Integrated Risk Management Decision-Making: A Worker's Compensation Loss Exposure Case Study

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ABSTRACT

This paper shows how Sharpe's measure and some financial constraints can be used to choose the best combination of risk management tools to handle a workers' compensation loss exposure. Because the sample firm data were too limited to estimate with confidence the mean of the Poisson probability distribution used in the analysis, the results were subjected to a sensitivity analysis. For the sample firm excess insurance, together with the optimum loss control efforts, was the best combination, the ex-medical plan combined with optimum loss control being a viable alternative.

I. Objective and Decision-Making Criteria

The objective of this paper is to present a method for determining the optimum allocation of the workers' compensation risk management budget among all applicable risk management techniques. Financial theorists assert that a firm's manager should choose the project with the highest net present value among mutually exclusive projects. In this context, he or she should seek the combination of risk management tools with the greatest contribution to the firm's value. However, using net present value as a decision-making criterion is justified if and only if appropriate discount rates are measurable under different combinations of risk management tools. Unfortunately, however, the only measurable discount rate is the one that exists under the combination of risk management tools currently being employed. In this paper the performance measure suggested by Sharpe [20] and some financial ratios are used as a substitute for these discount rates. Sharpe's measure considers not only the expected return on investment assets but also the degree of risk involved with that return. However, the net present value criterion takes into consideration more than the mean and standard deviation of the return. Additional factors considered include the capital-structure decision, the dividend decision, and earnings per share. Therefore, some financial ratios are used to supplement Sharpe's measure.

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Sharpe's measure is calculated by the following formula:

$$\frac{r - i}{STD(r)}$$

where r is the expected rate of return,
i is the risk-free rate of interest, and
STD(r) is the standard deviation of the rate of return.

The decision rule used in this paper is that, subject to certain financial constraints to be presented below, the combination of risk management tools with the highest Sharpe's measure for the next year is the best one. To determine Sharpe's measure, the mean and variance of a firm's cash flow after considering preloss and postloss risk management costs (this cash flow variable, hereafter, is referred to as the postloss cash flow) must first be computed.[1] The expected postloss cash flow rates of return and the standard deviation are computed as follows:

$$r = \frac{E(\widetilde{CF}_A)}{TA}$$

$$STD(r) = \frac{STD(\widetilde{CF}_A)}{TA}$$

where $E(\widetilde{CF}_A)$ is the expected postloss cash flow,
TA is the total assets of the firm, and
$STD(\widetilde{CF}_A)$ is the standard deviation of the postloss cash flow.

Financial constraints also must be considered in allocating the risk management budget. Backer and Gosman [1] argued that financial managers often set target financial ratios, which they believe would maximize the firm's value, given the mean and variance of the postloss cash flow. Acceptable standards for these financial constraints are difficult to determine. Thus the risk manager of the sample firm selected for this study was asked to make decisions regarding the optimum allocation of the risk management budget on the basis of both Sharpe's measure and financial ratios, if the probabilities of unfavorable financial ratios were considerably different, depending upon the combination of risk management tools. The financial ratios considered in the decision-making process are as follows:

A. *Debt Financing*

Elements to consider in determining the constraints on debt financing include long-term debt, minimum dividends, current liabilities, and postloss cash flows (minimum dividends may be paid out of the combination of postloss cash flows, long-term debt, and current liabilities).

Long-Term Debt: Unfavorable postloss cash flows upon the occurrence of losses may be restored by borrowing money. However, because the use of

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[1] The preloss risk management cost is defined as before-the-loss expenditures (e.g., insurance premiums, loss control expenditures, and so on) to deal with a loss exposure. The postloss risk management cost is defined as after-the-loss expenditures (cash flow, postloss lines of credit, and trade credit may be used to offset accidental losses).

debt beyond its optimum increases the cost of debt due to the increased danger of bankruptcy, it reduces the stock price of the firm [24]. Thus the use of debt must be considered as a possible solution to offset losses only in such a way that the debt/equity ratio remains close to the optimum target ratio.

Minimum Dividends: In determining the amount of debt financing that might be used to offset workers' compensation losses, minimum dividends payable to the firm's shareholders should be considered. Financial resources from postloss cash flows and debt financing should be equal to or above the minimum dividends. The requirement for the maximization of a firm's value is that dividends per share be stable over time (see Joy [9], Van Horne [25], and Solomon and Pringle [22]). However, the eroding effect of inflation should be offset by a stable increase in dividends over time (see Joy [9]).

Current Liabilities: When severe losses occur, the postloss cash flow may fall below zero. Severe losses resulting in negative postloss cash flows may be offset by selling current assets, or increasing current liabilities. Thus an analysis of liquidity ratios is necessary. Current and acid-test ratios equal to or above their targets imply that a firm's liquidity is sufficient to keep its value. Forced sale of current assets usually results in a shrinkage of the firm's assets. However, possible sources of current liabilities that can be used to offset losses are commercial bank lines of credit and trade credit. The maximum amount of additional current liabilities to offset workers' compensation losses is

$$\left(\frac{CR - CR^*}{CR^*}\right)(CL)$$

where CR is the present current ratios of the firm,
CR^* is the target current ratio, and
CL is the present current liabilities of the firm.

