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I. INTRODUCTION

Ownership and control of most large firms are generally separate functions with many directors or managers (acting as agents) making the financial decisions for the owners (the stockholders).[1] Since social costs may arise from this separation of ownership and control, devising a contract which minimizes these potential social costs is important.[2] George Dent, in an article which seeks to rejuvenate the debate over the separation of ownership and control, points out that "[m]ost observers . . . concede that the separation of ownership and control leads to economic inefficiency and mistreatment of shareholders."[3] For exam-

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1. For more details of the ownership and management of the firm, see WILLIAM J. BAUMOL, BUSINESS BEHAVIOR, VALUES AND GROWTH 27-32 (1959) and Michael C. Jensen & William H. Meckling, *Theory of the Firm: Managerial Behavior, Agency Costs and Ownership Structure*, 3 J. FIN. ECON. 305 (1976).

2. *See* Victor Brudney, *Corporate Governance Agency Costs and the Rhetoric of Contract*, 85 COLUM. L. REV. 1403-1444 (1985) (in particular the discussion of the principal-agent relationship beginning on page 1427).

3. *See* George W. Dent, Jr., *Toward Unifying Ownership and Control in the Public Corporation*, 1989 WIS. L. REV. 881 (1989).

ple, when directors incorrectly reject a profitable project the loss of wealth to the economy is called social costs (or equivalently agency costs). Similarly, if directors decide to undertake a project characterized by the creation of negative net wealth, social costs are incurred.[4]

This article analyzes possible social costs under alternative widespread compensation schemes in a multi-period context, as well as the general compensation problem and implications for public officials, managers, and other individuals. The article focuses on two areas: 1) the willingness of agents to take profitable but risky projects, and 2) the social costs arising from conflicts of interest between agents and principals. The goal of this article is to present a compensation formula that eliminates or minimizes these social costs.[5] In discussing these costs, the article distinguishes between "indirect" agency costs, which are defined as a reduction in the value of the firm due to errors made by the agent in the investment decision process, and "direct" agency costs stemming from conflicts of interests between agents and principals. More specifically, this article analyzes the costs stemming from conflicts of interests;[6] that is, the agent's willingness to take risky projects vis-á-vis the principal's willingness to take this risk. In addition, this article suggests basic ingredients to be incorporated in the compensation schemes in order to reduce the agency or social costs.[7]

Section II briefly reviews existing compensation schemes and the law in the executive compensation area. Section III presents a proposed compensation formula that minimizes social costs. In this model, the agent's talent (i.e., government official or manager) is measured by the probability of him making correct (i.e., value maximizing) investment decisions. The principal considers offering the agent a new contract in each successive contract period, and uses the observed annual cash flow from the firm's projects to estimate his talent. This

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4. For more details on the various categories of possible "Agency Costs", see Jensen & Meckling, *supra* note 1, at 308-310.

5. The model present in this paper also serves to address the issue of the reasonableness of bonus or additional compensation. *See* Holthusen v. Edward G. Budd Mfg. Co., 52 F. Supp. 125 (E.D. Pa. 1943).

6. For possible conflicts of interest due to the separation of management and ownership of the firm, see Eugene F. Fama, *Agency Problems and the Theory of the Firm*, 88 J. POL. ECON. 288 (1980) and Jensen & Meckling *supra* note 1, at 308-09.

7. Robert Haugen and Lemma Senbet's analysis of these agency costs suggest that instituting incentives may eliminate these costs. For more details, see Robert A. Haugen & Lemma W. Senbet, *Resolving the Agency Problems of External Capital Through Options*, 36 J. FIN. 629-47 (1981).

article defines talent as the probability that the agent does not commit errors in making investment decisions on behalf of the firm.[8] If the agent's talent falls short of a predetermined critical value, he is either dismissed or his compensation is reduced.[9]

In an efficient labor market, the reduction in the agent's compensation for poor performance is unavoidable.[10] Once low cash flow is observed, the owners of other firms which may hire the discharged agent likewise estimate the agent's talent. It is not surprising, therefore, that most firms establish compensation schemes covering four to five years.[11] This permits the firm to review periodically the agent's performance and either penalize him or pay him a bonus.[12] Two assessments of the agent's talent can occur in this model: First, the agent's talent is low and the principal correctly infers it to be low. Second, the agent's talent is high but the principal incorrectly determines that his talent is low.

Section IV discusses the main results of the proposed model, section V presents an example, and section VI provides a summary. Appendix A provides an explanation of the mathematical and statistical terms utilized in sections III, IV and V. Appendix B provides a mathematical formulation of the model presented in Section IV.

II. Common Compensation Schemes and Review of the Law in the Executive Compensation Area

In 1980, 90% of the one-thousand largest manufacturing firms in the United States used bonus plans to compensate their managers

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8. The agent's decisions are protected by the business judgment rule unless their actions result in waste of the corporate assets. Cohen v. Ayers, 596 F.2d 733, 1979 (7th Cir.).

9. There are many papers which deal with managerial compensation schemes. These studies assume a one-period model, see MILTON HARRIS & ARTHUR RAVIV, THEORY OF WAGE DYNAMICS, (1982) and Steven Shavell, *Risk Sharing and Incentives in the Principal and Agent Relationship*, 10 BELL J. ECON. 55 (1979). Our paper, however, uses multi-period models with a Bayesian approach to estimate the agent's talent. *See infra* note 28 for an explanation of a Bayesian estimate. In questioning the reasonableness of compensation, "salary must bear a reasonable relation to the officers ability and to the quantity and quality of the services he renders." Glenmore Distilleries Co. v. Seideman, 267 F. Supp. 915 (E.D.N.Y. 1967).

10. For an analysis of the interaction between the market for managers and the compensation scheme, see Fama, *supra* note 6, at 288-290.

11. *See* Jude Rich & John Larson, *Why Some Long-Term Incentives Fail*, 23 FIRST QUARTER COMPENSATION REV. 26-37 (1980).

12. Bonuses awarding an agent's performance must be reasonably related to the value of the services rendered to the corporation. Holthusen v. Edward G. Budd Mfg. Co., 52 F. Supp. 125 (D.C. Pa. 1943); Rogers v. Hill, 289 U.S. 582 (1933)(prohibiting payment of a bonus which has no relation to the value of the services rendered by an executive).

(i.e., chief executive officers). The median ratio of bonus to base salary of the firms studied was 52%, demonstrating that the total compensation of many managers consists of two components: 1) a base salary and 2) a bonus which is a function of the chief executive officer's performance.[13] If the bonus, for example, is tied to a target such as earnings or earnings per share, then the precise amount of the bonus is generally a percentage of the difference between the actual earnings over a predetermined earnings target.[14]

In determining a chief executive's total compensation,[15] an important element is the length of the executive's employment contract. The most significant development in executive compensation in the last fifty years has been the headlong rush of American companies to institute long-term performance based incentive plans.[16] Typically, these plans establish earnings goals for the next four or five years and the executive obtains the bonus if the predetermined goals are achieved.[17] While few corporations employed such plans in 1970, today more than 40% of the Fortune 500 companies employ a long-term bonus contract with the bonus determined as a function of a performance index over four to five years.[18] Virtually all empirical studies on executive contracts concentrate on the compensation paid when various

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13. For a discussion of compensation schemes of top executives, see 128 PUB. UTIL. FORTNIGHTLY 3, Aug. 1, 1991, which reports the use of bonus based plans in the public utilities industry increased from 25 to 65 % between 1983 and 1988.

14. For the formula suggesting the compensation scheme, see Paul Healey, *The Effect of Bonus Schemes on Accounting Decisions*, 14 J. FIN. ECON. 87 (1985). Using Healy's notation, the bonus denoted B_t is generally:

$$B_t = P_t \text{ Max } \{(E_t - L_t), 0\}$$

where E_t is the reported earnings, L_t is the *target earnings* or the bound in which a bonus is paid only if earnings are higher than this target, and P_t is some percentage figure. The empirical evidence shows that the total compensation is given by W + B(X) where W is the base salary and B(X) is the bonus which is a function of some random variable X (earnings).

15. The executive's salary must bear a reasonable relation to their ability and the quantity and quality of services that the person renders. Glenmore Distilleries Co. v. Seideman, 267 F. Supp. 915 (E.D.N.Y. 1967). Compensation may be based on the corporation's profits. *Id. See also* Moran v. Edison, 493 F.2d 400 (3d Cir. 1974); Erwin v. West End Dev. Co., 481 F.2d 34 (10th Cir. 1973).

16. Reasonableness of executive compensation should also take into account responsibilities assumed, difficulties involved and success achieved. McQuillen v. National Cash Register Co., 27 F. Supp. 639 (D.C. Md. 1939), *aff'd*, 112 F.2d 877, *cert. denied*, 311 U.S. 695 (1940).

17. *See* Rich & Larson, *supra* note 11, at 26-37.

18. *Id.* at 26-37. The reasonableness of executive compensation can be determined by comparison to other officers in the same company or in other corporations in comparable fields. McQuillen v. National Cash Register Co., 27 F. Supp. 639 (D.C. Md. 1959), *aff'd*, 112 F.2d 877, *cert. denied*, 311 U.S. 695 (1940).

goals are achieved.[19] However, the executive's penalty for not achieving the predetermined goals has not been studied. The study of poor executive performance is important since the executive may either incur a reduction in his base salary or be terminated when unacceptable performance is recorded.

