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On the Use of Nonfinancial Performance Measures in Management Compensation

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Abstract

It is often claimed that (i) managers work too hard on operational issues and do not spend enough effort on strategic activities and (ii) something can be done about this by introducing nonfinancial performance measures as for instance with a balanced scorecard. We give an explanation for both claims in a formal model. The distortion towards operational effort arises, because with financial performance measures strategic effort can only be rewarded in the future. But renegotiation-proof long term compensation plans entail too weak variable components in the future. This problem can be reduced by introducing performance measures that help to disentangle strategic and operational effects.

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1 Introduction

It has often been claimed in the management and accounting literature as well as in the business press[1] that managers seem to be too short-term oriented, that they neglect strategic activities and spend too much effort on improving current results. In this paper a simple formal model is developed to provide one explanation for this claim. We will argue that there is an inherent distortion in the optimal compensation for the manager if it is only based on financial performance measures. This distortion leads to an overprovision of effort for operational and an underprovision of effort for strategic tasks. This is due to the following effect: the total impact of a strategic activity can only be captured by a financial performance indicator after some time has passed. Financial indicators are *lagging* indicators of many aspects of organizational performance. If, for instance, a manager exerts effort to look for new business opportunities, this will positively affect financial indicators, like the firm's profit or cash flow only after some time has elapsed. Hence, future compensation should encompass some additional variability to provide incentives for current strategic activities. But once the effort for the strategic activity has been exerted and, hence, the costs of this effort are sunk, both contracting parties have a common interest to reduce the uncertainty in a risk averse manager's compensation. As this is anticipated by the manager he will underinvest in strategic activities. Therefore, any renegotiation-proof or time-consistent compensation plan entails incentives that are too weak as compared to a full commitment solution.

The firm may improve incentives for the strategic activity to some extend, by raising current variable compensation. But this in turn leads to an overinvestment in current operational activities, as the effects of operational and strategic activities on current financial indicators cannot be separated. It is exactly the last point that indicates how this problem may be partially resolved. If there are performance measures available that help to disentangle the effects of strategic and operational activities one could hope to set appropriate incentives for both. This

[1] For an overview see for instance the discussion in Hauser, Simester and Wernerfelt (1994).

may give an additional argument for the increasing importance of nonfinancial performance measures in management compensation. Nonfinancial indicators as for instance customer satisfaction or employee satisfaction ratings, the number of patents awarded to a research unit and so on are useful because they may be appropriate *leading* indicators of strategic performance.

We present a simple model, where a manager is employed in two periods and spends effort on an operational and a strategic activity. Whereas the effort on the operational activity has only an impact on current profits, the effort on the strategic activity also influences the next period's results. In a first part we assume that profit is the only performance measure on which the manager's compensation can be based. We start by solving for the optimal contract with full commitment. Then we analyze the effects of a possible renegotiation of the compensation contract after the first period. We will show that both parties will agree to reduce the variable part of the manager's compensation in this case. Taking this into account, we compute the optimal renegotiation-proof compensation contract, restricting the analysis to contracts that implement effort choices in pure strategies. It turns out, that as a response to reduced second period variable compensation, the contract entails a higher variable compensation in the first period. This is indeed done to mitigate the loss of strategic incentives. After the computation of the optimal contract, we examine its effect on managerial behavior and show that an underprovision of strategic and an overprovision of operational effort will result in the first period relative to the full commitment case. If the long-term return to the strategic activity is sufficiently large, the manager will even spend more on the operational activity than in the first-best solution.

To examine more closely whether additional nonfinancial performance measures may help to solve this problem, we will introduce an additional signal, that only measures the effort spent on the strategic activity. It will be constructed in such a way that it will never receive a positive weight in the full commitment case as it contains more noise than actual profits. We then show that the measure receives a positive weight in the manager's compensation when the contract has to be renegotiation-proof. The typical argument given in the literature for the application of nonfinancial measures is that they might provide more information on an agent's action and, hence, help to reduce uncertainty and, therefore, risk premia that have to be paid to the agent.[2] We do not want to contradict this argument but to strengthen it in one respect: Even a performance measure that will not get a positive weight in an optimal contract with full commitment will get a positive weight if commitment is infeasible.

There are of course other explanations for short-term orientation of managers. Naranayan (1985) considers managerial career concerns as a reason for short-term orientation. Stein (1989), Chen (1993) or Brandenburger and Polak (1996) show that share price maximization distorts decision-making in publicly traded companies.

The idea that renegotiation leads to a reduction of risk in a hidden action setting has first been analyzed by Fudenberg and Tirole (1990). They examine a one-period hidden action model, in which the contract can be renegotiated after the agent has chosen his unobservable effort but before the payments prescribed by the initial contract are made. They show, that if the principal makes a take-it-or-leave-it offer, renegotiation leads to a welfare loss.[3]

Distortions in performance measurement systems have been analyzed in static multitask agency models by Feltham and Xie (1994) and Datar, Kulp and Lambert (2001). They have stressed the importance of attaining a high congruence between the agents compensation as determined by the performance measurement system and the principal's objective function for generating appropriate undistorted incentives. In our dynamic model we show that, although a perfectly congruent performance measure is available—namely the principal's profit —renegotiation

[2]Much of the accounting literature refers to Holmström (1979) in this respect. See also Banker/Datar (1989), Feltham/Xie (1994) or the discussion in Injejikian (1999).

[3]However, the principal can implement more than the least cost action, as the agent may play a mixed strategy and the principal can offer a menu of contracts for screening reasons, of which one still contains some uncertainty. Ma (1994) shows that the first-best may be attained, if the agent makes a take-it-or-leave-it offer at the renegotiation stage. Hermalin and Katz (1991) show that the first-best can also be attained with renegotiation, if the agent's action is unverifiable but observable by the principal.

limits the possibility of achieving congruence.

Other studies that analyze the combination of financial and nonfinancial performance measures are Hemmer (1996) and Hauser, Simester and Wernerfelt (1994). Both papers have in common with our approach that nonfinancial measures help to overcome incentive problems caused by an agent's short-term orientation. But whereas in those papers agents are short-term oriented by assumption[4], in our paper short-termism arises endogenously due to renegotiation of the incentive contract.