Similarly, the additional financing through current liabilities to offset workers' compensation losses is limited to

$$\left(\frac{ATR - ATR^*}{ATR^*}\right)(CL)$$

where ATR is the present acid test ratio of the firm, and
ATR^* is the target acid test ratio.

Combining the minimum dividend constraint with debt financing through the maximum long-term debt and current liabilities produces the following statements of the minimum postloss cash flow:

$$\text{Min.}\tilde{CF}_A \geq (DPS^*)(N) - (D^* - D) - \text{Min.}\left[\left(\frac{CR-CR^*}{CR^*}\right)(CL), \quad \left(\frac{ATR - ATR^*}{ATR^*}\right)(CL)\right]$$

where DPS^* is the minimum dividend per share,
N is the number of shares outstanding,
D^* is the maximum acceptable amount of debt for the firm, and
D is the current level of debt.

The model determines the probabilities that the postloss cash flow is less than this minimum requirement for each of the combinations of applicable risk management tools.

B. *Dividend Payout Ratio and Dividend Per Share*

In the long-run, because dividends are adjusted to changes in earnings, a firm's earnings are the most important element affecting dividend levels. Thus corporations have target dividend payout ratios. In order to maintain the firm's value, $q \geqslant q^*$

where q^* is the target payout ratio, and
q is the dividend payout ratio.

The dividend payout ratio, q, is calculated by $\frac{DPS}{EPS}$,

where DPS is the dividend per share, and
EPS is the earnings per share.

To maintain minimum DPS, $DPS \geqslant DPS^*$

The model determines for each combination of risk management tools not only the probability that q is below q^*, but also the probability that the DPS falls below DPS^*.

C. *Earnings Per Share*

Many corporations set target growth rates of EPS because growth may be one of the major concerns of financial management. Thus the expected postloss cash flow should be above a given level in order to guarantee the minimum growth of EPS (see Spraakman [23]). The model calculates the expected values of EPS for each combination of applicable risk management devices.

II. Effect of Loss Control on the Aggregate Loss Amounts

A rule of thumb used by corporations in determining the size of their risk management budgets is that about two percent of sales is a sufficient amount to deal with all loss exposures (Geisel [4]). The sample company selected for this study allocated about $400,000 among all applicable risk management tools available to deal with its workers' compensation loss exposure.

Heinrich [6] contended that the hidden or indirect costs of industrial accidents were four times as much as the direct costs. The risk manager of the sample firm estimated that the four to one ratio is a good approximation for the indirect costs of industrial accidents of his firm. If he is correct, every one dollar of a workers' compensation loss will reduce the postloss cash flow by $5, i.e., $4 in indirect cost and $1 in direct cost.

Losses may be controlled by reducing the expected number of losses per year, by reducing the expected size of loss amounts, or by reducing both. According to Manuele [13], an accurate evaluation system has not been developed to help measure the effectiveness of loss control programs. This paper develops a useful methodology for estimating the effect of loss control on the expected aggregate loss amount.

Levitt [11] has argued that loss control expenditures reduce the number of accidents during a period at a decreasing rate. If he is correct, the relationship between loss control expenditures and the average number of losses during a period may be log-linear. Thus

$$\ln Y = b \ln X + \ln a$$

where Y is the expected number of losses during a year,
X is the annual frequency reduction expenditures, and
a and b are the parameters to be estimated.

For the number of accidents to drop at a decreasing rate due to loss control expenditures, some constraints should be imposed on the equation. These constraints are $b < 0$, $Y > 0$, and $X > 0$.

Rinefort [19] has indicated that meeting OSHA requirements could reduce the average number of losses by 18 percent. The risk manager of the sample firm informed the author that the annual expenditure required to meet the OSHA requirements was about $55,000. This $55,000 annual loss control expenditure had reduced the expected number of losses to 100 claims a year. Therefore, the expected number without loss control expenses would be 100 losses ÷ (100 percent − 18 percent) or 122 losses.

Piniat [16] has pointed out that a two-hour comprehensive safety training session costs $10,000 in consultant fees plus the lost wages of employees. At the end of 1980 the sample company had about 1,800 full-time employees. The average hourly earnings per worker were $7.27. The cost of a comprehensive safety program for the firm, therefore, would be $10,000 + ($7.27 × 2 × 1,800) = $36,172.

McKenna and Hale [14] have indicated that a four-hour emergency first aid training program in addition to the comprehensive safety training session would reduce the average number of losses to some extent. The cost of an emergency first aid training program for the firm, therefore, would be $7.27 × 4 × 1,800 = $52,344.