Unveiling the precise reason behind an executive's departure from his job is not a simple task. Normally, the firm announces a "resignation" of the chief executive officer rather than a direct firing.[20] Additionally, the precise reason for the firing is seldom provided, although a careful analysis of developments in the firm, as well as the firm's financial statements, may reveal "performance reasons" for the firing. While an empirical analysis of the board of directors' decisions regarding this issue lies beyond the scope of this article, a few examples reveal that poor performance several years in a row can lead to the dismissal of the chief executive.[21] The next section presents a bonus-penalty scheme, determined in conjunction with the investment decisions made by the chief executive officer.

III. The Model

The investment decision to be made by the chief executive officer can be analyzed by dividing all potential projects available to the firm into two mutually exclusive and comprehensive groups. The first group, group A, consists of projects expected to increase the value of the firm (profitable projects). The second group, group B, consists of projects which are not expected to increase the value of the firm. Determining the expected future value of a project requires forecasting the future mean cash flows to be generated by the project. Recognizing that money has time value, the expected future cash flows are discounted at the appropriate risk-adjusted discount rate to determine the present value of these cash flows.[22] The difference between the

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19. *See* Healy, *supra* note 14, at 87-90. Examples of a wide array of compensation schemes employed by various public utilities can be found in *Special Feature* 127 PUB. UTIL. FORTNIGHTLY, No. 10, May 15, 1991. For example, New York State Electric & Gas compensates senior executives for achieving predetermined targets in their business units. Wisconsin Power & Light, Co. reports exploring employee incentive plans but hesitates due to concern that employees will be over or under rewarded in the event of 'abnormalities.'

20. For the resignation of Aetna's chief executive officer, see WALL. ST. J., Aug. 31, 1984, § 3 co. 3, at 22.

21. *Id.*

22. The concept of present value is often employed in such claims as personal injury lawsuits where the future value of a claimant's life-time earnings is determined today.

present value of expected future cash flows of the project and its initial cost is called expected net present value.[23] If the expected net present value of a project is positive[24] then value is created since it is expected to be a profitable project; if the expected net present value is negative,[25] value is not created since it is not expected to be a profitable project.[26]

The cash flows *expected* to result from the project may, of course, differ from the *actual* cash flows received for two main reasons: a) the original estimate of the expected annual cash flows generated by the project was correct, but a random deviation from the mean cash flow occurred. In this case no errors were made by the executive in his earlier investment decision; and b) the original forecast of the cash flows was wrong. If an executive over-estimates the expected cash flows, the project will be accepted since he believes it is a profitable project when in fact it is not a profitable project. In addition, an executive may reject a project which should have been accepted because he under-estimates the cash flows to be generated by the project. In this case, he estimates that the expected net present value is negative when actually it is positive. Therefore, the future value of a firm depends on the talent of the executive and his ability to forecast correctly the expected cash flows generated by the project.[27]

For a given set of feasible projects, the talent of an executive is defined as the probability of the agent not committing errors in forecasting a project's cash flows. The true talent of the manager is denoted T. If the agent has perfect forecasting abilities (perfect talent) then $T = 1$; and if he has no talent $T = 0$.[28] The talent of the agent can,

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23. Expected net present value is denoted as E{NPV}.

24. Positive expected net present value is denoted as $E\{NPV\} \geq 0$.

25. Negative expected net present value is denoted as $E\{NPV\} < 0$.

26. For ease of exposition, if I denotes the project under consideration, NPV is the net present value of the project, E(NPV) is the true expected net present value, and ϵ in mathematical notation means "is an element of," then the projects in group A and B, respectively can be summarized as

$I \epsilon A$ if $E(NPV) \geq 0$

$I \epsilon B$ if $E(NPV) < 0$

$\hat{T}$ is the maximum likelihood estimate of the agent's true talent T. For a discussion of maximum likelihood estimators, see ALEXANDER MOOD & FRANKLIN A. GRAYBILL, INTRODUCTION TO THEORY OF STATISTICS 178-228 (2d ed. 1963).

27. Since it is assumed that no errors are made in estimating the risk of the project, the only errors which occur involve estimating the mean cash flows generated by the project.

28. In statistics, this is a Bayesian estimate of talent, T. Bayesian estimation means that we observe the agent's performance and from our observation we estimate his talent. It is like estimating the probability of tossing a coin and observing heads. Our initial estimate would be that the probability of observing heads is .5. However, after tossing the coin 10 times and observing heads 8 times, our Bayesian estimate might be .7 (versus .5).

therefore, be determined by considering the probability that he correctly accepts profitable projects, plus the probability that he correctly rejects unprofitable projects.[29] Rejecting projects which should be accepted and accepting projects which should be rejected thus reduces the agent's estimated talent.

The principal (for example, the board of directors) who hires the executive (agent) cannot, of course, directly observe the executive's talent. The principal can, however, observe the actual cash flows generated by the firm (or, for example, the growth in earnings per share). When the actual cash flows of the firm are below the expected cash flows, the principal can either interpret this deviation as a random deviation or as an error made by the agent (i.e., the agent has low talent). Suppose that the agent's current employer as well as other potential employers have some prior beliefs regarding the agent's talent. After observing the actual annual cash flow (observed performance), the principal formulates a distribution of beliefs regarding the agent's talent.[30] The principal will then estimate the mean value of the agent's talent.[31] The principal does not wish to employ an agent whose true talent is below some predetermined minimum level.[32] Therefore, if the principal's estimate of the agent's talent is below the predetermined tolerance limit, the agent is dismissed or faces a reduction in his base salary.[33]

Since the principal is not certain as to the breakdown of the deviation of the observed cash flows from the expected cash flows into the portion which is the random component and the portion which is agent's error, like in hypothesis testing, the principal may commit the following two errors:[34]

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29. That is, the variable T (talent) is defined between zero and one as:

$$T = \Pr(\text{Accept } I \mid I \in A) + \Pr(\text{Reject } I \mid I \in B)$$

Talent of the agent = Probability (Pr) of correctly accepting project I given I is an element (ϵ) of group A (increases firm value) + Probability of correctly rejecting project I given I is an element of group B (does not increase firm value).

30. Statistically speaking, the prior distribution of beliefs is denoted f(T). Employing a Bayesian approach (*see supra* note 28) the posterior density function is determined and denoted $g(T|X)$ where X is the observed cash flow.

31. The mean value of the agent's talent is denoted as $\hat{T}$. $\hat{T}$ is the maximum likelihood of T. For a discussion of the maximum likelihood estimators, see MOOD & GRAYBILL, *supra* note 26, at 178-87.

32. This minimum or critical value is denoted T_0.

33. Moreover, the future payment to the agent is monotonic (a strictly increasing function) with the value of the agent's talent T. In the Bayesian framework, when the cash flow X falls short of some critical value T_0, the estimate $\hat{T}$ falls below the critical value T_0.

34. For the procedure of hypothesis testing and the possible Type I and Type II errors, see MOOD & GRAYBILL, *supra* note 26, at 179.

1. The principal may dismiss the agent because the estimate of the agent's talent is below the tolerance limit[35] when actually the true talent of the agent is above the tolerance limit.[36]

2. The principal continues employing the agent because the estimate of the agent's talent is above the tolerance limit[37] when indeed the actual true talent of the agent is below the tolerance limit.[38]

Each of these two errors is costly, and the principal will choose the optimum tolerance limit by considering the magnitude of these two costs. For example, the principal may choose the critical value such that he minimizes the expected total costs. As in hypothesis testing, the principal may reduce the total cost due to these two errors by increasing the number of observations.[39] The number of observations implies evaluating the agent's performance every few years. The optimum number of years between contracts in this respect is a function of the various costs involved.

We do not analyze the costs induced by the various errors the principal may commit in detail, but simply assume a contract is arranged for a given number of years[40] with the executive's performance being evaluated at the expiration of the contract.[41] In the model presented, it is possible that the executive faces a reduction in his compensation in the case of relatively low cash flows (poor performance), even though the low cash flows may be due to random deviations from the mean cash flow and are not induced by errors on his part. Similarly, when a relatively high cash flow is observed, the principal pays the executive a bonus and the base salary is increased in the next contract cycle.[42]

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35. Denoted ($\hat{T} < T_o$).

36. Denoted ($\hat{T} > T_o$).

37. Denoted ($\hat{T} > T_o$).

38. Denoted ($T < T_o$). An example of the concerns expressed by Wisconsin Power & Light Co., *supra* note 19, provides a good example of these two errors.

39. Like in hypothesis testing, increasing the sample size (in our case number of years) reduces both Type I and Type II errors. *See* MOOD & GRAYBILL, *supra* note 26, at 289.

40. Denoted k years.

41. *See* Rich & Larson, *supra* note 11, at 26-37.

42. For the behavior of the market wage for agents see Milton Harris & Bengt Holmstorm, *A Theory of Wage Dynamics*, 49 REV. ECON. STUD. 315, 317-19 (1982). N. P. Narayanan claims that the managers have a strong incentive for short-term results (i.e., high cashflows in the first few years even if these cashflows will drastically decrease in the future), which will increase their bonus and even allow them to move to another job with a better contract, which is consistent with our compensation model. For more details, see N. P. Narayanan, *Managerial Incentives for Short-Term Results*, 40 J. FIN. 1469, 1473 (1985).

Other costs that may arise from the separation of ownership and control are conflicts of interest between the principal and the agent. These conflicts arise from many factors.[43] For example, a conflict may occur where the principal and agent have different degrees of risk aversion[44] (i.e., each is characterized by a different utility function).[45] Even where both have the same preferences for risk, possible conflicts of interest can arise if they possess different levels of initial wealth. These possible differences do not induce a systematic deviation in the agent's actions from those desired by the principal. The agent may be more or less risk averse than some stockholders, but it would be extremely unlikely that executives of all firms are systematically less (or systematically more) risk averse than all other stockholders. The fact that an agent and principal are characterized by different risk preferences may lead to a random deviation of the agent's action from the one desired by the principal, but it does not lead to any systematic and predictable deviation.