The use of nonfinancial indicators in organizational performance measurement has been popularized with the concept of the Balanced Scorecard proposed by Kaplan and Norton (1996), postulating that firms should use a balanced set of financial and nonfinancial indicators to measure organizational performace. In Kaplan and Norton (2001) the authors report case study evidence on companies implementing explicit compensation schemes based on performance measures in the balanced scorecard. There is some recent econometric evidence on the use of nonfinancial performance measures consistent with the results of this paper. Ittner, Larcker and Rajan (1997) examine the use of nonfinancial performance measures in compensation plans by analyzing a sample of firms that explicitly determine their CEO's compensation as a function of performance measures. First of all, 36% of the firms in their sample employ nonfinancial measures. Most interestingly, they find strong evidence that firms following an innovation oriented strategy[5] place a higher weight on nonfinancial measures in executive compensation, which is in line with our prediction, that the nonfinancial measure will be used when the importance of the strategic activity is sufficiently large. Bushman, Indjejikian and Smith (1996) investigate the importance of individual performance

[4]Hemmer (1996) analyzes a static model, where the agent's short-termism is modelled by assuming that a part of the firm's income is realized in the future and cannot be used in an incentive contract. Hauser, Simester and Wernerfelt (1994) assume that agents have a lower discount factor than the firm.

[5]As indicators for an innovation oriented strategy they apply the ratio of research and development to sales, the market-to-book ratio, the ratio of employee to sales and the number of new products and services.

evaluation of CEOs in their compensation plans as opposed to performance measures at the corporate, group, divisional or plant levels. Hence, individual performance evaluation in their definition comprises nonfinancial performance measures as well as subjective performance evaluation of a CEO by the board and excludes corporate or group profits. They find evidence that individual performance evaluation increases with growth opportunities and product time horizons.[6] Both factors can be viewed as corresponding to the long-term return of the strategic activity in our model. Banker, Potter and Srinivasan (2000) have analyzed time series data of performance measures within a firm before and after the introduction of nonfinancial performance measures in management compensation. They find strong evidence for increased values of financial as well as nonfinancial measures after a hotel chain introduced explicit weights on nonfinancial measures in its managers' compensation plans.[7]

2 The Model

We analyze in this paper a two period Holmström/Milgrom-type or LEN model. That is, contracts are linear, utility functions are exponential (i.e. agents have constant absolute risk aversion) and noise terms are normally distributed.[8]

A manager works for a firm in two consecutive periods $t \in \{1, 2\}$. Think of such a period as the duration of time for which a manager's compensation is determined. In each period he exerts two types of effort, one on an operational and one on a strategic activity. The effort spent on the operational activity is e_t,

[6] In their paper growth opportunities of a firm are measured by its market-to-book ratio. To examine the impact of time horizon, Bushman, Indjejikian and Smith categorize firms into short or long time horizon types, applying a classification scheme for industries based on development cycle time and product life cycle time.

[7] See the conclusion of this paper for an additional discussion of their results.

[8] See for instance Holmström and Milgrom (1987, 1991), Spremann (1987). Holmström and Milgrom (1987) have shown that the optimality of linear contracts can be derived in a more general setting, where an agent controls the drift rate of a stochastic process by his effort. For applications in the area of performance measurement see for instance Feltham and Xie (1994), Datar, Kulp and Lambert (2001), Wagenhofer (1999) or Dutta and Reichelstein (1999).

it affects the firm's profits only in the actual period. The effort for the strategic activity is i_t. Contrary to the operational effort the strategic effort in period 1 also affects profits in period 2. Think for instance of the operational effort as being spent on tasks like short-run promotion activities or immediate cost reductions whereas the strategic activity may contain the effort spent on finding new business opportunities, investing in a good long-term relationship with the firm's clients or the own employees and so on.

The firm's gross profits π_t are verifiable and, hence, the manager's compensation can be based upon them. In periods 1 and 2 they are given by[9]

$$\begin{aligned} \pi_1 &= \kappa e_1 + \theta_1 i_1 + \varepsilon_1 \text{ and} \\ \pi_2 &= \kappa e_2 + \theta_1 i_2 + \theta_2 i_1 + \varepsilon_2. \end{aligned}$$

Hence, κ is the marginal return of effort for the operational activity, whereas θ_1, θ_2 determine the marginal return profile of the strategic activity in both periods. That is, each unit of strategic effort spent in period 1 gives the firm a return of θ_1 in period 1 and θ_2 in period 2. All marginal returns are assumed to be positive. In addition, total profits in each period are also affected by some random noise term ε_t. We assume that ε_1 and ε_2 are stochastically independent with identical normal distribution with variance σ^2 and zero mean. In the first part of the paper gross profits are the only available performance measure.

The manager's costs for the two activities are given by a simple additively separable quadratic cost function

$$c\left(e_t, i_t\right) = \frac{1}{2} e_t^2 + \frac{1}{2} i_t^2.$$

Hence, the marginal costs for one activity are not affected by the effort spent on the other activity. The manager has a utility function with constant absolute risk aversion, which for income w_t and effort costs c_t in periods 1 and 2 is given by

$$u\left(w_1 - c_1, w_2 - c_2\right) = -\exp\left(-r\left(w_1 - c_1\right)\right) - \delta \exp\left(-r\left(w_2 - c_2\right)\right),$$

[9]It has been shown that the key results of this paper continue to hold in an example with a technology where strategic and operational efforts are perfect complements. The formal analysis of this example can be requested from the author. I thank an anonymous referee for pointing in that direction.

where r is the Arrow-Pratt measure of absolute risk aversion. Future utility is discounted by the manager with a factor $\delta \in (0,1]$. Furthermore, we assume that he has unrestricted access to the capital market, hence, he can borrow or lend money to smooth his consumption. In each period he has a deterministic reservation income of $\bar{w}$.

The manager's compensation is linear in first and second period profits. Hence, a long-term contract specifies a fixed wage α_t for each period and a variable bonus coefficient β_t. The manager's income in period t is then[10]

$$w_t = \alpha_t + \beta_t \pi_t. \tag{1}$$

As usual the firm is supposed to be risk neutral and we assume that it discounts future profits at the same rate δ as the agent. Total net profits of the firm are then given by

$$\Pi = \pi_1 - w_1 + \delta \left(\pi_2 - w_2 \right). \tag{2}$$

If both parties can commit to a long-term contract, the manager's compensation is now determined by maximizing Π taking into account the manager's optimal effort choice given his compensation package and a participation constraint.

We impose the additional assumption that the agent is infinitely lived after the end of the contract and still consumes his savings over time. Due to this assumption, the exponential utility function, normality of noise terms and linearity of the manager's compensation as well as the unrestricted access to the capital market, the manager's utility can be expressed as follows[11]

$$\begin{aligned} -\frac{1}{1-\delta} \exp \quad & \left(-r\left(1-\delta\right) \left[w_1 - c_1 - \frac{1}{2} r \left(1-\delta\right) V\left[w_1\right] \right.\right. \\ & \left.\left. + \delta \left(w_2 - c_2 - \frac{1}{2} r \left(1-\delta\right) V\left[w_2\right] \right) \right] \right). \end{aligned} \tag{3}$$

[10]Note that there is no need to make second period compensation contingent on first period profit: As firm and agent discount with the same factor and the agent has unrestricted access to the capital market at a corresponding interest rate, the same effect can be attained by increasing first period variable compensation β_1.