Heinrich [6] argued that an intensive safety program could reduce the average number of industrial accidents by 90 percent. Assuming that the comprehensive safety education together with the emergency first aid training every six months would reduce the number of losses by 90 percent, the total cost would be $232,032 a year, i.e., $55,000 + 2 × $36,172 + 2 × $52,344. Thus, if Heinrich is correct, an annual loss control expenditure of $232,032 would reduce the average number of losses to 122 × (100 percent − 90 percent) or 12 claims a year. Figure 1 shows the relationship between the annual loss control expenditures and expected number of losses during a year. Parameters of the log-linear relationship between these two variables were computed as follows:

$$\ln 100 = b \ln 55{,}000 + \ln a$$
$$\ln 12 = b \ln 232{,}032 + \ln a$$

Therefore, $a = 950{,}030{,}000$, and
$b = -1.472$.

Figure 1

Cost Effectiveness of Loss Control Efforts
(Frequency Reduction)

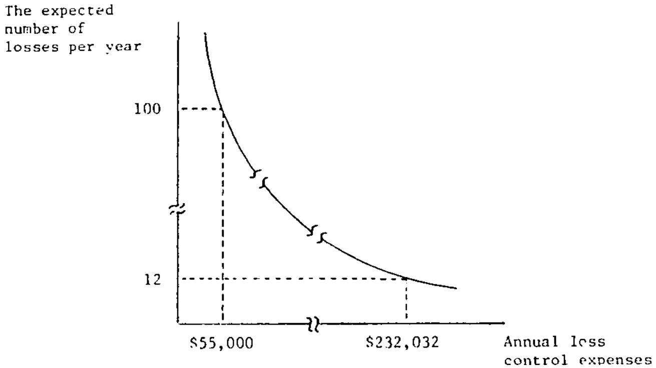
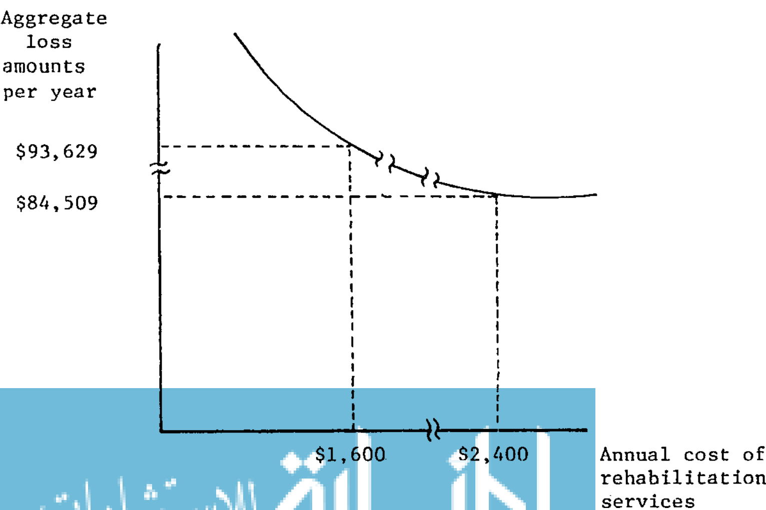


Figure 2

Cost Effectiveness of Loss Control Efforts
(Severity Reduction)



Nine possible levels of annual frequency reduction expenditures were assumed in this study: $55,000, $75,000, $95,000, $115,000, $135,000, $155,000, $175,000, $195,000, and $215,000.

Richbourg [18] has pointed out that many insurers provided rehabilitation service to injured workers to help reduce workers' compensation claims payments. Employers buying insurance may desire to reduce the average size of loss amounts through these services because severity reduction efforts would reduce current or future insurance premiums. Self-insurers also use rehabilitation services to help reduce postloss risk management costs. Richbourg [18] indicated that these services might reduce loss amounts up to about 50 percent, and that a dollar spent for these services reduced loss amounts up to $17 in long-term disability cases and $11.40 in other cases. The cost of these services range from $300 to $3,000 per case with the average cost about $800 per case.[2]

The expected annual aggregate workers' compensation loss amount of the sample firm adjusted for inflation and loss adjustment expenses was $120,829. Thus rehabilitation services for two long-term disability cases at an average cost of $800 each could reduce the aggregate losses by $27,200, i.e., 2 x $17 x $800. The new loss level then would be $93,629, i.e., $120,829 - $27,200. Applying these services to one short-term disability case at a cost of $800 could reduce the aggregate loss amount by another $9,120, i.e., $800×$11.40. The new loss level then would become $84,509, i.e., $93,629 - $9,120.[3]

Figure 2 shows the relationship between the annual cost of rehabilitation services and annual aggregate loss amounts, assuming that the relationship is log-linear. The parameters of the relationship are estimated as follows:

$$\ln 93{,}629 = d \ln 1{,}600 + \ln c$$
$$\ln 84{,}509 = d \ln 2{,}400 + \ln c$$

Therefore, $c = 600{,}789$, and
$d = .252$.

Five possible levels of severity reduction expenditures were assumed: $800, $1,600, $2,400, $3,200, and $4,000.