The assumptions in our model neutralize this random deviation, allowing us to concentrate on possible systematic deviations, and hence potential social costs. We assume that the principal and the agent choose their actions in an effort to maximize their expected utility[46] of consumption. The concept of utility recognizes that it is the satisfaction or happiness we derive from money which is important and not money itself.[47] To avoid "random" conflicts of interests, assume that

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43. For an analytical examination of this conflict, see Jensen & Meckling, *supra* note 1, at 305-10.

44. An investor is defined as risk averse if he is unwilling to invest in a risky asset whose mean cash flow is equal to the price of the asset. For example, if a stock yields $100 with a probability of ½ and $120 with a probability of ½, a risk averter will not buy this stock as long as its price is $110 (½ $120 + ½ $100 = $110) or more. For this concept, see HAIM LEVY & MARSHALL SARNAT, PORTFOLIO AND INVESTMENT SELECTION: THEORY AND PRACTICE 197-201 (1984).

45. The utility function is defined as U(W+X) where W is the initial wealth and X is the return on the risky asset. For more details on the role that the initial wealth plays in decision making, see LEVY & SARNAT, *supra* note 44, at 157-162.

46. While the utility function reflects the investor's attitude toward risk, the ultimate goal of every investor is to maximize expected utility. To be more specific suppose that one had to choose between two random variables X and Y, then X would be preferred to Y if and only if

$$EU\ (W+X) > EU\ (W+Y)$$

When E stands for the expectation operator, W the initial wealth and X and Y the returns on the two random variables. It can be proven mathematically that maximization of the expected utility is the ultimate goal, regardless of the precise shape of the utility function U under certain axioms. For the set of axioms and the mathematical proof, see LEVY & SARNAT, *supra* note 44, at 107-20 and App. 4.1, at 135-36.

47. Let U be the utility function (the preferences) of both the agent and the principal.

both the agent and the principal have the same initial wealth,[48] and hold the same number of shares in the firm. Therefore, they each have the same stake in the firm. The agent earns a set wage each year[49] for managerial services to the firm. The principal's income from wages and other sources not related to the firm is also a predetermined wage. Further, assume that the set wage is the income from a base salary and from investing in the "market portfolio."[50] In addition, the following hold:

1. Each year's consumption[51] is equal to the agent's or principal's available cash flow which is composed of both the wage and investment income.
2. An additive utility function[52] is assumed to enhance simplicity when decisions are analyzed over multiple periods.[53]

$$U(C_0, C_1 \dots C_N) = \sum_{t=0}^{N} \frac{U(C_t)}{(1+r)^t}$$

The total utility of consumption for N periods	The sum (Σ) of the present values of the utility of consumption in each period ($U(C_t)$) discounted at a risk free discount rate (r) for a total of N periods[54]

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48. Initial wealth is denoted W_o.

49. The annual wage is denoted W_t.

50. The "market portfolio" is defined as a portfolio composed of all available risky assets, where the market value of each asset divided by the total market value of all available assets is the proportion of this asset in the portfolio. *See* LEVY & SARNAT, *supra* note 44, at 409, 416-20.

51. Each year's consumption is denoted C_t.

52. For a two-period model, an additive utility function is of the general form $U(C_1, C_2) = U(C_1) + \alpha U(C_2)$ where α is a given positive constant and C_1 and C_2 stand for the consumption in periods 1 and 2, respectively. C_1 and C_2 can also stand for two alternative commodities (rather than consumption in two periods). *See* KENNETH JOSEPH ARROW, ESSAYS IN THE THEORY OF RISK-BEARING 54 (1971).

53. Jonathan Eaton and Harvey Rosen employ a non-additive utility function of the form $U(C_1, C_2, e)$ (where e is the manager's effort). However, they admit that in this general framework the analysis of the firm-executive relationship is very complicated. An additive utility function of the form $U(C_1, C_2) = U(C_1) + \alpha\ U(C_2)$ greatly simplifies the analysis. For more details see Jonathan Eaton & Harvey Rosen, *Agency, Delayed Compensation, and the Structure of Executive Renumeration*, 38 J. FIN. 1489, 1490 (1983).

54. The risk-free rate of interest is the appropriate discount rate when the cashflows are certain. However, in our case C_1 is not certain, but by calculating the expected utility (see eq. (1) in section IV), the discounted term can be considered certain or the "certainty equivalent". For the concept of a certainty equivalent see LEVY & SARNAT, *supra* note 44, at 157.

We assume that the agent, as well as the principal, act to maximize their multi-period expected utility given above.

3. The following multiperiod contract is analyzed:[55] The agent has an employment contract for a given number of years. He receives a base salary during these years and at the end of the contract period his performance is evaluated by the principal. A bonus may be paid at the end of the contract, if his performance is good. The bonus in a given year (if paid) and the base salary in the second contract period are a function of the observed performance in the first contract period. The bonus (if paid) in the second contract is a function of the performance during the second contract period. Thus, every so many years a new contract is signed or in the case of bad performance the executive is fired.

4. There are many stockholders. If a bonus is paid to the agent, its effect on each stockholder is negligible and can be ignored. This assumption simplifies the analysis.

5. Returns are independent over time.[56] Thus, the observed performance index (e.g., growth in earnings per share, growth in the market value of stocks, etc.) for one contract period is independent of the performance index in a different contract period. This assumption is not crucial to our analysis but simplifies the mathematical proofs.

Under these assumptions, the agent's decisions and the possible existence of agency (or social) costs are analyzed. Various contracts that the principal can employ to reduce the agency or social costs are also analyzed in the next section.

IV. THE RESULTS

Equipped with the model developed in section III above, alternative contracts can be formulated and possible conflicts of interest analyzed. The mathematical notations used below are presented in Appendix A. Suppose that the total planning horizon is N years. The agent is considering executing an investment (project) whose initial outlay is I. This new project is expected to generate a future net cash

55. A contract for a number of years rather than one year is very common. *See* Rich & Larson, *supra* note 11, at 26-37.

56. If X_1 and X_2 are two independent random variables then the expected value of the product of two random variables is equal to the product of the expected value of each random variable; that is, $E(X_1 \cdot X_2) = E(X_1) E(X_2)$. This is not true if the random variables are not independent. The empirical evidence taken from the stock market support the independence assumption, see LEVY & SARNAT, *supra* note 44, at 667.

flow (a random variable) in year t of $X_t(I)$. The principal desires to take this project if and only if the expected utility of the principal from undertaking the project is greater than if it were not undertaken. The proposed approach to identifying agency costs is as follows: to determine the conditions under which the expected utility of undertaking a project differs between the principal and agent (that is, when for a given project $E_pU(\bullet) \neq E_aU(\bullet)$, where p stands for the principal and a for the agent) in spite of the fact that both the principal and the agent have the same utility function. Under these conditions, conflicts of interest may arise.[57] If these conflicts of interest are systematic and predictable, the firm can take action to eliminate them.

Using the notation developed in section III and Appendix A, the principal would like the investment to be taken if the following holds: (note that X_o, I, and Y_t are scaled for the proportion of shares held in the firm by the agent and the principal):

Equation (1)

$$E_PU(\bullet) = U(W_o + X_o - I) + \sum_{t=1}^{N} \frac{EU(W_t + Y_t)}{(1 + r)^t} >$$

$$U(W_o + X_o) + \sum_{t=1}^{N} \frac{EU(W_t + X_t)}{(1 + r)^t} \equiv M(\bullet)$$

where $E_pU(\bullet)$ stands for the expected utility of consumption of the principal, W_o stands for the *current* wage income (from other sources including holding of the "market portfolio"),[58] X_o stands for the current income received from the firm at time t_o, and W_t is the future principal's salary income (where t = 1,2 ... N). Should the project be taken, the future income from the firm would consist of two components X_t and $X_t(I)$, where X_t is the future income from the firm when the project is not taken, and $X_t(I)$ represents the additional income due to the new project whose initial cash outflow is I. The total future cash flow of the firm then consists of the cash flow from existing projects plus the cash flow from new projects and is denoted Y_t. Y_t is therefore defined as $Y_t \equiv X_t + X_t(I)$ (where $\equiv$ is the mathematical symbol meaning "is defined as").

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57. Although the principal and agent have the same utility function, their expected utility may differ since they face different cash flows. This definition is in line with the graphical analysis suggested by Jensen & Meckling, *supra* note 1, at 316.

58. *See supra* note 50.

For simplicity, we assume that without the bonus (or possible penalty) the agent faces the same base income in each year W_t. Thus, the agent's income in the first contract period is identical to the principal's income in the first contract period. However, at the end of the first contract period when the agent's performance is evaluated, the agent faces the following possible income depending on whether he receives a bonus or not. T_1 stands for the agent's performance in the first contract period, D stands for "disaster" or the poor performance target, S stands for "success," and $B(T_1)$ is the bonus paid to the agent.

Equation (2)

$$\text{Income in the } k^{th} \text{ year} = \begin{cases} W_k & \text{if } T_1 \leq S \\ W_k + B(T_1) & \text{if } T_1 > S \end{cases}$$

If $D \leq T_1 \leq S$, no bonus or penalty action is taken and this is considered normal or standard performance.[59] Moreover, the principal would consider this standard and acceptable performance and hence renew the agent's contract by repeating the terms of the previous contract. If the agent's performance is greater than the performance target,[60] the agent is considered successful; that is, he achieved more than the target and he is paid a bonus for performance in the first contract period.[61] In this case, the principal will offer the agent a new contract with an increase in base salary. If an increase in his salary is not offered, the agent will move to another firm which will make him this offer.[62] This will occur since other firms also observe his performance and similarly estimate his talent. After receiving the bonus at the end of the first contract period, the agent faces another contract for the next contract period and he tries to achieve the target set for him in the next contract period. (This target, of course, may be changed from one contract to another.)