[11]$V\left[w_1\right]$ denotes the variance of w_t. For the proof of this result see Dutta and Reichelstein (1999) or Sliwka (2000) .

Hence, utility of different uncertain income streams of an agent can be compared simply by comparing the expression in square brackets. A mean-variance formulation for an intertemporal certainty equivalent of the agent's utility is obtained. This, in a way extends the well known results for the static model. Note that here the agent's risk premia are multiplied by $(1-\delta)$. The agent is less risk averse, as he can smooth consumption over time.

3 The Optimal Long-term Contract

In this section we derive the optimal contract when the firm and the manager can commit to a long-term compensation scheme and will not renegotiate this scheme after the end of the first period. First, as a benchmark we compute the first-best strategic and operational effort levels in both periods. To obtain those we simply maximize the expected sum of discounted gross profits $\pi_1 + \delta\pi_2$ minus the costs of effort, that is

$$\max_{e_1,i_1,e_2,i_2} \kappa e_1 + \theta_1 i_1 - \frac{1}{2}e_1^2 - \frac{1}{2}i_1^2 + \delta\left(\kappa e_2 + \theta_1 i_2 + \theta_2 i_1 - \frac{1}{2}e_2^2 - \frac{1}{2}i_2^2\right).$$

Due to our simple specification of the cost function this yields the following optimal values for the manager's strategic and operational effort in both periods:

$$\begin{aligned} e_1^{FB} &= e_2^{FB} = \kappa, \\ i_1^{FB} &= \theta_1 + \delta\theta_2, \\ i_2^{FB} &= \theta_1. \end{aligned}$$

First-best operational effort simply corresponds to the marginal return to operational effort, first-best strategic effort to its discounted sum of marginal returns in both periods.

To obtain the second-best long-term contract, we have to consider the manager's incentive compatibility and participation constraints. In each period the manager maximizes his expected utility for a given compensation scheme. Note that the effort choice has no impact on the uncertainty of the manager's income.

Hence, in the second period he simply solves

$$\max_{e_2,i_2} \left(\kappa e_2 + \theta_1 i_2 + \theta_2 i_1^*\right) \beta_2 - \frac{1}{2} e_2^2 - \frac{1}{2} i_2^2.$$

Of course, at this point in time the first period strategic effort i_1 is already given. Due to the linear formulation of the model the size of i_1 has no impact on second period effort choices. In the first period, however, the agent takes into account the effect of his strategic effort choice on the expected second period compensation. Hence, he maximizes the following function:

$$\begin{aligned} \max_{e_1,i_1} \quad & \left(\kappa e_1 + \theta_1 i_1\right) \beta_1 - \frac{1}{2} e_1^2 - \frac{1}{2} i_1^2 \\ & + \delta \left(\left(\kappa e_2^* + \theta_1 i_2^* + \theta_2 i_1\right) \beta_2 - \frac{1}{2} e_2^{*2} - \frac{1}{2} i_2^{*2} \right). \end{aligned}$$

The solution of these equations gives us the following incentive compatibility constraints, stating the choice of strategic and operational efforts as a function of the compensation scheme:

$$\begin{aligned} e_2^* &= \kappa \beta_2, & (IC_2) \\ i_2^* &= \theta_1 \beta_2, \\ e_1^* &= \kappa \beta_1 \text{ and} & (IC_1) \\ i_1^* &= \theta_1 \beta_1 + \delta \theta_2 \beta_2. \end{aligned}$$

Furthermore, the principal has to take into account that the manager's total expected utility must exceed the utility of his reservation wage, that is the expression in square brackets in (3) has to be greater or equal than the discounted sum of the manager's reservation wage given by $(1 + \delta)\,\bar{w}$. As usual the participation constraint must hold with equality. Otherwise, the fixed wages α_t could be reduced without violating any constraint and this would raise the principal's utility. Hence, one can solve for the discounted sum of fixed wages α_t and substitute this in the principal's objective function (2). Similar to the static model, the principal's objective function is equal to the total expected surplus less the risk premia that have to be paid to the agent. The optimal bonus coefficients β_1 and β_2 are obtained by maximizing this objective function subject to the incentive compatibility constraints (IC_1) and (IC_2), that is

$$\begin{aligned} \max_{\beta_1,\beta_2} \quad & \kappa e_1 + \theta_1 i_1 - \frac{1}{2}e_1^2 - \frac{1}{2}i_1^2 - \frac{1}{2}r\left(1-\delta\right)\beta_1^2\sigma^2 \\ & +\delta\left(\kappa e_2 + \theta_1 i_2 + \theta_2 i_1 - \frac{1}{2}e_2^2 - \frac{1}{2}i_2^2 - \frac{1}{2}r\left(1-\delta\right)\beta_2^2\sigma^2\right) \\ \text{s.t.} \quad & (IC_1), (IC_2). \end{aligned} \tag{4}$$

The solution of this problem leads to the following result:

Proposition 1 *In the optimal long-term contract the first and second period bonus coefficients (β_1^*, β_2^*) solve the following system of equations*

$$\begin{aligned} \beta_1^* &= \frac{\kappa^2 + \theta_1^2 + \delta\theta_1\theta_2\left(1-\beta_2^*\right)}{\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2}, \\ \beta_2^* &= \frac{\kappa^2 + \theta_1^2 + \delta\theta_2^2 + \theta_1\theta_2\left(1-\beta_1^*\right)}{\kappa^2 + \theta_1^2 + \delta\theta_2^2 + \left(1-\delta\right)r\sigma^2}. \end{aligned} \tag{5}$$

There is always underinvestment in strategic and operational effort in the first period.

Proof: See Appendix.

For the explicit solution for the two coefficients also refer to the Appendix. We only give the equations (5) here, as these are more directly interpretable. First, note that both bonus rates are partial substitutes, both can in principle be used to augment the incentives for the strategic task in period 1, as effort for this task affects first and second period gross profits. This can be directly seen from equations (5). The optimal first period rate β_1^* is decreasing in β_2^* as well as vice-versa. The higher the second period rate, the lower can be the first period rate to elicit appropriate incentives for the strategic activity. Furthermore, note that this is only true if the strategic effort has an impact on first and second period profits, i.e. θ_1 and θ_2 are both strictly positive. Otherwise the rates for both periods are set independently. In addition, note that if β_2^* had the value one for some reason, the expression for β_1^* would be completely independent from the value of θ_2. If first-best incentives are set for the second period consequences of the manager's effort choice, the first period rate is only determined by first period incentive considerations.

