while only 27 percent were hedges. The benchmark, convex pay, yielded hedges on 41 percent of the trials and reverse-hedges on 52 percent. Sign tests support statistically significant differences in median H1 for concave and bonus pay relative to convex pay in both the reference and insurance scenarios ($p << 0.05$ in all cases). However, only 39 of the 280 choices were optimal under concave pay, not many more than the 33 equal to $5,000,000 under convex pay. It is also notable that the majority of optimal choices under concave pay were made by a minority of participants. Twenty-eight of the 39 optimal choices were made by six of the 20 players facing concave pay. Eighty optimal choices were made under bonus pay, or almost twice the number of H1s equal to -5,000,000 under convex pay. But, again, more than two-thirds of these were accounted for by six out of the 20 participants in the two bonus pay treatment groups.

Hedging was more frequent and reverse-hedging less frequent under the insurance scenario for all pay treatments. A sign test supports a significantly higher median under the insurance scenario than under the reference scenario for convex pay ($p = 0.011$). This provides preliminary evidence of a context effect.

Figure 6
Lottery Screen

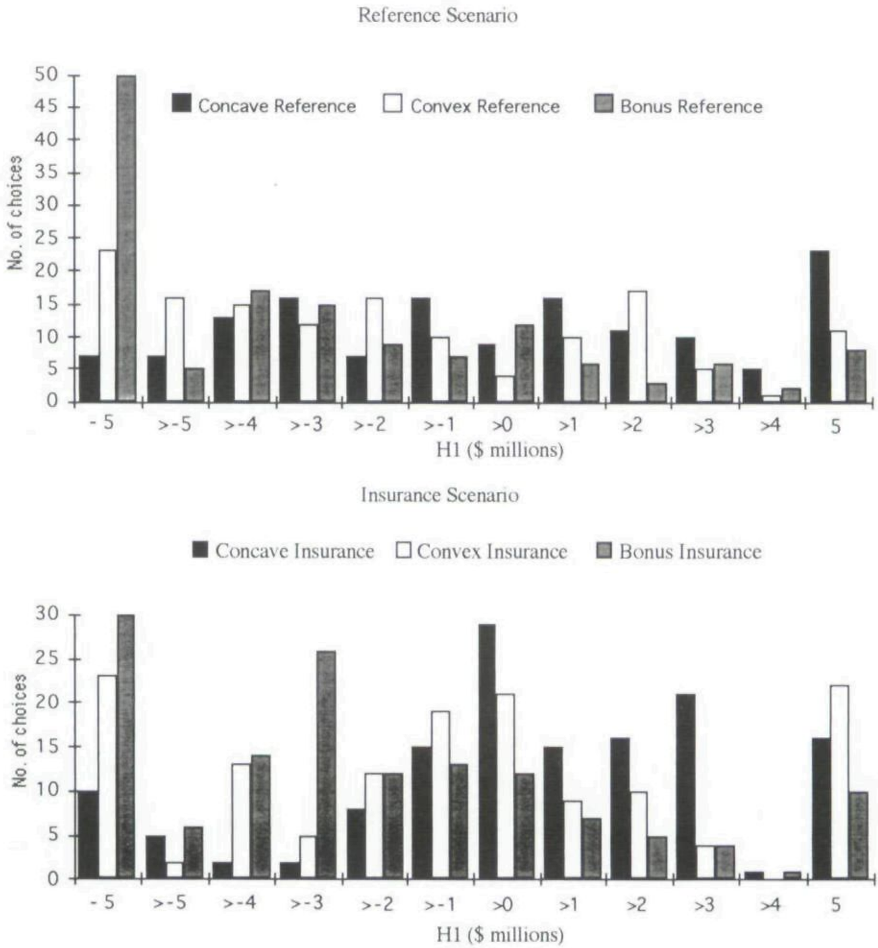


Parametric Estimation

The effect of the six experimental treatments (three pay functions times two scenarios) and two other variables on hedging choice was estimated by a two-limit Tobit regression to account for the censoring of H at -\$5 million and +\$5 million (Table 2).[9] Because convex pay in the reference scenario is the benchmark against which concave and bonus pay are measured, that treat-