III. Postloss Cash Flows Under Various Combinations of Risk Management Tools

The model developed to compute postloss cash flows for all combinations

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[2] Telephone conversation with an offical, in early June, 1981, of the Department of International Rehabilitation, Insurance Company of North America, 1600 Arch Street, Philadelphia, PA 19101.

[3] An investigation of the loss records of the firm reveals that on average two cases are eligible for long-term rehabilitation services per year. This paper chose one short-term disability case since any possible pick yields the same result, assuming the log-linear relationship.

of risk management tools for the workers' compensation loss exposure is discussed here.

A. *Risk Avoidance*

The avoidance of an investment is appropriate if the expected postloss cash flow under the best combination of risk management tools is negative, because investments in such business are not worthwhile.

B. *Complete Risk Retention With Loss Control*

$$\widetilde{CF}_A(CR) = \widetilde{CF}_B - FR(1-T) - SR(1-T) - \sum_{i=1}^{n} \widetilde{L}_i(1-T) - 4 \sum_{i=1}^{n} \widetilde{L}_i(1-T)$$

where $\widetilde{CF}_A(CR)$ is the postloss cash flow under complete risk retention together with loss control,

$\widetilde{CF}_B$ is the preloss cash flow,

FR and SR are frequency and severity reduction expenditures, respectively,

n is the number of losses per year,

T is the marginal corporate tax rate,

$\widetilde{L}_i$ is the i'th loss amount, and

$4 \sum_{i=1}^{n} \widetilde{L}_i(1-T)$ is the after-tax hidden costs of industrial accidents.

Preloss risk management costs such as FR and SR are subject to the maximum workers' compensation risk management budget constraint ($400,000 for the sample company).

Irving Finston, an independent practitoner engaged in risk management, informed the author that handling workers' compensation claims under complete risk retention or self-insurance takes about 30 minutes per claim. The expected value of this cost is ½ x the average hourly salary of a worker x the expected number of losses a year or ½ x $7.27 x 100 losses = $363.50 per year. Because net income and depreciation collected from the sample company's annual report are rounded to the nearest thousand dollars, this cost falls within the error range of the preloss cash flow, and is, therefore, excluded from the study.

C. *Stop-loss Aggregate Insurance With Loss Control*

Under stop-loss aggregate insurance, the aggregate loss amount in excess of the stop-loss limit chosen is paid by the insurer, and the employer absorbs the rest of the aggregate loss amount. The postloss cash flow under stop-loss aggregate insurance is computed as follows:

$$\widetilde{CF}_A(STOP) = \widetilde{CF}_B - FR(1-T) - SR(1-T) - SPR(1-T)$$
$$- \sum_{i=1}^{n} \widetilde{L}_i(1-T) - 4 \sum_{i=1}^{n} \widetilde{L}_i(1-T)$$

$$\text{if} \quad \sum_{i=1}^{n} \tilde{L}_i \leq LMT$$

$$= \tilde{CF}_B - FR(1-T) - SR(1-T) - SPR(1-T) - LMT(1-T)$$

$$- 4 \sum_{i=1}^{n} \tilde{L}_i (1-T)$$

$$\text{if} \quad \sum_{i=1}^{n} \tilde{L}_i > LMT$$

where $\tilde{CF}_A$ (STOP) is the postloss cash flow under stop-loss aggregate insurance together with loss control,

SPR is the premium for the stop-loss aggregate insurance, and

LMT is the stop-loss limit.

D. *Specific Excess Insurance With Loss Control*

Under specific excess insurance, the insurer pays each loss amount in excess of the specific excess limit, and the employer retains the rest. The postloss cash flow under specific excess insurance is computed as follows:

$$\tilde{CF}_A(SPEX) = \tilde{CF}_B - FR(1-T) - SR(1-T) - SEPR(1-T) - A - B$$

$$\text{where } A = \sum_{i=1}^{\ell} SELMT(1-T) + 4 \sum_{i=1}^{\ell} \tilde{L}_i (1-T) \text{ if } \tilde{L}_i\text{'s} > SELMT,$$

$$B = \sum_{i=1}^{n-\ell} \tilde{L}_i (1-T) + 4 \sum_{i=1}^{n-\ell} \tilde{L}_i (1-T) \text{ if } \tilde{L}_i\text{'s} \leq SLEMT,$$

where $\tilde{CF}_A$(SPEX) is the postloss cash flow under specific excess insurance together with loss control,

SELMT is the specific excess limit, and

SEPR is the premium for the specific excess insurance.

E. *Cost Stabilization Plan With Loss Control*

A cost stabilization plan uses the insurance mechanism to reduce fluctuations of the cost of handling the workers' compensation loss exposure. The stabilized premium is the moving average of the claims during the most recent ten-year period plus the loading for the insurer profit.

$$\tilde{CF}_A(MED) = \tilde{CF}_B - FR(1-T) - SR(1-T) - MPR(1-T) - \sum_{i=1}^{n} \tilde{ML}_i (1-T)$$

$$- 4 \sum_{i=1}^{n} \tilde{L}_i (1-T)$$

where $\tilde{CF}_A$(CSP) is the postloss cash flow under a cost stabilization plan together with loss control,

m is the number of years selected to stabilize the cost, and
Y is the loading for the insurer.