The underinvestment result is of course due to the manager's risk aversion. For small values of the Arrow-Pratt-measure of absolute risk aversion r the bonus rates β_1 and β_2 tend to one, therefore both strategic and operational efforts tend to the first-best values. For $r = 0$ the first-best efforts are achieved.

Feltham and Xie (1994) for a single performance measure and Datar, Kulp and Lambert (2001) for multiple measures have stressed that one important aspect which has to be considered when designing an optimal incentive scheme is the congruity[12] between the total outcome and the agent's compensation. As Datar, Kulp and Lambert (2001) argue, congruence can be raised if the weights for different performance measures in the agent's compensation can be adapted in such a way to replicate the effect of his actions on the total outcome. If we transfer their idea to the dynamic case considered in our paper there are two performance measures (first and second period profits) and the outcome is just the discounted sum of both profits. Therefore, perfect congruity is achieved if full commitment is feasible. In this sense profit does not perform too bad as a performance measure if both parties can commit to a long-term compensation package. The agent's variable compensation in the future is determined taking into account the effect on strategic effort in the preceding period. By exerting more effort on strategic activities in the present, the manager increases future profits and he knows that he will get an appropriate share of those profits. But, if both parties are not able to commit to a long-term compensation scheme, this picture changes as we will see in the next section.

[12]Datar, Kulp and Lambert (2001) propose the sum of squared distances between the slope of the firm's outcome and the slope of the agent's compensation with respect to his actions as a measure of non-congruity.

4 On the Negligence of Strategic Activities

4.1 Reducing Variable Compensation

Now consider the situation in which the manager has signed the long-term contract as described in the previous section. Suppose that, at the beginning of period 2, both parties reconsider the compensation scheme. Note that the value of β_2^*, the manager's second period variable compensation, is partly explained by its incentive effect on first period strategic effort. But the manager has already exerted his first period strategic and operational efforts and the costs for both are sunk. So, why not reduce β_2^* to some extend, taking only into account its effect on second period incentives? The manager can be compensated for his loss in variable compensation by a higher fixed payment. As he is risk averse this should lead to a Pareto-improvement.

We restrict the analysis to equilibria in pure strategies and assume that the principal makes a take-it-or-leave-it offer to the agent at the beginning of period 2. To see the impact of renegotiations formally, consider the total surplus created in the second period, given that the first period strategic effort has been i_1^*:

$$\kappa e_2 + \theta_1 i_2 + \theta_2 i_1^* - \frac{1}{2} e_2^2 - \frac{1}{2} i_2^2 - \frac{1}{2} r \left(1 - \delta\right) \beta_2^2 \sigma^2.$$

Now, of course, the first period incentive constraints can be ignored and only the second period incentive constraints have to be taken into account to determine the optimal value of β_2. Recall that they are given by $e_2 = \kappa \beta_2$ and $i_2 = \theta_1 \beta_2$. Solving this program yields the following result:

Lemma 1 *If both parties can adapt the compensation scheme before the beginning of period 2, they will change the second period variable compensation. The optimal variable compensation rate in period 2 of any renegotiation-proof contract is given by*

$$\beta_2^R = \frac{\kappa^2 + \theta_1^2}{\kappa^2 + \theta_1^2 + r\left(1 - \delta\right) \sigma^2}. \tag{6}$$

It is smaller than the bonus rate β_2^* with full commitment.

Proof: See Appendix.

To give an intuition for this result we separate the total effect of a change in β_2 into its impact on incentives on the one hand, and on the risk premium on the other hand. As long as there is underinvestment in strategic effort—which is always the case as we have seen in Proposition 1—the marginal impact of β_2 on incentives is positive. Furthermore, from the perspective of period 1 the marginal impact of β_2 on incentives is composed of its effect on second period as well as first period effort. But from the perspective of period 2 only its effect on second period incentives matters. Hence, the marginal return on the incentive side from an increased β_2 is lower from the perspective of period 2. On the other hand, the marginal cost due to a higher risk premium for the uncertainty from β_2 is unchanged. Therefore, the variable compensation will be reduced in the second period.[13]

Clearly, this has an impact on first period incentives of the manager. As he will get a smaller variable compensation in period 2 we should expect, that he will exert less effort on strategic activities. But the principal will of course anticipate renegotiation and adapt the first period contract and take into account those effects. To see how the first period contracting changes when the parties may change the compensation plan after the first period, we now look for the optimal renegotiation-proof long-term contract. Therefore program (4) has to be solved with an additional renegotiation-proofness condition which boils down to imposing that $\beta_2 = \beta_2^R$. This yields the following result:[14]

[13]Note that we restricted the analysis to a pure strategy equilibrium. Hence, the agent and the principal both know in equilibrium the first period strategic effort exerted by the agent. If mixed strategy equilibria were taken into account, the negotiations before period 2 would be under asymmetic information, as the principal would not know the effort exerted by the agent in the first period. See Fudenberg and Tirole (1990) for a model where mixed strategy equilibria are taken into account and, hence, renegotiation under asymmetric information is analyzed.

[14]Again, we give the explicit value of β_1^R in the Appendix, as the expression for β_1^R as function of β_2^R given here is more directly interpretable.

Proposition 2 *In the optimal renegotiation-proof contract the first and second period bonus coefficients solve the following equations:*

$$\begin{aligned} \beta_1^R &= \frac{\kappa^2 + \theta_1^2 + \delta\theta_1\theta_2\left(1-\beta_2^R\right)}{\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2}, \\ \beta_2^R &= \frac{\kappa^2 + \theta_1^2}{\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2}. \end{aligned} \tag{7}$$

The second period variable compensation is lower, the first period variable compensation is higher than in the full-commitment case.

Proof: See Appendix.

Note that for a given β_2 the choice of β_1 is unaffected by the renegotiation possibility: The expression for β_1^R in (7) as a function of β_2 corresponds exactly to the expression for the long-term contracting case in (5). As we have seen in the preceeding section, the present and future variable compensation rates β_1 and β_2 are (of course imperfect) substitutes for generating strategic incentives: the optimal value of β_1 is a decreasing function of β_2. It becomes immediately clear from this fact, that the firm will respond to reduced second period variable compensation by increasing the first period rate. This will partially compensate for the loss in strategic incentives.

But certainly this comes at a cost. A higher value of the present variable compensation not only increases incentives for the strategic, but also those for the current operational activity. Those two effects cannot be disentangled, hence, a distortion in the incentive system will arise.