Note that the executive's total compensation is a function of both a base salary as well as a bonus.[63] The base salary does not remain

59. Using Healy's terminology, the realized earnings by the manager E_t are lower than the target earning L_t, *see* Healy, *supra* note 14, at 87-88.

60. Denoted $T_1 > S$.

61. As an example of such compensation policy, Healy quotes the compensation scheme employed by Standard Oil Company of California: "The annual fund from which an award may be made is two percent of the amount by which the company's annual income for the award year exceeds six percent of its annual capital investment for such year," see Healy, *supra* note 14, at 87.

62. This is in line with the suggestion of Fama who advocated an efficient labor market for managers (or agents), see Fama, *supra* note 6, at 292-98.

63. The bonus is denoted as B(T).

constant but is also a function of the agent's performance. In the event of successful performance, the increase in the agent's base salary can be viewed as a function of his performance.[64] Likewise, when the agent's performance is below some target level,[65] the agent's base salary assigned in the next contract will be reduced.[66] The penalty for poor performance results in a reduction in the base salary when a new contract is signed, or the firing of the agent by the firm. If the agent is fired, the penalty is measured by the difference between the agent's current income and the income he obtains from his new job.[67]

The principal analyzes performance after the second contract period for the agent's effectiveness during those years. If successful performance is observed, a bonus is paid in at the end of the second contract period.[68] Our analysis considers two consecutive contracts[69] or an 8-10 year period.[70] With the above framework established, we now turn to determining the specific conditions under which the expected utility of undertaking a project differs between the principal and agent and the agency costs which may arise.

Recall that the principal and agent have the same risk preferences or utility function. Assume that the agent is considering a new investment whose economic life is the length of two consecutive contracts.[71] For simplicity assume that *without* the new project the agent's performance is standard with certainty.[72] Thus, we can analyze the marginal effect of the new project on the agent's decision. With the above assumptions, the agent's expected utility if the new project is not

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64. Denoted $\Psi(T_1)$.

65. The target level is denoted D. Recall that there is a one-to-one correspondence between the observed cash flow and the estimated talent of the agent $\hat{T}$. Therefore, while the principal can base his decision on the estimated value of the agent's talent $\hat{T}$, the contract is normally set in terms of observed performance such as growth in earnings, observed cashflows, etc.

66. This reduction is assumed to be according to the function denoted $\Phi(T_1)$.

67. Recall that all employers use the same approach to estimate the agent's talent, and a lower base income will be offered to the agent by the new employer in a case of observed bad performance.

68. T_2 denotes the talent index in the second period.

69. Denoted as $N = 2k$ years.

70. The extension to more than two contract cycles is similar. However, due to discounting the value of the years beyond 8-10 years is less significant. The further in the future that the cash flow is obtained, the smaller its contribution to the net present value, hence the smaller its effect on the decision making process. For an elaboration of this notion, see LEVY & SARNAT, *supra* note 44, at 35.

71. The entire analysis holds for a project with a life less than N years or for $N > 2k$ years (a case where we need to consider more than two contract cycles).

72. This means $D \leq T_1 \leq S$ with probability equal to one.

taken is exactly equal to the principal's expected utility (see the value M on the right-hand side of equation (1) above). However, if the project is taken, the principal's expected utility is given by $E_pU(\bullet)$,[73] (which is the left-hand side of the equation (1) for the specific case where there are two consecutive contracts),

Equation (3)

$$EU_p(\bullet) = U(W_o+Y_o-I) + \sum_{t=1}^{k-1} \frac{EU(W_t+Y_t)}{(1+r)^t} + \sum_{t=k}^{2k} \frac{EU(W_t+Y_t)}{(1+r)^t}$$

The total expected utility of the principal	=	Current utility of total net income	+	The present value of the expected utility of total income in the first contract period	+	The present value of the expected utility of total income in the second contract period

Similarly, the agent's expected utility for two contract periods, which incorporates the bonus and/or penalty (which we denote as terms A, B and C), is given by $EU_a(\bullet)$,[74]

Equation (4)

$$EU_a(\bullet) = U(W_o+Y_o-I) + \sum_{t=1}^{k-1} \frac{EU(W_t+Y_t)}{(t+r)^t} + A + B + C$$

The total expected utility of the agent	=	Current utility of total income	+	The present value of the expected utility of total income from base salary in first contract, year 1 to k-1	+	The present value of the expected utility from income including bonus or penalty in last year of the first contract, year k		The present value of the expected utility from income during the second contract period years k+1 to 2k-1		The present value of the expected utility of income including any bonus or penalty in the final year, year 2k

To analyze potential conflicts of interest between the agent and the principal with this commonly employed compensation scheme, we calculate the *difference* in the expected utility of the principal and the agent in the case where the project is executed. The difference in the

73. This is due to the fact that an additive utility function is assumed.

74. Since the agent's performance is evaluated only at year k, up to year k-1 neither a bonus or a penalty is involved. Indeed terms A, B and C of equation (4) below incorporate a possible bonus or penalty.

expected utilities is the difference between equations (3) and (4) above,[75] which we denote Δ.

Equation (5)

$$\Delta \equiv EU_p(\bullet) - EU_a(\bullet)$$

The expected utility of the principal minus the expected utility of the agent	≡	Equation 3	–	Equation 4

Note that up to the year before the first contract ends and the bonus or penalty is determined, all terms are identical and hence the first two terms in equation (3) cancel with the first two terms in equation (4), leaving the last term in equation 3 and the last three terms in equation (4).

Equation (6)

$$\Delta = \sum_{t=k}^{2k} \frac{EU(W_t + Y_t)}{(1+r)^t} - (A + B + C)$$

The difference in the expected utility of the principal and agent	=	The present value of the expected utility of the principal in the second contract period	–	The present value of the expected utility of the agent in year k (term A), years k+1 to 2k-1 (term B), and year 2k (term C), respectively

Recall that the principal evaluates the performance of the agent and either pays him a bonus or imposes a penalty at the end of the first contract and at the end of the second contract. Denote by Δ_1 the expected utility difference between the principal and agent corresponding to the last year of the first contract, Δ_2 is the difference corresponding to the period when the base salary is determined by the success or failure of the agent in the first contract period (years k+1 . . . 2k-1), and Δ_3 is the difference due to the last year of the second contract. The *total* difference is, of course, the sum of these three, or $\Delta = \Delta_1 + \Delta_2 + \Delta_3$. In Appendix B we derive each Δ_i (i=1,2,3)

75. If $\Delta > 0$ this means that the principal derives a greater expected utility than the agent. Thus, it may be that the agent rejects a project desired by the principal a possible conflicts of interest arise, see Jensen & Meckling, *supra* note 1, at 308-09, 316-19.

and use the derivation to analyze the sign of Δ under various scenarios. Δ reflects the conflicts of interest arising over the entire contract period. While in general the difference between the expected utility of the principal and agent as well as the bonus and penalty cannot be predicted in advance, conclusions can be drawn by analyzing several possible bonus-penalty schemes.[76]

First, let us analyze the case where a bonus and an increase in wages are not awarded in the event of success, but a penalty is imposed in the event of failure. Ignoring nonpecuniary income, this scenario may be appropriate for government officials, such as, the financial manager of the foreign exchange reserves of a given country. These government officials may lose their jobs in the case of failure but get no bonus in the case of success. Note that the same results hold even when a bonus is paid but it is small relative to the penalty involved. Let us analyze possible social costs for various cases.

Case 1: In this case no bonus is paid in the first period or in the second period and no increase in the base wage occurs.[77] In this case, the difference in the expected utility of the principal and agent in the first contract year is equal to zero but is positive in each successive period. Since the expected utility of the principal is greater than the expected utility of the agent, agency costs may exist and profitable projects may be rejected by the agent. The explanation of this result is obvious: if a risky but profitable project is considered, its acceptance may follow a penalty but no bonus, hence this asymmetry in the cash flows from the agent's point of view results in its rejection. That is, the higher the variability of the project's cash flows, the higher penalty in the base wage[78] and therefore the greater the difference in utility.[79] Thus, agency costs[80] would be relatively large in firms which face relatively risky projects and are run by a government official. For projects with a relatively small amount of risk, for example public utilities, agency costs would be smaller or even completely nonexistent.

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76. That is $\Delta \gtreqless 0$ and the sign depends on the functions Ψ, Φ, and $g(T)$. For the definition of Δ, see App. B of this paper.

77. That is, $\Psi(T_1) = B(T_1) = B(T_2) = 0$ and it is easy to show (due to monotonicity) that $\Delta_1 = 0$, $\Delta_2 > 0$ and $\Delta_3 > 0$ hence $\Delta > 0$. Namely, no bonus or wage increase takes place, see Appendix B of this paper. Monotonicity asserts that for any two levels of wealth W_1, W_2, if $W_1 > W_2$ then also $U(W_1) > U(W_2)$ must hold where U is the utility function. *See*, LEVY & SARNAT, *supra* note 44, at 119.

78. Denoted by $\Phi(T_1)$.

79. Utility is denoted Δ in equation (6).

80. If the principal prefers that the project be taken but the agent rejects it, the value of the firm is lower than what it could be. This reduction is the value of the firm is called agency costs, see Jensen & Meckling, *supra* note 1, at 308, 316-19.