$\left(\frac{\sum_{j=1}^{m} \sum_{i=1}^{n} \tilde{L}_{ij}}{m}\right)$ (1+Y) is the before-tax premium payable to the insurer under the cost stabilization plan.

F. *Ex-Medical Plan With Loss Control*

The medical coverage of workers' compensation insurance policies may be excluded by endorsement. Unless the insured is a hospital, however, the employer must obtain authorization for such coverage from the rating bureau having jurisdiction. The class rate for an ex-medical plan is the class rate for full coverage of the exposure minus 70 percent of the medical rate. The exclusion of the medical coverage does not eliminate the medical rate completely because 1) the insurer is obligated to pay medical expenses if the employer becomes bankrupt and 2) insurers may provide rehabilitation services to injured workers to help speed their recovery and return to work, thus reducing the insurers' obligations.

$$\tilde{CF}_A(MED) = \tilde{CF}_B - FR(1-T) - SR(1-T) - MPR(1-T) - \sum_{i=1}^{n} \tilde{ML}_i(1-T) - 4 \sum_{i=1}^{n} \tilde{L}_i(1-T)$$

where $\tilde{CF}_A$(MED) is the postloss cash flow under an ex-medical plan together with loss control,
MPR is the premium for the ex-medical plan, and
$\tilde{ML}_i$ is the loss amount of the i'th medical case.

G. *Prospective Experience Rating Plan With Loss Control*

$$\tilde{CF}_A(PROS) = \tilde{CF}_B - FR(1-T) - SR(1-T) - PROS(1-T) - 4 \sum_{i=1}^{n} \tilde{L}_i(1-T) + ASC(1-T)$$

where $\tilde{CF}_A$(PROS) is the postloss cash flow under the prospective experience rating plan together with loss control,
PROS is the prospective experience insurance premium, and
ASC is the insurer administrative services cost.

Insurance premiums for retrospective and prospective experience rating plans include the cost of administrative services, e.g., loss analysis, hazard analysis, loss control services, and loss record-keeping services. The cost of these administrative services must be added back in determining postloss cash flows under these plans because the minimum frequency reduction expenses to meet OSHA requirements ($55,000 for the sample firm) include this component regardless of different combinations of risk management tools.

H. *Retrospective Experience Rating Plan With Loss Control*

$$\widetilde{CF}_A(\text{RETRO}) = \widetilde{CF}_B - FR(1-T) - SR(1-T) - RTRPR(1-T) - 4\sum_{i=1}^{n} \widetilde{L}_i(1-T) + ASC(1-T)$$

where $\widetilde{CF}_A$(RETRO) is the postloss cash flow under the retrospective experience rating plan together with loss control, and

RTRPR is the retrospective experience insurance premium reflecting the current loss experience of the employer.

IV. The Data

To determine the best combination of risk management tools for the sample company the author collected the following data: 1) balance sheets and income statements on an annual basis from 1973 to 1980, 2) annual aggregate workers' compensation loss amounts from 1973 to 1980, 3) the amount of each loss and the number of losses per year from 1978 to 1980, and 4) current insurance premiums for the company for all risk management tools using insurance, such as stop-loss aggregate insurance, specific excess insurance, the cost stabilization plan, the ex-medical plan, and the prospective and retrospective experience rating plans.

Preloss cash flows were adjusted for inflation. The best indexes for this adjustment are gross national product deflators. The three components of the gross national product deflators are business nonfarm, farm, and government. The business nonfarm gross national product deflators were used in this study to adjust the preloss cash flow of the sample firm because the company falls in this category. Loss amounts were adjusted for inflation and loss adjustment expenses. Workers' compensation claims may be classified into payments for loss of income and indemnity for medical expenses. Payments for loss of income were adjusted for inflation by the index of average weekly earnings of manufacturing industries; medical expenses were adjusted by the consumer price index of medical care expenses. According to Kallop [10], loss adjustment expenses are about 12.5 percent of loss amounts. So this percentage was used to adjust upward the loss amounts.