4.2 Managerial Behaviour

We can now examine the effects of the reduction of future variable compensation on the manager's behaviour. To do this we have to insert the optimal values for the variable compensation rates into the agent's reaction function given in the incentive compatibility conditions (IC_1) and (IC_2). Recall that the manager's effort choice is determined by

$$\begin{aligned} e_2 &= \kappa\beta_2, \\ i_2 &= \theta_1\beta_2, \\ e_1 &= \kappa\beta_1 \text{ and} \\ i_1 &= \theta_1\beta_1 + \delta\theta_2\beta_2. \end{aligned}$$

First of all, it is clear that the second period efforts for the strategic as well as the operational activity are reduced, as β_2^R is smaller than β_2^*. More interesting are the effects on first period incentives. As we have seen above, the first period variable compensation β_1 is increased, hence the manager will exert more effort on the operational activity as the choice of e_1 only depends on β_1. The effect on the strategic activity cannot be directly seen from the equation above. On the one hand, β_2 and therefore the future return to effort for strategic activities is lower. On the other hand, the present return determined by β_1 is increased. We show in the Appendix that the second effect is always dominated by the first. First, we want to state a result which summarizes those considerations. After that we give some additional intuition for these claims.

Corollary 1 *The renegotiation-proof compensation scheme has the following properties*
(i) There will be lower second period efforts than in the full-commitment case.
(ii) In the first period there is always an overprovision of operational and underprovision of strategic effort relative to the full-commitment case.
(iii) The manager will spend a higher operational effort than in the first-best solution if and only if the long-term return to strategic activities θ_2 is larger than a certain cut-off value.

Proof: The proofs of claim (i) and the first part of claim (ii) follow from the text. For the other claims see the Appendix.

The only reason for an increased value of the variable compensation in the present (β_1^R) is that stronger incentives for the strategic activity have to be generated to compensate for the reduction of the variable compensation in the future. But those additional strategic incentives come at a cost: operational incentives are also strengthened, which will lead to a distortion. Given the renegotiated rate, generating additional incentives for the strategic activity with a higher β_1 is more costly than would be with a higher β_2 due to that distortion (Otherwise the optimal long-term contract would have done it that way). Hence, generating incentives for the strategic activity is more expensive when renegotiation takes place. Consequently a lower strategic effort level will be implemented.

Nonetheless, the first period variable compensation may be raised to such an extend that the agent exerts even more operational effort than the first-best level. This will happen if the long-term return to strategic effort is sufficiently large. The larger this strategic return, the more harmful is the loss in strategic incentives due to weak second period variable compensation. And this can—as we have seen—only be compensated by raising variable compensation in the first period which will also raise operational effort.

As we have discussed above, with full commitment the principal has two degrees of freedom to attain a high congruence of the performance measurement system with the total payoffs, namely the first and second period variable compensation rates. When renegotiation-proof contracts have to be considered, however, the contract choice is restricted as the second period variable rate has to be taken as given. Hence, the possibilities to increase congruence are limited for the principal and the incentive system will be distorted.

5 Nonfinancial Performance Measures

It may now be asked what can be done to overcome this problem. Recall that the reason for a distortion in first period incentives is that the effects of strategic and operational effort cannot be disentangled, when the manager's compensation is based only on profits. This does not pose a large problem, when full commitment to a long-term compensation plan is feasible, as the manager can be compensated appropriately in the future. But if this is not the case, and such a plan can—and as we have shown above will indeed—be adapted in the future, profit alone seems not to be an appropriate performance measure. We should expect, that the situation can be improved if the manager's compensation can be made contingent on other performance measures that help to disentangle the management's strategic and operational efforts.

To examine whether this is indeed the case, we assume that there is an additional performance measure available in the first period which is only affected by the manager's effort on strategic activities. This may for instance be a combination of different nonfinancial measures like the number of new product launches, the number of patents awarded or similar indicators of strategic performance. We assume that such a measure can only get a positive weight in the agent's compensation. This assumption can be justified, if the agent can always manipulate such a measure downwards, which seems a quite reasonable assumption for nonfinancial performance indicators.[15]

Let the additional performance measure be given by

$$s_1 = \theta_1 i_1 + \mu.$$

Of course, if it had a smaller variance or was independent from first period profits, it would come at no surprise that the measure is useful. Therefore, we assume that the noise term μ is just a weakly "noisier" version of ε_1, that is $\mu = \varepsilon_1 + \tau$, where $\tau \sim N\left(0, \sigma_\tau^2\right)$ with $\sigma_\tau^2 \geq 0$. Let γ be the bonus coefficient for the new signal. The agent's compensation is now given by

$$\begin{aligned} w_1 &= \alpha_1 + \beta_1 \pi_1 + \gamma s_1, \\ w_2 &= \alpha_2 + \beta_2 \pi_2. \end{aligned}$$

The only incentive compatibility condition that changes when we introduce the

[15]For some types of non-financial measures it may be the case that they can be manipulated by the principal and hence, are unverifiable. Then of course a commitment problem exists. A formal analysis of such a situation is for instance given in Baker, Gibbons and Murphy (1994) or Schmidt and Schnitzer (1995).

additional measure is of course that for the first period strategic effort i_1. This condition, i.e. the value for effort i_1 given the contract, is

$$i_1 = \theta_1 (\beta_1 + \gamma) + \delta\theta_2\beta_2. \tag{8}$$

There are now three levers to influence first period strategic activity: the bonus coefficients for first and second period profits and the coefficient for the strategic performance measure. First, we will show, that this measure will not be used in the full commitment case. After that, we demonstrate why it may be used if the manager's compensation is renegotiated.

Proposition 3 *In the optimal long-term contract the additional strategic performance measure will not get a positive weight in the agent's compensation.*

Proof: See Appendix.

To understand why this is the case, note that a change in either γ or β_1 has an identical effect on first period strategic effort. Suppose now that γ would be positive. Then, one could reduce it and raise β_1 by the same amount. The risk premium will be weakly lower as profits are by assumption less noisy than the new signal. Strategic incentives remain unchanged, but operational incentives are higher, because γ has no effect on e_1 but a higher β_1 leads to higher operational effort. As long as there is underinvestment in operational effort, this is a good thing. And, as we have seen before, indeed there is underinvestment in the full commitment case.[16]

Hence, it can never be optimal to give a positive weight to the additional signal if the compensation plan is not renegotiated. Effort for strategic activities will be

[16]Note that our assumption that γ has to be nonnegative is of importance. If negative values for γ were possible, it might be optimal set γ to a negative value. To see this consider the following: assume a situation in which $\gamma = 0$. Reduce γ by an infinitesimal amount and increase β_1 instead by the same amount. The risk premia remain unchanged as the first derivative of the risk premium with respect to γ is zero at $\gamma = 0$, i_1 also remains unchanged but e_1 increases. As long as e_1 is smaller than the first-best, this raises total surplus. A negative value of γ would, hence, allow to increase the incentives for the operational task.

rewarded by an appropriate share of future profits in this case. Hence, the compensation plan is not distorted towards a higher current variable compensation, possibly yielding an overprovision of operational effort. Profit alone is therefore an appropriate performance measure.