Case 2: Most prior literature dealing with the agent-principal relationship assumes a one-period model; hence, a base wage and a bonus are incorporated into the analysis, but a penalty is not considered.[81] This analytical shortfall emphasizes the need to analyze the agent-principal relationship in a multi-period framework where a penalty is explicitly considered. Nevertheless, in the multi-period framework, the no-penalty assumption can easily be incorporated by setting the penalty reduction in the base wage[82] equal to zero, and the bonus paid in both the first and second period being non-negative as well as the change in the base wage if a bonus is paid being non-negative.[83] This scenario may occur when the agent has a life-time or very long contract with a given base salary (hence he cannot be fired) and with a bonus attached to it. In this case the expected utility of the agent is greater than or equal to the expected utility of the principal in every one of the three sub-periods analyzed. This is true in the last year of the first contract year since the bonus in the first contract period is non-negative. In the second period, since the base wage in the second contract is also a function of success in the first period and hence may increase. Finally, at the end of the second contract, a bonus may be paid which causes a difference in the expected utility.[84]

Once again, the higher the variability of the project's cash flows, the more negative the total expected utility difference. In other words, the expected utility of the agent is greater than the expected utility of the principal. In this case, risky projects with negative net present values may be accepted and agency costs incurred. This distortion in decision-making where the agent is made better off at the expense of the principal being worse off (lower expected utility) may explain why companies avoid life-time or very long-term contracts.[85]

Although case 1 and 2 above represent extreme compensation schemes, they are not symmetric in the agency costs they induce. In case 1, the agent may reject projects with positive net present value, hence the firm's profit would be low relative to the other firms in the same industry. At the termination of the contract, the principal can dismiss the agent who shows relatively low observed performance. In

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81. *See, e.g.*, Jensen & Meckling *supra* note 1, at 314-16; Steven Shavell, *Risk Sharing and Incentives in the Principal and Agent Relationship*, 10 BELL J. ECON. 57, 57-9 (1979).

82. Denoted $\Phi(T_1)$.

83. I.e., $\Psi(T_1)$, $B(T_1)$ and $B(T_2)$ all being non-negative.

84. See equation (A-7) in Appendix B for this specific condition.

85. Most companies offer a contract for several years rather than one year, *see* Rich & Larson, *supra* note 11.

case 2, the agency costs are induced by two sources. First, projects with negative net present value are taken (direct agency costs) which may push the firm into the red. Second, since no penalty exists, the manager may be characterized by a relative low talent (i.e., low probability of making correct investment decisions), hence he induces additional "indirect" agency costs by making many wrong decisions. Since by assumption the firm cannot impose a penalty by dismissing this agent, the damage to the firm (and hence society) persists during the agent's life-time. Thus, a compensation scheme with no bonus is not as harmful as a compensation scheme with no penalty (i.e., a life-time contract).

Case 3: The conclusions of case 1 and 2 above are preference-free. We can refine the analysis further if we assume risk-aversion.[86] First, we will assume that a long-term bonus does not exist, but a reduction or an increase in the base salary may occur when a new contract is signed.[87] The possible increase or reduction in future wages are symmetric functions with the probability of a reduction or an increase in the base salary equally likely.[88] In this case, the expected utility of the principal is equal to the expected utility of the agent in the last year of the first contract (year k).[89] This occurs because, by assumption, the bonus is zero.[90] However, the principal's expected utility during the second contract is greater than the agent's expected utility, due to risk aversion and the symmetry of the increase and reduction in the agent's base salary.[91]

Since risk aversion plays an important role in determining the sign of Δ_2 as well as the sign of Δ_3, an elaboration on this claim is useful. If the utility function is linear (i.e., the principal and agent are risk-neutral) then each unit increase in wealth results in a unit increase in utility. This one-for-one relationship is true for *every* level of wealth.

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86. When the second derivative of the utility function is negative ($U'' < 0$), we assert that risk aversion prevails. *See* LEVY & SARNAT, *supra* note 44, at 123 n.26.

87. That is, we assume $B(T_1) = B(T_2) = 0$ (no long-term bonus is paid) and $\Phi(T_1) > 0$ and $\Psi(T_1) > 0$.

88. A restatement of this condition in terms of our mathematical notation is $\Phi(T_1) = \Psi(T_1)$ and $g(T_1)$ are symmetric density functions with $Pr(T<D) = Pr(T>S)$.

89. That is $\Delta_1 = 0$ in the k^{th} year.

90. However, when $B(T_1) = 0$ equation A-4 in Appendix B becomes $\Delta_1 = \int_S^\infty \int_{-\infty}^\infty 0\, f(T_1, Y_k)\, dT_1 dY_k = 0$.

91. See Appendix B for a presentation of risk aversion and symmetric density functions. $\Delta_2 > 0$ since we assume risk aversion and $g(T_1)$ is symmetric with $\int_{-\infty}^D g(T_1)dT_1 = \int_S^\infty g(T_1)dT_1$ and $\Phi(T_1) = \Psi(T_1)$.

However, if the utility function is non-linear, and assuming risk aversion, then the utility function is concave. Thus, the utility of wealth increases at a decreasing rate (i.e., the first derivative of the utility function is positive ($U'>0$), but the second derivative is negative ($U''<0$)). The implication of a concave utility function is that utility increases with increasing wealth, but it increases at decreasing rate. Because of this implication, along with the assumption that the probability function is assumed to be symmetric, the utility gain of the agent is smaller than his utility loss and hence $\Delta_2 > 0$ and $\Delta_3 > 0$.[92] Thus, the principal's expected utility is greater than the agent's expected utility for the entire two contract periods. Therefore, the agent may reject projects with positive expected net present values and in case of compensation scheme with no bonus component, potential social[93] costs exist. This is consistent with Dent's statement that "[m]anagers may shun risks attractive to shareholders and pursue steady, albeit modest, returns that will assure steady compensation."[94] Note that any payment to the manager implies a reduction in cash flow to the principal and any penalty implies an increase in the cash flow to the principal. However, since there are many owners (stockholders), the fraction of the increase or the reduction in the agents base salary is small and hence when the number of stockholders is large this figure can be ignored.[95]

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92. See the utility terms in the bracket of equation (A-5) in Appendix B for the special case where $\Phi(T_1) = \Psi(T_1)$ is denoted V. The difference in the expected utility of the principal and agent in years k+1 to 2k-1 (i.e., Δ_2) when the increase and reduction in the base salary is symmetric reduces to $[U(W_t + Y_t) - U(W_t + Y_t - V)] - [U(W_t + Y_t + V) - U(W_t + Y_t)]$. If utility is linear, these two terms cancel and $\Delta_2 = 0$. However, since we assume risk aversion, it implies that which means that for the same increase in wealth the corresponding increment in utility is diminishing as the initial wealth of the individual is higher. Since $W_t + Y_t + V > W_t + Y_t$ the utility gain due to the first term above is greater than the utility loss due to the second term. Since the probability function $g(T_1)$ is assumed to be symmetric (equal probability for a bonus or penalty) $\Delta_2 > 0$. Looking at the difference in expected utility in year 2k (that is, the sign of Δ_3), we must compare pairs of terms ($A + B > 0$, see equation (A-6) in the Appendix C). This stems exactly as in the explanation for the difference in expected utility for years k+1 to 2k-1, Δ_2, from the assumptions of risk aversion and symmetric bonus-penalty functions. The term $D = 0$ (see eq. (A-7)) since by assumption $B(T_2) = 0$. Terms $C + E > 0$, since by assumption $B(T_2) = 0$, $\Phi(T_1) = \Psi(T_1)$, $g(T_1)$ is symmetric and risk aversion is assumed.

93. Social costs and agency costs are identically defined in this article; namely, the decline in the market value of the firm due to non-optimal decision making, for example, rejecting a project with a positive net present value.

94. *See* Dent, *supra* note 3, at 886.

95. That is, $\Phi(T_1)/n$ or $\Psi(T_1)/n$ where n is the number of stockholders. For firms where n is very large, the last few terms can be ignored.

One way to decrease the agency or social costs arising from the above case is to set the values of a disaster and success (i.e., D and S, respectively) in such a way that the probability that the agent's talent is low is less than the estimate of the probability that his talent is high (i.e., $Pr(T < D) < Pr(T > S)$). Namely, the probability of a disaster is smaller than the probability of a success. In this case the probability of penalty is smaller than the probability that a bonus will be paid which in turn increases the expected utility of the agent. Increasing the expected utility of the agent reduces the difference in the expected utility of the principal and the agent, and Δ decreases (see equation 5 above). Thus by decreasing D and increasing S, Δ decreases.

In general, where there is no long term bonus or penalty, social costs exist. It is not surprising, therefore, that 40% of the Fortune 500 companies have adopted long-term compensation schemes.[96] Relaxing the analysis above to include a long-term bonus or penalty, it is not possible to unambiguosly determine the existence of social costs. The degree of social or agency costs depends on the relative magnitudes of the difference in the expected utility of the principal and agent during the three periods analyzed (i.e., Δ_1 versus Δ_2 versus Δ_3).[97] Nevertheless, we can unambiguosly determine that without a long-term bonus, the expected utility of the principal is greater than the expected utility of the agent ($\Delta \geq 0$) and social costs exist. With a long-term bonus scheme $\Delta \gtreqqless 0$, but the magnitude of the difference in the expected utility of the principal and agent decreases in comparison to the no-bonus case since Δ_1 decreases, Δ_2 remains unchanged and Δ_3 decreases [See equation (A-7) in Appendix B]. Thus, the social costs decrease as long as the bonus is not "too large" relative to the other wage components. However, the social costs may, at some point, even increase due to large bonuses. To be more specific, while without a bonus or penalty, projects with positive expected net present values may be rejected, with a bonus scheme this tendency decreases.