V. Experimental Design

In an experimental design, independent variables are called factors, and the dependent variable the response. The response for this study is the postloss cash flow under each combination of risk management devices. Factors are the preloss cash flow, preloss risk management costs, and postloss risk management costs. These factors can be subdivided into five mutually exclusive groups; (1) preloss cash flow, (2) frequency reduction expenditures, (3) severity reduction expenditures, (4) preloss risk management costs other than loss control expenses such as SPR(1-T), SEPR(1-T),

$\frac{\sum_{j=1}^{m} \sum_{i=1}^{n} \tilde{L}_{ij}}{m}$ (1+Y) (1-T), MPR(1-T), PROS(1-T), and RTRPR(1-T), and

(5) post-loss risk management costs such as $\sum_{i=1}^{n} \tilde{L}_i(1-T) + 4 \sum_{i=1}^{n} \tilde{L}_i(1-T)$,

$LMT(1-T) + 4 \sum_{i=1}^{n} \tilde{L}_i(1-T)$, $\sum_{i=1}^{1} SELMT(1-T) + 4 \sum_{i=1}^{1} \tilde{L}_i(1-T)$, $4 \sum_{i=1}^{n} \tilde{L}_i(1-T)$, and

$\sum_{i=1}^{n} \tilde{ML}_j(1-T) + 4 \sum_{i=1}^{n} \tilde{L}_i(1-T)$.

Appropriate combinations of factors can be selected among these five mutually exclusive factor groups.

Because Naylor, Balintfy, Burdick, and Chu [15] have pointed out that the normal distribution is a good approximation for earnings of a firm, the normal distribution was selected to estimate the preloss cash flow. The mean and variance of the adjusted preloss cash flow data were used as parameters in estimating this variable.

Greene [5], Longley-Cook [12], Cummins and Freifelder [2], and Hewitt [7] have argued that the Poisson distribution is a good approximation of the probability distribution of the number of losses when multiple losses can occur in a given period. Because the sample firm could incur multiple losses, the Poisson distribution was used in the study, the mean being the observed mean of 100.

Rennie [17] and Shpilberg [21] have argued that loss amounts are log-normally distributed. On the other hand, Cummins and Freifelder [2] rejected the log-normal distribution as an approximation of the loss amount distribution. Dropkin [3] has also argued that this distribution was not a good approximation of workers' compensation loss amounts. Because the sample company experienced 393 workers' compensation losses during the last three years (from 1978 to 1980), the sample size is sufficient for the empirical distribution (instead of a theoretical distribution) to be used to estimate the size of a loss.

To compute Sharpe's measures for all combinations of risk management tools, the mean and variance of the postloss cash flow must be calculated for each combination of risk management tools. Postloss cash flows are determined by combining preloss cash flows and aggregate loss amounts.

The firm's ability to pay the combination of uninsured losses and minimum dividends out of the firm's financial resources under each combination can be measured by generating random numbers for the preloss cash flow, the number of losses during a year, and loss amounts. According to Cummins and Freifelder [2], considering the cost-benefit tradeoff, 1,000 iterations for the number of losses are enough to reduce random errors to an acceptable level. Consequently, the number of losses during a year and the preloss cash flow were estimated 1,000 times.

Because Hunter and Naylor [8] suggested that a fractional factorial design was useful when some of the combinations can be dropped without sacrificing the quality of a study considerably, this approach was used to select applicable combinations of factors.

VI. Empirical Results

A. *The Application of the Decision-Making Criteria*

For all combinations of risk management devices under the two optimum sets of loss control efforts, Table 1 shows (1) Sharpe's measures, (2) the probabilities of unfavorable financial ratios, and (3) the expected values of EPS. The "Preloss cost" column shows the preloss risk management costs for risk management tools other than frequency and severity reduction measures. Frequency and severity reduction expenditures are presented separately in the table. Sharpe's measures, shown in the "Sharpe's measure" column, were negative under all combinations, which implies that the expected rate of return on the total assets of the firm was less than the risk-free rate of interest. Negative Sharpe's measures occurred because the risk-free rate of interest increased sharply towards the end of 1980. This rate (on three-month treasury bills) increased to 13.61 percent at the end of 1980 from 9.15 percent at the end of the third quarter.[4]

The probabilities of unfavorable financial ratios are the number of simulated situations in which financial ratios deviate from targets in the undesirable directions divided by 1,000, the total number of simulated situations. Preloss cash flows that fall below the sum of the minimum dividends and the preloss and postloss risk management costs increase the probabilities shown in the "Debt," "DPR," and "DPS" columns under all combinations of risk management tools. Consequently these probabilities increased to some extent not because of risk management decision-making but because of low preloss cash flows.

Generally Sharpe's measures increase as the loss control expenditures increase, regardless of the combination of risk management devices used. As indicated earlier, nine ($55,000, $75,000, $95,000, $115,000, $135,000, $155,000, $175,000, $195,000, and $215,000) levels of frequency reduction expenses and five ($800, $1,600, $2,400, $3,200, and $4,000) levels of severity reduction expenses were examined to choose the optimum loss control expenses. On the basis of Sharpe's measures and financial constraints, the optimum loss control expenditures were $175,000 or $215,000 on frequency reduction, depending upon the other risk management tools used, and $4,000 on severity reduction.[5]

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[4] *Federal Reserve Bulletin*, Board of Governors of the Federal Reserve System, Washington, D.C., Volume 67 No. 5 (May 1981), p. A3.

[5] The optimum loss control expenditures were selected after examining Sharpe's measure and financial constraints for all combinations of risk management tools.