As we have seen, this may not be the case in a renegotiation-proof compensation plan. Recall that the possibility of renegotiation introduces a distortion: We have shown that if the future return to the strategic activity θ_2 is large there will be overinvestment in operational effort relative to the first-best. A performance measure that is available already in the first period and yields information on the agent's strategic effort alone might therefore be useful. The reduction in second period return to the strategic activity due to renegotiation can be compensated by raising the weight on this new measure without affecting the incentives for operational activities. And indeed, the additional performance measure will become useful in that case as we show with the following result:

Proposition 4 *If the contract is renegotiated the additional strategic performance measure gets a positive weight in the agent's compensation if and only if the long-term return to strategic effort θ_2 is larger than a certain cut-off value.*

Proof: See Appendix.

As we have seen in Corollary 1, with renegotiation there is possibly overinvestment in operational effort. This overinvestment can be reduced without sacrificing too much strategic incentives, if γ is raised and β_1 is lowered. Such a change in the compensation plan may induce higher risk costs, but will lead to a smaller distortion. The higher the long-term impact of strategic effort θ_2, the higher is the extend of overinvestment in operational effort as we have shown in Corollary 1. Hence, for high values of θ_2 it will become beneficial to base the manager's compensation also on the additional strategic performance measure.

6 Conclusion

As we have pointed out, variable compensation for a manager based on financial results serves two purposes: first of all it provides incentives for the manager to exert a higher effort in the future. But in addition, it also rewards the manager's performance in the past, as the strategic components of his performance are only captured by financial indicators after some time has passed. Our model indicated that there is an inherent tendency to neglect the latter purpose. If a manager is risk averse, the contemporaneously optimal variable compensation is set only taking into account its effect on future incentives.

As we have shown, this leads to a distortion in the incentive system. However, this distortion is mitigated when additional nonfinancial measures can be used in the incentive contract. In particular such additional measures become valuable if the long-term impact of a strategic task is sufficiently high. This prediction is in line with the empirical studies cited in the introduction, giving evidence that nonfinancial measures are much more important in firms following an innovation oriented strategy or having larger growth opportunities.

In their recent investigation of time-series data from a hotel chain that changed its compensation plan by including nonfinancial performance measures Banker, Potter and Srinivasan (2000) find that this lead to improved nonfinancial as well as financial performance indicators. Furthermore, nonfinancial indicators such as customer satisfaction are leading indicators (with a lag of six month in the examined case) of financial measures. The authors raise the question why managers did "not exert the appropriate effort to improve customer satisfaction" (Banker, Potter and Srinivasan (2000), p. 89) before the nonfinancial measures have been included in the compensation plan. This would as well have raised profits and, hence, future compensation. An explanation given in their paper is that managers, although being aware of the relationship, did not know either its timing or magnitude. Our paper suggests a different explanation: the extent of the bonus payment conditional on financial performance only may have simply been too small to provide the appropriate incentives. As we have seen in our model this underprovision of incentives results if the compensation plan is based only on the financial measure and has to be time-consistent. This commitment problem can be solved by including nonfinancial measures in the manager's compensation.

7 Appendix

Proof of Proposition 1:

Substituting the incentive contraints in the total surplus (4) yields:

$$\max_{\beta_1,\beta_2} \left(\kappa^2\beta_1 + \theta_1\left(\theta_1\beta_1 + \delta\theta_2\beta_2\right)\right) - \frac{1}{2}\left(\kappa\beta_1\right)^2 - \frac{1}{2}\left(\theta_1\beta_1 + \delta\theta_2\beta_2\right)^2 \qquad (9)$$
$$-\frac{1}{2}r\left(1-\delta\right)\beta_1^2\sigma^2 + \delta\left(\kappa^2\beta_2 + \theta_1^2\beta_2 + \theta_2\left(\theta_1\beta_1 + \delta\theta_2\beta_2\right) - \frac{1}{2}\left(\kappa\beta_2\right)^2\right.$$
$$\left.-\frac{1}{2}\left(\theta_1\beta_2\right)^2 - \frac{1}{2}r\left(1-\delta\right)\beta_2^2\sigma^2\right).$$

The first-order conditions for β_1 and β_2 give:

$$\kappa^2 + \theta_1^2 - \kappa^2\beta_1 - \left(\theta_1\beta_1 + \delta\theta_2\beta_2\right)\theta_1 - r\left(1-\delta\right)\beta_1\sigma^2 + \delta\theta_2\theta_1 = 0 \qquad (10)$$

and $\delta\theta_1\theta_2 - \left(\theta_1\beta_1 + \delta\theta_2\beta_2\right)\delta\theta_2 +$

$$\delta\left(\kappa^2 + \theta_1^2 + \delta\theta_2^2 - \kappa^2\beta_2 - \theta_1^2\beta_2 - r\left(1-\delta\right)\beta_2\sigma^2\right) = 0.$$

From where we immediately get equations (5):

$$\beta_1^* = \frac{\kappa^2 + \theta_1^2 + \delta\theta_1\theta_2\left(1-\beta_2^*\right)}{\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2},$$
$$\beta_2^* = \frac{\kappa^2 + \theta_1^2 + \delta\theta_2^2 + \theta_1\theta_2\left(1-\beta_1^*\right)}{\kappa^2 + \theta_1^2 + \delta\theta_2^2 + \left(1-\delta\right)r\sigma^2}.$$

Solving this system of equations we get the explicit values

$$\beta_1^* = \frac{\left(\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2 + \delta\theta_2^2\right)\left(\theta_1^2 + \kappa^2\right) + \delta\theta_1\theta_2\left(r\left(1-\delta\right)\sigma^2 - \theta_1\theta_2\right)}{\left(\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2 + \delta\theta_2^2\right)\left(\theta_1^2 + \kappa^2 + r\left(1-\delta\right)\sigma^2\right) - \delta\theta_1^2\theta_2^2},$$
$$\beta_2^* = \frac{\left(\kappa^2 + \theta_1^2 + \delta\theta_2^2\right)\left(\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2\right) + \theta_1\theta_2\left(r\left(1-\delta\right)\sigma^2 - \delta\theta_1\theta_2\right)}{\left(\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2 + \delta\theta_2^2\right)\left(\kappa^2 + \theta_1^2 + r\left(1-\delta\right)\sigma^2\right) - \delta\theta_1^2\theta_2^2}.$$

There will be underinvestment in the strategic activity, when $\beta_1^*\theta_1 + \delta\beta_2^*\theta_2 < \theta_1 + \delta\theta_2$ holds. Substituting β_1^* and β_2^* and simplifiying gives:

$$-r\left(1-\delta\right)\left(\delta\theta_2 r\sigma^4\left(1-\delta\right) + \theta_1 r\sigma^4\left(1-\delta\right) + \delta\theta_2\sigma^2\kappa^2 + \theta_1\kappa^2\sigma^2 + \theta_1^3\sigma^2\right) < 0.$$

As the expression in brackets is always positive, the left hand side is clearly negative which establishes the claim.