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96. *See* Rich & Larson, *supra* note 11.

97. In the case of asymmetry in the bonus-penalty scheme with $\Psi(T_1) = \Phi(T_1) \geq 0$, $B(T_1) \geq 0$ and $B(T_2) \geq 0$, we have $\Delta_1 < 0$ (since $B(T_1) \geq 0$ hence $U(W_k + Y_k) - U(W_k + Y_k + B(T_1))$ in equation A-4 in Appendix B is less than zero), $\Delta_2 > 0$ since $\Psi(T_1) = \Phi(T_1)$ and U is concave. The explanation of risk aversion in determining that $\Delta_2 > 0$ is exactly as before when $B(T_1) = 0$. With respect to Δ_3, the sign is ambiguous since as before due to the assumption of risk aversion $A + B \geq 0$, $D \leq 0$ (since $B(T_2) \geq 0$). Recall that if $B(T_1) = 0$, $C + E > 0$ as explained before. However, with $B(T_1) > 0$ the negative term E (see equation A-7 in App. B) becomes even smaller and therefore $C + E$ may even become negative. Therefore $C + E \gtreqqless 0$ depending on the relationship between $B(T_2)$ and $\Phi(T_1)$, and hence $\Delta \gtreqqless 0$.

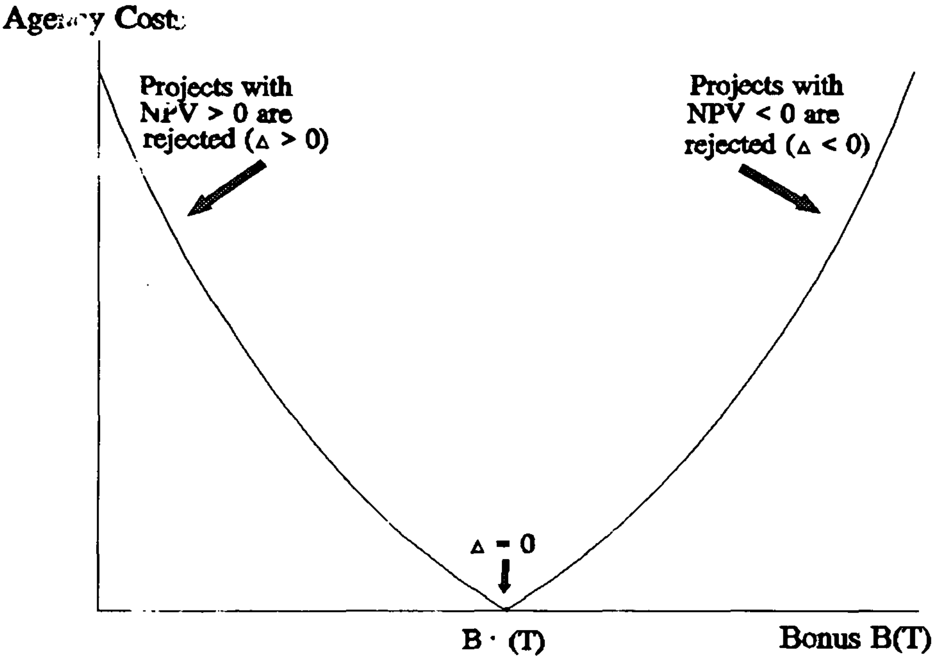

Figure 1

Moreover, the agent may even accept undesirable projects (i.e., those with negative net present values) if the bonus or penalty is large, which again induces social costs. The optimum bonus should be such that the expected utility of the principal is exactly equal to the expected utility of the agent, i.e., Δ is exactly equal to zero.[98] A company can create this equality by changing the bonus function or by changing the length of the agent's contract. Recall, however, that due to the discounting process (i.e., present values), the greater the number of years of the contract, the less important the bonus relative to the other components of the multi-period utility function. Figure 1 describes the agency costs as a function of the bonus B(T). When the bonus scheme is optimal, (i.e., $B(T) = B^*(T)$) agency costs are zero (since $\Delta = 0$).

A common feature of all of the compensation schemes discussed above is that when the risk profile of the firm is very small, there is little chance that the actual cash flow falls outside the range of disaster or success and agency costs are unlikely to exist.[99] For these low risk

98. If $\Delta = 0$, the expected utility of the principal and the agent are identical, hence no conflicts of interest arise and no agency costs exist.

99. This characterizes firms with stable sales and stable cash flows, e.g., electric companies.

firms, the need for a large bonus to eliminate agency costs is not necessary. However, for firms where the cash flows are characterized by a large variance, a large component of the agent's compensation should be in the form of a long-term bonus.

Another crucial factor in the compensation scheme is the duration of the contract. The less that is known about the agent's true talent, the shorter the length of the optimal contract since this strategy allows the principal to dismiss the agent should cash flows be relatively low. However, a contract for a very short period of time may induce a relatively large estimation error. That is, the observed performance index (or the Bayesian estimate of the agent's talent) may be subject to a wide margin of error. If the length is too short, the principal may dismiss a talented agent, or give an untalented agent a bonus. Thus, there is a need for a number of observations (years) before an evaluation of the agent's performance can be determined with a reasonable margin of error. As in hypothesis testing, the firm should find the optimum contract duration which balances the cost of having an untalented agent who continues making errors in the investment decision-making process and the cost of dismissing a talented agent.[100]

Both direct and indirect agency costs arise in the above analysis. For example, if an agent has a lifetime contract with a fixed wage and no bonus or penalty (Case 1), he may serve the firm to the best of his ability such that direct agency costs are not incurred. However, suppose that the principal discovers that the agent has very low talent (using the previous terminology the agent's true talent T is less than the predetermined critical value T_o). In this case, the firm suffers from many errors in the investment decision-making process and indi-

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100. Social costs are defined in this paper exactly as agency costs; namely, the decline in the market value of the firm due to non-optimal decision making, *e.g.*, rejecting a project with a positive net present value (NPV $\geq$ 0). For example, suppose that the firm chooses the optimum contract duration of k years which minimizes the expected costs. In evaluating the agent every k years, the firm faces the following cost function,

$C = \alpha_k C_1 + \beta_k C_2 + C_k$

when α_k is the probability of committing a type I error; that is, the firm dismisses the agent when his true talent is relatively high ($T > T_o$), and β_k is a type II error, where the principal continues to employ the agent when his true talent is relatively low ($T < T_o$). C_1 is the present value of the costs involved with replacing the agent, C_2 is the present value of losses induced by the agent during the period of the *second* contract, and C_k are the present values of losses due to errors made during the years of the *first* contract. By reducing k (the number of years for each contract), C_k is reduced (since the firm can dismiss the agent relatively early) but like in hypothesis testing α_k and β_k increase. Thus, the firm has to find the optimum contract duration which minimizes this function.

rect social or agency costs are induced. Since the agent cannot be dismissed, the loss can be quite large from errors made during his life-time employment.

Finally, in a compensation scheme where only a bonus is paid when the observed performance during a given number of years passes some critical value,[101] two additional biases, neither of which were considered above, can occur. For example, suppose that at the end of the second contract, the agent's talent is very close to the predetermined critical value. In the k^{th} year the agent may benefit from taking a very risky project even if it is not expected to be profitable. In the case of success, he would get a bonus; in the case of failure (unless it is an extreme failure) he would not be penalized since it is at the end of the contract cycle. This approach also induces social costs. This behavior questions the earlier assumption of independence of the income cash flows.[102] To avoid these social costs and the income dependency over time, the firm may establish a bonus-penalty function such that when the agent's performance equals an index denoted T* (for example the industry average), neither a bonus nor a penalty occurs. For performance which is different from T* a bonus in relation to the difference in the size of the bonus $B(T - T^*)$ is paid. (Similarly, the penalty would be a function of the distance $\Phi(T^* - T)$). Under this modified bonus-penalty scheme, the agent has no incentive to accept a risky but profitable project even if his performance is close but less than the value T* since T may diminish and his bonus in the k^{th} year may be reduced. The results of this paper remain intact when a continuous bonus-penalty function is incorporated into the analysis.

V. CONCLUDING REMARKS

Assuming either risk neutrality[103] or alternatively risk aversion, the economic literature of the agent-principal issue investigates one-period contract schemes which constitute an optimal solution.[104] This article analyzes various commonly used incentive schemes in a multi-period context. The talent of the agent is measured by the probability

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101. *See* Healy, *supra* note 12, at 87-88.

102. This occurs since a set of values $Y_1 \ldots Y_{k-1}$, which happen to induce a performance index which is close to the threshold value, determines the distribution of Y_k by the agent's project selection.

103. This implies a linear utility function, or U with U'=0. *See* LEVY & SARNAT, *supra* note 44, at 129.

104. Harris & Raviv, *supra* note 8, at 23.

of him not making errors in the investment decision-making process. The agent may commit errors in his investment decision-making and the principal may commit errors in estimating the agent's true talent. This article analyzes these two types of errors.

When the principal bases the agent's compensation on a base wage only, which is predetermined for a relatively long period of time, even if the agent makes every effort to reach an optimal investment decision (from the principal's and hence society's point of view), his talent may be limited and indirect agency costs incurred. It is not surprising, therefore, that most firms report using compensation schemes covering only 4-5 years.[105] The need for evaluating the agent's performance every few years and not every year is due to minimizing the statistical errors the firm may commit in estimating the agent's talent.