Table J

Sharpe's Measures and Financial Constraints

Criteria / Combinations	Preloss Cost	Sharpe's Measure	Probabilities of Unfavorable Financial Ratios			E(EPS)
			Debt	DPR	DPS	
Frequency reduction ($ 175,000) Severity reduction ($ 4,000)						
Complete risk retention	$ 0	-.9538	.034	.032	.203	$2.53
Stop-loss agg. insurance						
$500,000 limit	14,212	-.9561	.034	.032	.204	2.52
600,000 limit	5,579	-.9547	.034	.032	.204	2.52
700,000 limit	2,325	-.9542	.034	.032	.204	2.52
800,000 limit	884	-.9539	.034	.032	.204	2.52
900,000 limit	193	-.9538	.034	.032	.203	2.53
Specific excess insurance						
$ 50,000 limit	54,099	-.9616	.034	.032	.207	2.51
75,000 limit	41,501	-.9603	.034	.032	.205	2.52
100,000 limit	32,218	-.9589	.034	.032	.205	2.52
150,000 limit	21,378	-.9572	.034	.032	.204	2.52
200,000 limit	15,192	-.9562	.034	.032	.204	2.52
250,000 limit	11,433	-.9556	.034	.032	.204	2.52
Cost stab. plan	93,396	-.9640	.034	.033	.205	2.51
Ex-medical plan	33,338	-.9564	.034	.032	.203	2.52
Prospective rating plan	213,753	-.9744	.034	.034	.207	2.50
Retrospective rating plans						
Plan A	185,567	-.9699	.034	.033	.209	2.50
Plan B	130,493	-.9609	.034	.032	.205	2.52
Plan C	121,957	-.9594	.034	.032	.205	2.52
Plan J	171,327	-.9676	.034	.033	.208	2.51

Table 1 (continued)

Sharpe's Measures and Financial Constraints

Criteria / Combinations	Preloss Cost	Sharpe's Measure	Probabilities of Unfavorable Financial Ratios: DEBT	DPR	DPS	E(EPS)
Frequency reduction ($ 215,000) Severity reduction ($ 4,000)						
Complete risk retention	$ 0	-.9533	.034	.031	.206	$2.53
Stop-loss Agg. insurance						
$500,000 limit	14,212	-.9555	.034	.031	.206	2.52
600,000 limit	5,579	-.9542	.034	.031	.206	2.52
700,000 limit	2,325	-.9536	.034	.031	.206	2.53
800,000 limit	884	-.9534	.034	.031	.206	2.53
900,000 limit	193	-.9533	.034	.031	.206	2.53
Specific excess insurance						
$ 50,000 limit	54,099	-.9614	.034	.033	.206	2.51
75,000 limit	41,501	-.9598	.034	.032	.206	2.52
100,000 limit	32,218	-.9584	.034	.032	.206	2.52
150,000 limit	21,378	-.9567	.034	.031	.206	2.52
200,000 limit	15,192	-.9557	.034	.031	.206	2.52
250,000 limit	11,433	-.9551	.034	.031	.206	2.52
Cost stab. plan	93,396	-.9649	.034	.033	.206	2.51
Ex-medical plan	33,338	-.9566	.034	.032	.206	2.52
Prospective rating plan	213,753	N.A.	N.A.	N.A.	N.A.	N.A.
Retrospective rating plans						
Plan A	185,567	-.9699	.034	.034	.206	2.50
Plan B	130,493	-.9604	.034	.032	.206	2.52
Plan C	121,957	-.9586	.034	.032	.206	2.52
Plan J	171,327	-.9676	.034	.033	.206	2.51

The "Debt" column shows the probabilities that the preloss and postloss risk management costs will exceed the preloss cash flows minus the minimum dividends payable to shareholders. These probabilities remained stable, ranging from .034 to .057, because the combination of annual aggregate loss amounts, preloss risk management costs, and minimum dividends did not have a substantial impact on annual preloss cash flow. Usually, the probabilities of "Debt" decrease as the loss control expenditures increase. The probabilities of "Debt" under the optimum loss control efforts were .034 for all combinations.

The "DPR" column shows the probabilities that the dividend payout ratio will fall below the target dividend payout ratio. These probabilities ranged from .031 to .047. Generally these probabilites decreased as the frequency reduction expenditures increased and reached the minimum when these expenditures were $135,000. Similarly they decreased as severity reduction expenditures increased. When the frequency reduction expenditures were $135,000 and the severity reduction expenditures $4,000, the probabilites were .031 for all combinations except for prospective and retrospective experience rating plans. The "DPS" column shows the probabilities that the dividend per share will fall below the target dividend per share. These probabilities ranged from .203 to .258. Usually they decreased with the increase in the loss control expenses. At the optimum loss control efforts these probabilities were between .203 and .209.

The "E(EPS)" column shows expected earnings per share for all combinations which ranged from $2.29 to $2.53. The expected value of EPS increased with loss control expenditures. Under the optimum loss control efforts these expected values ranged from $2.50 to $2.53.