To see whether there is also underinvestment in operational effort, we have to check, whether $\beta_1 < 1$ or

$$\begin{aligned}&\left(\theta_1^2+\kappa^2+r\left(1-\delta\right)\sigma^2+\delta\theta_2^2\right)\left(\theta_1^2+\kappa^2\right)+\delta\theta_1\theta_2\left(r\left(1-\delta\right)\sigma^2-\theta_1\theta_2\right)\\&<\left(\theta_1^2+\kappa^2+r\left(1-\delta\right)\sigma^2+\delta\theta_2^2\right)\left(\theta_1^2+\kappa^2+r\left(1-\delta\right)\sigma^2\right)-\delta\theta_1^2\theta_2^2.\end{aligned}$$

This can be simplified and we get

$$\begin{aligned}\delta\theta_1\theta_2 &< \theta_1^2+\delta\theta_2^2+\kappa^2+r\left(1-\delta\right)\sigma^2\\ \Leftrightarrow 0 &< \theta_1^2-\delta\theta_1\theta_2+\delta\theta_2^2+\kappa^2+r\left(1-\delta\right)\sigma^2.\end{aligned}$$

But the right hand side of this inequality is larger than

$$\theta_1^2-\sqrt{\delta}\theta_1\sqrt{\delta}\theta_2+\delta\theta_2^2,$$

which in turn is larger than

$$\theta_1^2-2\theta_1\sqrt{\delta}\theta_2+\delta\theta_2^2=\left(\theta_1-\sqrt{\delta}\theta_2\right)^2\geq 0,$$

and this completes the proof. ∎

Proof of Lemma 1:

First, substitute the second period incentive constraints in the expression for the total surplus and this gives:

$$\kappa^2\beta_2+\theta_1^2\beta_2+\theta_2 i_1^*-\frac{1}{2}\left(\kappa\beta_2\right)^2-\frac{1}{2}\left(\theta_1\beta_2\right)^2-\frac{1}{2}r\left(1-\delta\right)\beta_2^2\sigma^2.$$

Taking the first derivative with respect to β_2 yields

$$\kappa^2+\theta_1^2-\kappa^2\beta_2-\theta_1^2\beta_2-r\left(1-\delta\right)\beta_2\sigma^2=0.$$

Finally, we can solve for β_2 and get:

$$\beta_2^R=\frac{\kappa^2+\theta_1^2}{\kappa^2+\theta_1^2+r\left(1-\delta\right)\sigma^2}.$$

Clearly, it can never be the case that a long-term contract, that should not be renegotiated after period 1, encompasses a second period variable compensation different from β_2^R. There would always be the possibility of a Pareto-improvement, as β_2^R is defined as the variable rate that maximizes total surplus in the beginning of period 2. Hence, a long-term contract is renegotiation-proof if and only if $\beta_2 = \beta_2^R$.

To see that $\beta_2^R < \beta_2^*$ compare

$$\frac{\left(\kappa^2+\theta_1^2+\delta\theta_2^2\right)\left(\kappa^2+\theta_1^2+r\left(1-\delta\right)\sigma^2\right)+\theta_1\theta_2\left(r\left(1-\delta\right)\sigma^2-\delta\theta_1\theta_2\right)}{\left(\kappa^2+\theta_1^2+r\left(1-\delta\right)\sigma^2+\delta\theta_2^2\right)\left(\kappa^2+\theta_1^2+r\left(1-\delta\right)\sigma^2\right)-\delta\theta_1^2\theta_2^2}$$
$$\overset{?}{>}\frac{\kappa^2+\theta_1^2}{\kappa^2+\theta_1^2+r\left(1-\delta\right)\sigma^2}.$$

But this can be re-arranged and we get the equivalent condition

$$\theta_2\left(1-\delta\right)r\left(r\theta_2\sigma^4\delta\left(1-\delta\right)+r\theta_1\sigma^4\left(1-\delta\right)+\theta_2\kappa^2\delta\sigma^2+\theta_1^3\sigma^2+\theta_1\kappa^2\sigma^2\right)>0,$$

which is clearly always the case. ■

Proof of Proposition 2:

The total surplus is maximized taking into account the renegotiation-proofness constraint, which defines the only feasible value of β_2. Again we can substitute the effort choices resulting from the incentive constraints into the expression for the total surplus (4) and get (9), with the only difference that we maximize only over β_1, with β_2 given by

$$\beta_2^R=\frac{\kappa^2+\theta_1^2}{\kappa^2+\theta_1^2+r\left(1-\delta\right)\sigma^2}.$$

The first-order condition for β_1 of course then corresponds to the one obtained in the proof of Proposition 1, namely (10). Hence, we have the identical expression for β_1 as a function of β_2, which is given in the first part of (5). But this is clearly decreasing in β_2. We have shown in Lemma 1 that $\beta_2^R < \beta_2^*$. Therefore, we must have $\beta_1^R > \beta_1^*$. Finally, substituting β_2^R in the equation for β_1^R in (7) yields the optimal first period rate

$$\beta_1^R=\frac{\left(\theta_1^2+\kappa^2\right)\left(\kappa^2+\theta_1^2+r\left(1-\delta\right)\sigma^2\right)+\delta\theta_1\theta_2 r\left(1-\delta\right)\sigma^2}{\left(\theta_1^2+\kappa^2+r\left(1-\delta\right)\sigma^2\right)^2}. \tag{11}$$

■

Proof of Corollary 1:

For the last part of claim (ii) that the first period strategic effort is lower when the contract is renegotiated consider the following. For a given β_2 and an optimally adapted β_1 the effort for the first period strategic activity is given by:

$$\begin{aligned} i_1(\beta_2) &= \theta_1\beta_1(\beta_2) + \delta\theta_2\beta_2 \\ &= \theta_1 \frac{\theta_1^2 + \kappa^2 + \delta\theta_1\theta_2(1-\beta_2)}{\theta_1^2 + \kappa^2 + r(1-\delta)\sigma^2} + \delta\theta_2\beta_2. \end{aligned}$$