Since utility is maximized with increases in wealth, risky projects which are not expected to increase the value of the firm may be executed when compensation consists of a base salary plus a wage increase and a bonus (which is paid every k years). When the agent's compensation alternatively consists of a base salary and a penalty, such as being fired, risky projects that are expected to increase the value of the firm may be rejected. While the latter compensation scheme is not common in the business community, it does characterize the employment contracts of government officials (e.g., managers of the cash reserves of the central bank of various countries). When a symmetric increase or decrease in the base salary (with no bonus) is possible, a risk-averse agent would tend to reject risky projects with a positive expected net present value and social costs arise.

Supportive evidence that this type of conflict between the principal and the agent takes place can be found in a comprehensive survey conducted by Blume, Friend and Westerfield.[106] That study found that even though the industry cost of capital was 12.4%, managers on average set a cut off rate well above 12.4%. Therefore, projects that would earn the required rate of return would be rejected.

This article demonstrates that a symmetric increase or decrease in the agent's base salary is not sufficient to avoid agency or social costs. To avoid social costs the firm should institute an asymmetric compensation scheme such that the bonus income exactly offsets the penalty of income loss in utility terms. For example, a firm can add a bonus every k years which is a function of the observed performance

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105. *See* Rich & Larson, *supra* note 10, at 23.

106. *See* Marshall E. Blume, Irwin Friend & Randolph Westerfield, *Impediments to Capital Formation*, RODNEY L. WHITE CENTER FOR FINANCIAL RESEARCH 25 (1980).

during the k years. Under such a structure, conflicts of interest can be completely eliminated.

Agency or social costs can be reduced by various means. However, the optimum combination of compensation scheme ingredients are yet to be investigated. For example, it is not clear whether a large bonus every ten years is better from the firm's point of view than a smaller bonus every five years. Or, should the firm skip the bonus altogether and establish a larger increase in the base salary? An alternative way to reduce agency costs is to keep the change in the base salary symmetric, but reduce the critical value for successful performance. In finding the optimum combination, a firm must consider both direct and indirect social costs induced by possible errors in estimating the agent's talent.

One alternative to reduce conflicts of interest is to structure the bonus paid to the agent as a fraction of the market value of the firm. By rejecting a risky but profitable project, the manager reduces his potential bonus. He thus has an incentive to avoid rejecting risky but profitable projects. However, this will not completely eliminate the social costs since accepting a risky project may lead to the agent's dismissal because of a possible sequence of low cash flows. In terms of utility, acceptance of a risky project may hurt the agent more than would benefit him due to the extra bonus. In this case, he would still reject the risky but profitable project.

Thus, when managers hold a relatively larger proportion of their wealth in the firm, it may decrease the agency costs but not completely eliminate them. Indeed Lewellen[107] finds that stock ownership by the senior executives of large, publicly-held corporations constitutes a significant proportion of their reward. It seems that many firms employ this compensation structure to reduce potential agency costs. In summary, there is no one operational way which completely eliminates potential agency or social costs but there are several ways, as suggested in this paper, to reduce them.

107. *See* Wibur G. Lewellen, *Management and Ownership of the Large Firm*, 24 J. FIN. 299, 312-13 (1969).

Appendix A

I. The following terms are introduced in section III and used throughout the remainder of the paper:

Group A: Projects which are considered to be profitable and therefore expected to increase total firm value.

Group B: Projects which are not considered to be profitable and therefore *not* expected to increase total firm value.

E(NPV) The expected net present value of a project where the net present value is the difference between the present value of the expected future cash flows emanating from the project and the initial cost of a project.

T Denotes the *true* talent of the agent (manager) in making correct investment decisions.

$\hat{T}$ The principal's best *estimate* of the agent's true talent.

T_0 A predetermined *target* of the agent's talent determined by the principal from which the agent's observed talent will be measured.

X Observed cash flows of the firm.

k The number of years within which the agent's talent will be determined; i.e., the length of the contract.

U General notation for the utility curve of both the agent and principal. A utility curve is simply a way of describing an individuals preferences for uncertain consumption.

t The specific year being considered.

C_t General notation for consumption in each period t. For example, C_0 is consumption today, C_1 is consumption next year, C_2 is consumption in the second year, and so on.

N The number of consumption periods or total number of years considered (called the planning horizon).

r Denotes the risk-free rate of interest per period (per year in this case).

I Denotes the initial cost of the project (the investment).

Pr Denotes probability.

ϵ Mathematical notation which means "is an element of a set".

Σ The mathematical notation which means sum (or addition) of a series of numbers.

E The statistical notation for expected value (i.e., expected value operator).

$\int$ Integral which means "find the cumulative value under some given curve."

Δ The total difference in the expected utility of the principal and the agent.

Δ_1 The difference in the expected utility of the principal and agent in the last year of the first contract (when the bonus or penalty for performance in years 1 to k-1 is determined).

Δ_2 The difference in the expected utility of the principal and agent during the second contract period (years k+1 to 2k–1).

Δ_3 The difference in the expected utility of the principal and agent when the second bonus or penalty is determined (year 2k).

II. The following *new* terms are defined in section IV.

$X_t(I)$ The *future* net cash flow (X) in the specific year (t) generated from a new project (I). $X_t(I)$ is a random variable.

a Abbreviation for the agent.

p Abbreviation for the principal.

$E_pU(\bullet)$ Denotes the expected utility of the principal.

$EU_a(\bullet)$ Denotes the expected utility of the agent.

W_t Base income in each year t which is the same for the principal and the agent.

W_o Defines the *total* current income (both from wages and other sources) of both the principal and the agent.

X_t The income generated by the firm's *existing* projects. Thus X_o is the income generated by the firm at t_o, where t_o is today (the present), t_1 is the next period, etc.

Y_t The *total* cash flow expected from both the firms existing projects (X_t) and the new project if it is undertaken (X_t (I)). Therefore, $Y_t \equiv X_t + X_t (I)$.

W_k The income of the principal in the k^{th} year.

T_1 The observed performance index during the first contract period (which is the first k years).

$B(T_1)$ The bonus paid to the agent at the end of the 1st contract.

B(T) Is a general notation for the bonus.

S Denotes success (i.e., good investment decisions were made).

D Denotes disaster (i.e., bad investment decisions were made).

$\Psi(T_1)$ Function which measures the *increase* in the agent's base salary as a function of his performance.

$\Phi(T_1)$ The function which defines how the agent's salary is reduced if his actual performance is below a predetermined target.

APPENDIX B

In this Appendix, we analyze the terms A, B and C of equation (4) in section IV, and the conditions under which the terms of equation (5) are either positive, negative or ambiguous.

Term A is given by,

$$A \equiv (1+r)^{-k} \underbrace{\int_{-\infty}^{S}\int_{-\infty}^{\infty} U(W_k+Y_k)f(T_1, Y_k)dT_1dY_k}_{\text{(which is failure in the first period)}} + \underbrace{\int_{S}^{\infty}\int_{-\infty}^{\infty} U(W_k+Y_k+B(T_1))f(T_1, Y_k)dT_1dY_k}_{\text{(which is success in the first period)}} \quad \text{(A-1)}$$

where $f(T_1, Y_k)$ stands for the joint density function of T_1 and Y_k which are, of course, dependent (recall that T_1 is the performance index of the previous k years, including the k^{th} year whose income is Y_k). Namely, if $T_1 \leq S$ no bonus is paid while if $T_1 > S$ a bonus, $B(T_1)$ is paid, which is a function of T_1. The larger the observed performance measure, T_1, the larger the bonus paid when the first contract is terminated. The term B is given by,

$$B \equiv \sum_{t=k+1}^{2k-1} (1+r)^{-t}[\int_{-\infty}^{\infty} f(Y_t) \{ \underbrace{\int_{-\infty}^{D} g(T_1)U(W_t+Y_t-\Phi(T_1))dT_1}_{\text{(which is failure in the first period)}}$$

$$+ \underbrace{\int_{D}^{S} g(T_1)U(W_t+Y_t)dT_1}_{\text{(which is standard performance in the first period)}} + \underbrace{\int_{S}^{\infty} g(T_1)U(W_t+Y_t+\Psi(T_1))dT_1\}dY_t]}_{\text{(which is success in the first period)}} \quad \text{(A-2)}$$

Note that years k+1 up to year 2k correspond to the new (second) contract. If in the first cycle $T_1 < D$ (hence the integral is $-\infty$ to D) the new base salary is reduced by $\Phi(T_1)$. If $T_1 > S$ (hence the integral is from S to ∞), the agent was successful in the first period, hence in the new contract, the base salary increases by $\Psi(T_1)$. In the case of the standard performance $D \leq T_1 \leq S$ (hence the integral is from D to S), the base salary is unchanged.

The function $g(T_1)$ and $f(Y_t)$ are the density functions of T_1 and Y_t, respectively. Here it is reasonable to assume that Y_t (corresponding to years k+1, ..., 2k–1) is independent of T_1. However, existing dependency, like in term A above, would not change the results (see the analysis of term A below).