[9] Censored samples are discussed in Judge et al. (1985, p. 779). The two-limit censored regression used in this study is a generalization due to Rosett and Nelson (1975) of Tobin's (1958) one-limit model. The observations for each participant were multiplied by the reciprocal of the estimated standard deviation of that subject's responses, with the weights scaled to sum to the sample size to reduce biases caused by heteroskedasticity (Hurd, 1979). Amemiya (1973) proved the consistency and asymptotic normality of the maximum likelihood estimator for censored regressions. These are also strongly consistent and asymptotically normal in the presence of serially correlated errors (Robinson, 1982). The parameters were estimated with a subroutine of Greene's (1988) *LIMDEP* econometric software.

Figure 7
Distribution of Hedging Choice, H1



ment represents the intercept term in the statistical model. Thus, the estimated coefficients of the other five treatments are incremental effects.[10]

An additional variable, investment climate, $CL = W_{t-1} - E(W_t|H1^*)$, is motivated by Rapoport (1984). It gauges whether subjects make riskier decisions when the opportunities they face are expected to reduce income. The investment climate is favorable when expected salary under the optimal

[10] The data were pooled. Sixty subjects made 14 choices each for a total of 840 observations. The first of the 14 trials for each subject was lost because of the lagged prize dummy, PL, leaving a total of 780 observations. The data was pooled to explain the different hedging behavior of firms, as opposed to individuals, as a function of different compensation practices. Each treatment is like a small-scale firm, representing the decisions of a number of managers over a number of periods.

Table 2
Censored Regression of Investment Payoff H1 on Treatment Variables
(Two-Limit Tobit Estimates)

	Variable	*Coefficient*	*Standard Error*	*T-ratio*	*P-value*
Convex Reference	XR	-1,182,150	314,717	-3.756	0.000
Concave Reference	CR	1,881,390	429,276	4.383	0.000
Bonus Reference	BR	-1,514,870	350,441	-4.323	0.000
Convex Insurance	XI	946,907	317,966	2.978	0.003
Concave Insurance	CI	1,886,480	360,695	5.230	0.000
Bonus Insurance	BI	-649,786	411,482	-1.579	0.114
Investment Climate	CL	-33	9	-3.686	0.000
Lagged Prize	PL	264,534	163,150	1.621	0.105
	σ	2,722,300	82,455	33.016	0.000

Note: XR = base response to convex pay, CR = incremental response to concave pay, BR = incremental response to bonus pay, XI = incremental response to insurance scenario, CI = incremental response to concave pay and insurance scenario, BI = incremental response to bonus pay and insurance scenario, σ = the estimated standard deviation of the regression. The p-value = the probability of observing a t variable at least as large as the absolute value of that observed.

strategy, $E(W_t|H1^*)$, is higher than salary earned in the previous trial; CL would be negative. The climate is unfavorable when CL is positive. If the salary earned in the previous trial becomes a psychological reference point, then an unfavorable investment climate may motivate a riskier choice, that is, $H1_t < H1_{t-1}$; a favorable climate may motivate $H1_t$ at least as big as $H1_{t-1}$. The null hypothesis is that H1 and CL are unrelated; the alternative is that they are inversely related.

The coefficient estimates in Table 2 allow a test of the weak hypotheses about the direction or rank ordering of the risk incentives of pay. The intercept, XR, representing convex pay under the reference scenario, is significantly negative. The coefficients of the concave and bonus pay treatments, CR and BR, are measured against XR. The coefficient for concave pay is significantly positive and that for bonus pay is negative, consistent with the model. The baseline response to the insurance scenario is captured by the coefficient of XI. It is significantly positive, consistent with previous studies showing that a label which is strongly associated with risk avoidance influences hedging in that direction.