B. *The Best Combination of Risk Management Devices*

For the sample firm the optimum annual frequency reduction expenditure was $175,000 or $215,000, depending upon risk management tools, and the optimum annual severity reduction expenditure $4,000. Thus the expected number of losses under the optimum frequency reduction effort was 18 or 13 claims per year, and the average percentage reduction in the aggregate loss amount due to the optimum severity reduction efforts 38.5 percent.

Due to the intensive loss control efforts under optimum loss control, the probabilities of unfavorable financial ratios were similar for all combinations. Thus the combination of risk management devices with the highest Sharpe's measure would normally be selected as the best combination. In this case, Sharpe's measures under different combinations of risk management tools were also similar but, because the firm's total assets were rather large, these similar measures were associated with substantial differences in terms of cash flows. For example, when $175,000 and $4,000 were spent on frequency reduction and severity reduction, respectively, Sharpe's measures under a $900,000 limit stop-loss aggregate insurance and retrospective experience rating plan A were -.9538 and -.9699, respectively. Sharpe's measure,

$\frac{r-1}{STD(r)}$, can be rewritten as $\frac{E(\widetilde{CF}_A) - TA \times 1}{STD(\widetilde{CF}_A)}$. Because the firm's total assets were worth $10 million, a difference of .0161 in Sharpe's measures would result in a $161,000 difference in terms of cash flows. This $161,000 difference is substantial considering the $400,000 total risk management budget of the firm.

Complete risk retention happened to have the highest Sharpe's measure (-.9533) because widely varying loss experiences under complete risk retention did not have substantial impacts on preloss cash flows (this conclusion is not generalizable since Sharpe's measure considers not only $E(\widetilde{CF})$ but also $VAR(\widetilde{CF})$). Stop-loss aggregate insurance was more attractive as the stop-loss limit increased (from -.9555 for a $500,000 limit to -.9533 for a $900,000 limit). Specific excess insurance rated higher when the specific excess limit increased (from -.9614 for a $50,000 limit to -.9551 for a $250,000 limit). The ex-medical plan (-.9564) was less appealing than stop-loss aggregate insurance, but more so than specific excess insurance with low specific excess limits (up to $150,000). The other risk management tools (a cost stabilization plan, and prospective and retrospective experience rating plans) were the least attractive.

Many states do not allow the use of complete risk retention in dealing with the workers' compensation loss exposure. Instead, self-insurers are required to buy excess insurance to transfer catastrophic losses to insurers. Thus self-insurance with a high stop-loss limit together with the optimum loss control was the best combination of risk management tools for the sample company. Self-insurance with a high specific excess limit or the ex-medical plan combined with the optimum loss control were viable alternatives.

C. *Sensitivity Analysis*

The sample firm incurred 100 claims on the average over the last eight years (from 1973 to 1980). Because this sample size is not large enough to place too much confidence in the Poisson distribution used in the analysis, the author performed a sensitivity analysis. The following expected number were used: 33.3, 50, 100, 200, and 300 claims per year. The optimum frequency reduction expenditures increased with the expected number of losses. These optimum expenditures for 33.3, 50, 100, 200, and 300 average claims per year were $115,000, $155,000, $175,000, $215,000, and $215,000, respectively. The optimum severity reduction expenses were $4,000 regardless of the expected number of losses per year.

Attractive risk management tools combined with the optimum loss control efforts remained attractive, regardless of the expected number of losses except for the ex-medical plan. This plan was attractive when the expected number is 100, 200, and 300 claims per year, but becomes unattractive when the average number of losses is 33.3 or 50 claims per year. The reason is that when the average payments for loss of income is substansially less than the present level (about 50 percent), the cost of the ex-medical plan is more expensive than the average value of these claims. However, if the expected payments for loss of income is considerably higher (more than 100 claims per year), the ex-medical plan became attractive in dealing with the workers' compensation loss exposure.

Complete risk retention had the highest Sharpe's measure for all levels of the average number except for 300 losses per year. Due to the legal constraints prohibiting the use of complete risk retention for the workers' compensation loss exposure, stop-loss aggregate insurance and specific excess insurance with a high limit ($250,000) combined with the optimum loss control were the most attractive, regardless of the average number of losses per year.

D. *Limitations of the Model*

Workers' compensation insurance premiums fluctuate from year to year depending upon the loss experience of the insurance industry, benefit level changes due to law amendments, and so on. Also the loss experience of a particular company affects current or future insurance premiums. So in one year, buying insurance on a prospective experience rating plan may be attractive; in another year self-insurance may be attractive. Because risk management decision-making should be reviewed periodically, a single-period static model has been used in this study.

Loss control expenditures are expected to reduce the aggregate loss amounts. One of the problems of a static model is that the effect of loss control efforts on future insurance premiums cannot be incorporated in the model. A dynamic model would not have this problem but it is not consistent with the need for a periodic review of risk management decisions. Future research should be directed toward developing both static and dynamic models.

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