The term C corresponding to year 2k (the last year of the second contract) is more complicated since it incorporates the possible changes in the base salary (a function of the performance in the first period (T_1) and a possible bonus in case that the agent is successful in the second period, namely that the performance index T_2 is greater than

S). Thus, we have to consider all combinations of the three ranges of T_1 and T_2 which determine the bonus in year 2k. Consequently, C has six terms and is given by,

$$C \equiv (1+r)^{-2k}\{ \int_{-\infty}^{D} g(T_1) \int_{-\infty}^{\infty} \int_{-\infty}^{S} g(T_2, Y_{2k})U(W_{2k}+Y_{2k}-\phi(T_1))dT_1dT_2dY_{2k}$$

(which is failure in the first period and no success in the second period)

$$+ \int_{D}^{S} g(T_1) \int_{-\infty}^{\infty} \int_{-\infty}^{S} g(T_2, Y_{2k})U(W_{2k}+Y_{2k})dT_1dT_2dT_{2k}$$

(which is standard performance in the first period and no success in the second period)

$$+ \int_{S}^{\infty} g(T_1) \int_{-\infty}^{\infty} \int_{-\infty}^{S} g(T_2, Y_{2k})U(W_{2k}+Y_{2k}\Psi(T_1))dT_1dT_2dY_{2k}$$

(which is success in the first period and no success in the second period)

$$+ \int_{-\infty}^{D} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{\infty} g(T_2, Y_{2k})U(W_{2k}+Y_{2k}-\phi(T_1) + B(T_2)dT_1dT_2dY_{2k}$$

(which is failure in the first period and success in the second period)

$$+ \int_{D}^{S} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{\infty} g(T_2, Y_{2k})U(W_{2k}+Y_{2k}+B(T_2))\, dT_1dT_2dY_{2k}$$

(which is standard performance in the first period and success in the second period)

$$+ \int_{S}^{\infty} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{\infty} g(T_2, Y_{2k})U(W_{2k}+Y_{2k}\Psi(T_1)+B(T_2))\, dT_1dT_2dY_{2k}\}$$

(which is success in both the first period and the second period.)

(A-3)

If $\Delta = 0$ no social costs are incurred. Denote by Δ_i (i=1,2,3) the expected utility difference corresponding to the k^{th} year, k+1 up to 2k–1 years, and $2k^{th}$ year respectively. Hence Δ of equation (5) is $\Delta = \Delta_1 + \Delta_2 + \Delta_3$.

Ignoring the discount factor (which is common in both terms) we have,

$$\Delta_1 = \int_{-\infty}^{\infty} U(W_k+Y_k)f(Y_k)dY_k-A$$

Since the first term is independent of T_1, adding the integral over T_1 does not change the results since it is like multiplying the first term +1, Δ_1 can be rewritten as

$$\Delta_1 = \int_{-\infty}^{\infty} \int_{-\infty}^{\infty} U(W_k+Y_k)f(T_1, Y_k)dT_1dY_k-A$$

Substituting for A (see equation (A-1)), yields, where the first term is the expected utility of the principal in the k^{th} year and the second term is the expected utility of the agent from the income in this year

$$\Delta_1 = \int_S^{\infty} \int_{-\infty}^{\infty} \{U(W_k+Y_k) - U(W_k+Y_k+B(T_1)\} f(T_1, Y_k)dT_1dY_k$$

(which is success in the first period) (A-4)

since the integral over the range $(-\infty, S)$ cancels out. (Therefore the first term of A, see equation (A-1), vanishes and the integral of the first term of Δ_1 is from S to ∞ rather than $-\infty$ to ∞). Let us turn to the term Δ_2. (Once again, ignore the common discount factor.)

$$\Delta_2 = \sum_{t=k+1}^{2k-1} EU(W_t+Y_t) - B$$

$$= \sum_{t=k+1}^{2k-1} \int_{-\infty}^{\infty} f(Y_t)(\int_{-\infty}^{D} g(T_1)U(W_t+Y_t)dT_1 + \int_D^S g(T_1)U(W_t+Y_t)dT_1$$

$$+ \int_S^{\infty} g(T_1)U(W_t+Y_t)dT_1)dY_t - B$$

Thus, we multiply $EU(W_t + Y_t)$ by $\int_{-\infty}^{\infty} g(T_1)dT_1 = 1$ and break the last integral into three integration intervals (namely,

$$\int_{-\infty}^{\infty} g(T_1)B(T_1) = \int_{-\infty}^{D} g(T_1)B(T_1) + \int_D^S g(T_1)B(T_1) + \int_S^{\infty} g(T_1)B(T_1)).$$

Plugging in the three terms corresponding to B, the integral over in range (D,S) cancels out, and what is left is,

$$\Delta_2 = \sum_{t=k+1}^{2k-1} \int_{-\infty}^{\infty} f(Y_t)\{ \int_{-\infty}^{D} g(T_1)[U(W_t+Y_t) - U(W_t+Y_t-\Phi(T_1)]dT_1$$

(which is failure in the first period)

(A-5)

$$- \int_S^{-\infty} g(T_1)[U(W_t+Y_t+\Psi(T_1)-U(W_t+Y_t)]\, dT_1\}dY_t$$

(which is success in the first period)

Note that the first term corresponds to failure of the manager in the first period while the second term corresponds to success during this period. In the case of standard performance in the first period $D \leq T_1 \leq S$, no increase or decrease in the agent's wage takes place. The analysis of Δ_3 is more complicated since it includes more terms. First rewrite $EU(W_{2k} + Y_{2k})$ as,

$$EU(W_{2k}+Y_{2k}) \equiv (1+r)^{-2k}\{ \int_{-\infty}^{D} g(T_1) \int_{-\infty}^{\infty} \int_{-\infty}^{S} g(T_2, Y_{2k})U(W_{2k}+Y_{2k})dT_1dT_2dY_{2k}$$

(which is failure in the first period and no success in the second period)

$$+ \int_{D}^{S} g(T_1) \int_{-\infty}^{\infty} \int_{-\infty}^{S} g(T_2, Y_{2k})U(W_{2k}+Y_{2k})dT_1dT_2dY_{2k}$$

(which is standard performance in the first period and no success in the second period)

$$+ \int_{S}^{\infty} g(T_1) \int_{-\infty}^{\infty} \int_{-\infty}^{S} g(T_2, Y_{2k})U(W_{2k}+Y_{2k})dT_1dT_2dY_{2k}$$

(which is success in the first period and no success in the second period)

$$+ \int_{-\infty}^{D} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{\infty} g(T_2, Y_{2k})U(W_{2k}+Y_{2k})dT_1dT_2dY_{2k}$$

(which is failure in the first period and success in the second period)

$$+ \int_{D}^{S} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{\infty} g(T_2, Y_{2k})U(W_{2k}+Y_{2k})dT_1dT_2dY_{2k}$$

(which is standard performance in the first period and success in the second period)

$$+ \int_{S}^{\infty} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{\infty} g(T_2, Y_{2k})U(W_{2k}+Y_{2k})dT_1dT_2dY_{2k}$$

(which is success in both periods.) (A-6)

Note that to achieve this result we simply multiply $EU(W_k + Y_k)$ by $\int_{-\infty}^{\infty} g(T_1)dT_1 = 1$ and as before we break the integral into three ranges $(-\infty, D)$, (D,S), and (S,∞). Also we integrate the joint density function $g(T_2, Y_{2k})$ over the whole range of T_2 and since T_2 does not appear in the utility we simply obtain the marginal density function $g(Y_{2k})$. (Recall from statistics that by definition $\int_{-\infty}^{\infty} g(T_2, Y_{2k})dT_2dY_{2k} = g(Y_{2k})$.)[108] We decompose the left term of equation (A-6) into six terms which are parallel in the integration ranges to the six terms given in equation (A-3). Hence, an analysis of Δ_3 is possible. In calculating Δ_3 (ignoring the discount factor), the integral over one range $D_1 \leq T_1 \leq S$, $-\infty < T_2 \leq S$ cancels out and the following terms are left,

$$\Delta_3 = \int_{-\infty}^{D} g(T_1) \int_{-\infty}^{\infty} \int_{-\infty}^{S} g(T_2, Y_{2k})[U(W_{2k}+Y_{2k}) - U(W_{2k}+Y_{2k}-\Phi(T_1))]dT_1dT_2dY_{2k} \quad \text{(A)}$$

(which is failure in the first period and standard performance in the second period)

$$- \int_{S}^{\infty} g(T_1) \int_{-\infty}^{\infty} \int_{-\infty}^{S} g(T_2, Y_{2k})[U(W_{2k}+Y_{2k}+\Psi(T_1)) - U(W_{2k}+Y_{2k})]dT_1dT_2dY_{2k} \quad \text{(B)}$$

(which is success in the first period and no success in the second period)

108. *See* MOOD & GRAYBILL, *supra* note 26, at 91 equation 4.

$$+\int_{-\infty}^{D} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{\infty} g(T_2, Y_{2k})[U(W_{2k}+Y_{2k}) - U(W_{2k}+Y_{2k}-\Phi(T_1+)B(T_2)]dT_1 dT_2 dY_{2k} \quad \text{(C)}$$

(which is failure in the first period and no success in the second period)

(A-7)

$$+\int_{D}^{S} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{-\infty} g(T_2, Y_{2k})[U(W_{2k}+Y_{2k}) - U(W_{2k}+Y_{2k}+B(T_2))]dT_1 dT_2 dY_{2k} \quad \text{(D)}$$

(which is failure in the first period and success in the second period)

$$-\int_{S}^{\infty} g(T_1) \int_{-\infty}^{\infty} \int_{S}^{\infty} g(T_2, Y_{2k})[U(W_{2k}+Y_{2k}+\Psi(T_1)+B(T_2)) - U(W_{2k}+Y_{2k})]dT_1 dT_2 dY_{2k} \quad \text{(E)}$$

(which is success in the first period and success in the second period)

In calculating Δ_1, Δ_2, Δ_3 we deal with the most general case when the penalty and the bonus exist. However, by inserting $B(T_1) = B(T_2) = 0$ we can analyze a compensation scheme with no bonuses. By inserting $\Psi(T_1) = 0$, we have the formula for a compensation scheme with no increase in wages in the second cycle, and finally by inserting $\Phi(T_1) = 0$, we have a compensation scheme with no penalty.