The coefficient of the investment climate variable, CL, is significantly negative. This is consistent with the prediction of prospect theory that managers are more likely to take greater risks if expected pay is below some personal reference point. A similar result is obtained if salary earned during the previous period replaces the investment climate variable. While the coefficient of investment climate is statistically significant, it is arguably economically insignificant. Because it is not known what a relevant reference point is, or how often it is adjusted, investment climate was necessarily an arbitrary choice. The experiment gave participants no indication about the state of well-being that might be obtained from a particular level of pay; it offered no guidance as to what an appropriate frame of reference ought to be.[11] Its negative relationship with hedging is still provocative. Also, the hypothesis that a prize won on a previous trial is irrelevant cannot be rejected at significance levels below 10 percent.

Table 3 shows the results of Wald tests of linear restrictions on the regression coefficients. The first two hypotheses concern the risk incentives of pay under the insurance scenario. Just as XR is the baseline against which the effects of CR and BR are tested, XR + XI is the baseline against which the effects of CI and BI are tested. XI measures the insurance response and then, relative to that, CI and BI reveal the risk incentives of pay. We therefore test whether CI - XI and BI - XI are significantly different from zero. The Wald statistics show that CI - XI is significantly positive and BI - XI is significantly negative, consistent with the hedging and reverse-hedging incentives of concave and bonus pay functions.

We can ask which pay function produces the greatest risk incentive. Hypotheses 3 and 4 in Table 3 compare the absolute sizes of the pay effect in the reference and insurance scenarios. One might surmise that the bonus pay function provides a more transparent relationship between pay and firm value, and therefore might induce the stronger risk effect. There is, however, no significant difference between the two under the reference scenario, and, for the insurance scenario, we cannot conclude a difference at significance levels better than 8 percent.

For completeness, the table also reports results of tests of the predicted sizes of the coefficients (hypotheses 5 to 8). The sum of the intercept and the coefficients for concave and bonus pay should be 5,000,000 and -5,000,000. These are rejected by a wide margin.

The last five hypotheses in Table 3 concern participants' responses to the insurance scenario. As shown in Table 2, the baseline response to the insurance scenario was significantly positive. The insurance response under concave pay (CI - CR) is insignificant (hypothesis 9), while that under bonus pay (BI - BR) is significantly positive (hypothesis 10). Hypotheses 11 to 13 are statements about the relative size of the insurance effect across pay treatments. The insurance effect was greatest under convex pay (compare hypothesis 11 and hypothesis 9), *insignificantly less* so under bonus pay (hypothesis 12) and significantly less so under concave pay (hypothesis 13).

The influence of context is therefore greatest when there is no risk incentive (convex pay) and least when the risk incentive is to hedge anyway (concave pay). For bonus pay, there is still significant reverse-hedging under the insurance scenario but less so than under the reference scenario. In other words, when economic incentives and context are presumably mutually reinforcing

[11] Gordon, Paradis, and Rorke (1972), in contrast, created a strong reference point or context by their intentional use of non-neutral language in a portfolio choice experiment. Their game described a bankruptcy state called "dire straits." Subjects in that state switched from risk-averting to risk-seeking investment behavior in a way that is dramatically more in keeping with the prediction of prospect theory than the results obtained here.

Table 3
Tests of the Effects of Pay and Context on Managerial Hedging Decisions

	Coefficient	*Null Hypothesis*	*Wald Statistic*	*P-Value*
Risk Incentives of Pay in the Insurance Scenario				
1. CI-XI	939,600	0	19.357	0.000
2. BI-XI	-1,597,000	0	30.677	0.000
Differential Risk Incentives of Concave versus Bonus Pay				
3. |CR|-|BR|	366,500	0	0.272	0.602
4. |CI-XI|-|BI-XI|	-1,237,000	0	3.011	0.083
Strong Hypotheses about Risk Incentives of Pay				
5. CR+XR	699,200	5,000,000	184.237	0.000
6. BR+XR	-2,697,000	-5,000,000	133.578	0.000
7. CI+XR	704,300	5,000,000	405.235	0.000
8. BI+XR	-1,832,000	-5,000,000	113.616	0.000
Insurance Effects in Concave and Bonus Treatments				
9. CI-CR	5,090	0	0.000	0.989
10. BI-BR	865,100	0	6.987	0.008
Differential Insurance Effects Across Pay Treatments				
11. (CI-CR)-XI	-941,800	0	3.872	0.049
12. (BI-BR)-XI	-81,820	0	0.032	0.857
13. (BI-BR)-(CI-CR)	860,000	0	3.139	0.076

Note: This table presents the results of tests on linear combinations of the regression coefficients from Table 2. XR = base response to convex pay, CR = incremental response to concave pay, BR = incremental response to bonus pay, XI = incremental response to insurance scenario, CI = incremental response to concave pay and insurance scenario, BI = incremental response to bonus pay and insurance scenario.

(concave pay), context has no influence; when economic incentives and context are non-opposing or, more accurately, when there are no risk incentives (convex pay), then context effects are significant; when economic incentives and context are opposing (bonus pay), context effects are significant, but they do not reverse the risk-taking incentives of pay.

The Choice Process

Having found weak support for the managerial hedging model, and a role for context, it is interesting to look more closely at the decision-making process. Were choices dependent on past state outcomes despite the trials being independent? Did participants learn to make optimal choices during the course of the trials?

Despite being instructed a number of times that outcomes are random and independent, participants requested summary information about past trials an average of once per trial.[12] The examination of participants' requests for information and their switching choices is motivated by Kroll, Levy, and Rapoport (1988a, 1988b). The correlation between the number of trials during which each player made a request and experimental payoff is 0.098 ($p = 0.23$), and the correlation between the number of trials during which a request was made and the number of suboptimal choices (concave and bonus pay only) is 0.1308 ($p = 0.21$). Thus, the frequency of requesting useless information did not affect the optimality of the choices or the profitability of participating.

Players tended to switch from hedges to reverse-hedges and vice versa depending on the state outcome of the previous one or two trials. They switched 218 times, or on 32 percent of their chances to do so. Switching consistent with a negative recency effect (gambler's fallacy) was somewhat more frequent (34 percent) than with a positive recency effect (29 percent), and the former typically involved a change from a hedge to a reverse-hedge. Switching behavior does not lend itself to an easy interpretation here. It may reflect a risk perception bias referred to as the "law of small numbers" (Kahneman, Slovic, and Tversky, 1982), in which people expect the properties of large samples to be exhibited in small ones. It may just as easily reflect recent past pay or expected changes in pay (investment climate) having been adopted as a reference point.[13]

Did participants learn about the hypothesized relationships? In addition to being instructed and quizzed about the relevant relationships, they were permitted to experiment with different choices of H1 on any trial without actually committing themselves. Therefore, it would be surprising if many participants' series of H1s displayed trends to increasingly higher or lower values. One might expect early jumps to optimal H1 or at least H1 of predicted sign and subsequent choices that did not deviate much from those if the model were supported more strongly. The Tobit model was re-estimated with the six treatment variables for each of the three subperiods across all trials after the first. In every case, no significant upward trend for concave pay or downward trend for bonus pay in the magnitudes of the coefficients could be detected. An

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[12] Basic statistical concepts such as random sampling and independence elude many people, even highly trained researchers, and people will make order even out of randomness (see, for example, Kahneman, Slovic, and Tversky, 1982, and Fischhoff, 1982).

[13] The design of the experiment mitigated the possibility that boredom caused participants to search for distributional information, to switch their choices, or to otherwise adopt simple, mechanistic strategies for hedging. The game was self-paced, so players could work through it quickly if they were so inclined. The number of trials was small. Assuming that players grasped the mechanics of the experiment after at most two trials, there were only 12 choices left to be made. This compares very favorably with 33 paired choices required of subjects in a real money wager conducted by MacCrimmon and Wehrung (1986, p. 158), who consider that number small, and a maximum of 100 trials per session in Kroll, Levy, and Rapoport (1988b, p. 392). Another mitigating factor was that subjects actually won or lost money. They were not given a "bank balance" or prior stake, but were made $15 richer at the outset. They did not know the number of trials, and therefore did not know how much could be won or lost; the instructions stated only that *some* of the money might have to be repaid.

inspection of series of choices by individual players revealed that, of those whose choices suggested a pattern (22 out of 60), the majority were of the type where a jump was made to a "preferred" range of H1.

Overall, the pay functions considered here motivate risk taking in the predicted direction, albeit weakly. Only a handful of managers in this study made choices that were consistent with maximizing expected utility under concave and bonus pay. The majority of managers were inconsistent in the risks they took, often flipping between hedges and reverse-hedges and seldom taking the riskiest or riskless positions predicted. It appears that managers tend toward some intermediate range of risk and that they attempt to adjust risks to meet the perceived needs of their circumstances. One result that stands out in the experimental literature on risk taking in psychology (e.g., see Libby and Fishburn, 1977, and Payne, 1973) and in business (e.g., Greer, 1974) is that the perception of risk and, consequently, the behavior incited by that perception is most strongly related to the failure to obtain a reference level of return in dollars or percent. This may have been at play here. Although this study was not designed to assess whether a model grounded in frames of reference describes risky choice more accurately than expected utility theory, that is certainly a possibility for further work. Both Frank (1989) and Gordon (1980) make cogent arguments for models that treat utility as being attuned to changes relative to some reference rather than to absolute levels.

One might question whether cognitive limitations prevented participants from learning the relationships among H1, W, and the lottery. In purely mechanical terms, the optimal hedge was simply that H1 which maximized the sum of the shaded areas on the two prize clocks (Figure 4). This could be discovered with a bit of trial and error at no cost (other than time). Or could it? If cognitive complexity causes expected utility theory to fail here, then we might expect the same in the field, where managers' decisions are far more complex, and feedback is sporadic and noisy.

One might also ask whether the responses obtained are a result of a failure of the lottery mechanism to induce logarithmic utility. The lottery had to be both understood and salient, and several steps were taken to ensure that it was.[14] Walker, Smith, and Cox (1990) report evidence that casts a shadow on the lottery mechanism's reliability. Ideally, one would want to run additional experimental sessions without the lottery in an attempt to gauge its effect, keeping in mind that a failure of expected utility theory and a failure of the lottery mechanism will be difficult to sort out.[15]

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[14] Subjects were provided with written and on-screen instructions about the lottery; they were allowed to ask questions at any time; they were provided with pictures of a generic prize clock and possible prize clocks for a hypothetical choice of H1; they were quizzed about the way the lottery works; and, most importantly, they were required to view possible prize clocks before committing to their choice.

[15] It should be emphasized that the lottery operated across *every* treatment, that is, across pay types and scenarios, so that it is difficult to interpret the main findings as somehow being a result of a confounding influence of the lottery.

Conclusion

Some firms hedge some risks but not others. Some appear not to hedge at all. Hedging instruments are being used increasingly, with the volume of futures contracts having grown from thousands to millions over the past decade and notional swap principal having grown from a few billion dollars to hundreds of billions of dollars in an even shorter time. The results of this study are consistent with the observation of differential hedging of unsystematic risks by firms. Reliance by some firms on compensation plans to create desired managerial risk incentives discourages or encourages hedging. The effect of different pay schemes on the distribution of hedging choices over time for a "firm" of managers has the expected rank ordering. Concave pay functions motivate hedging, and appropriately specified bonus pay functions motivate reverse-hedging on average.

Individual hedging behavior is inconsistent and susceptible to framing or contextual effects, however. Expected utility theory makes precise predictions about the optimal hedges here, and the discrepancies between these and the observed responses are large. Managers might change hedges too often and for no apparent economic reason. This fickleness may be consistent with the enormous volume of futures trading and currency exchange. Furthermore, the labeling of an activity as "insuring" motivates risk avoidance tendencies, which may reinforce or oppose the risk-taking incentive of compensation.

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