We show, that this function is increasing in β_2. As β_2^R is smaller than β_2^* this will establish the claim. Taking the first derivative we get

$$\frac{\partial i_1(\beta_2)}{\partial \beta_2} = \theta_1 \frac{-\delta\theta_1\theta_2}{\theta_1^2 + \kappa^2 + r(1-\delta)\sigma^2} + \delta\theta_2.$$

This is larger than zero if and only if

$$\begin{aligned} &\theta_1 \frac{-\delta\theta_1\theta_2}{\theta_1^2 + \kappa^2 + r(1-\delta)\sigma^2} + \delta\theta_2 > 0 \\ &\Leftrightarrow 1 > \frac{\theta_1^2}{\theta_1^2 + \kappa^2 + r(1-\delta)\sigma^2} \\ &\Leftrightarrow \theta_1^2 + \kappa^2 + r(1-\delta)\sigma^2 > \theta_1^2. \end{aligned}$$

This is clearly always the case. Hence, a reduced second period return to strategic effort is not fully compensated by a resulting adaption of the first period return.

We show claim (iii), i.e. that first period operational effort will be larger than the first-best level if and only if θ_2 is larger than a certain cut-off value by checking that β_1^R as given in (11) is larger than 1. That is the case iff

$$\begin{aligned} &\left(\kappa^2 + \theta_1^2 + r(1-\delta)\sigma^2\right)\left(\theta_1^2 + \kappa^2\right) + \delta\theta_1\theta_2 r(1-\delta)\sigma^2 \\ &> \left(\kappa^2 + \theta_1^2 + r(1-\delta)\sigma^2\right)^2 \end{aligned}$$

$$\begin{aligned} \Leftrightarrow\quad & \delta\theta_1\theta_2 r(1-\delta)\sigma^2 > \left(\kappa^2 + \theta_1^2 + r(1-\delta)\sigma^2\right) r(1-\delta)\sigma^2 \\ \Leftrightarrow\quad & \delta\theta_1\theta_2 > \kappa^2 + \theta_1^2 + r(1-\delta)\sigma^2 \\ \Leftrightarrow\quad & \theta_2 > \frac{\kappa^2 + \theta_1^2 + r(1-\delta)\sigma^2}{\delta\theta_1}. \end{aligned}$$

The right hand side yields the cut-off value for θ_2. ■

Proof of Proposition 3:

The contracting problem is now as follows

$$\max_{\beta_1,\beta_2,\gamma,e_1,e_2,i_1,i_2} \kappa e_1 + \theta_1 i_1 - \frac{1}{2}e_1^2 - \frac{1}{2}i_1^2$$
$$-\frac{1}{2}r\left(1-\delta\right)\left(\beta_1+\gamma\right)^2\sigma^2 - \frac{1}{2}r\left(1-\delta\right)\gamma^2\sigma_\tau^2$$
$$+\delta\left(\kappa e_2 + \theta_1 i_2 + \theta_2 i_1 - \frac{1}{2}e_2^2 - \frac{1}{2}i_2^2 - \frac{1}{2}r\left(1-\delta\right)\beta_2^2\sigma^2\right)$$

s.t.

$$\begin{aligned} e_1 &= \kappa\beta_1, \\ i_1 &= \theta_1\beta_1 + \delta\theta_2\beta_2 + \theta_1\gamma, \\ e_2 &= \kappa\beta_2, \\ i_2 &= \theta_1\beta_2 \quad \text{and} \\ \gamma &\geq 0. \end{aligned}$$

We can substitute again the incentive constraints directly into the objective function. Denote this surplus function by $S\left(\beta_1,\beta_2,\gamma\right)$. Hence the problem is simply given by

$$\max_{\beta_1,\beta_2,\gamma} S\left(\beta_1,\beta_2,\gamma\right)$$
$$\text{s.t. } \gamma \geq 0.$$

We will show that the solution to this problem is $\left(\beta_1^*,\beta_2^*,0\right)$, where β_1^* and β_2^* are the incentive coefficients that are optimal in the full commitment case. Note that S is concave as it is the sum of concave functions. The Kuhn-Tucker conditions—which are in this case necessary and sufficient— yield

$$\left.\frac{\partial S\left(\beta_1,\beta_2,\gamma\right)}{\partial\gamma}\right|_{\beta_1^*,\beta_2^*,0} \leq 0 \tag{12}$$

$$\left.\frac{\partial S\left(\beta_1,\beta_2,\gamma\right)}{\partial\beta_1}\right|_{\beta_1^*,\beta_2^*,0} = 0 \tag{13}$$

$$\left.\frac{\partial S\left(\beta_1,\beta_2,\gamma\right)}{\partial\beta_2}\right|_{\beta_1^*,\beta_2^*,0} = 0 \tag{14}$$

Clearly, conditions (13) and (14) hold at the proposed solution, as they then correspond to the definition of β_1^* and β_2^*. Furthermore, observe that

$$\frac{\partial S}{\partial \beta_1} - \frac{\partial S}{\partial \gamma} = \kappa^2 (1 - \beta_1) + r (1 - \delta) \gamma \sigma_\tau^2. \tag{15}$$

The difference of the marginal impacts of γ and β_1 consists of two parts. First, β_1 influences the operational in addition to the strategic effort. Second, γ encompasses a higher risk premium. From condition (13) we have that $\partial S / \partial \beta_1 = 0$. Solving for $\partial S / \partial \gamma$ and substituting this in condition (12), we must have that

$$-\kappa^2 (1 - \beta_1^*) \leq 0.$$

As we have seen in Proposition 1, β_1^* is always smaller than 1. Hence, $\beta_1 = \beta_1^*$, $\beta_2 = \beta_2^*$, $\gamma = 0$ is indeed the optimal solution. ■

Proof of Proposition 4:

We proceed similar to the proof of Proposition 3, but now show that γ will be larger than 0 if and only if θ_2 is larger than a cut-off value. When the contract is renegotiated β_2 will always be equal to β_2^R, hence, we have to solve

$$\max_{\beta_1, \gamma} S\left(\beta_1, \beta_2^R, \gamma\right)$$
$$\text{s.t. } \gamma \geq 0.$$

If the solution to this program entails $\gamma = 0$ we must have that $\beta_1 = \beta_1^R$ as this results from the first-order conditions for this case. Furthermore, the Kuhn-Tucker conditions for this to be optimal are

$$\begin{aligned} \left.\frac{\partial S\left(\beta_1, \beta_2^R, \gamma\right)}{\partial \gamma}\right|_{\beta_1^R, 0} &\leq 0 \\ \left.\frac{\partial S\left(\beta_1, \beta_2^R, \gamma\right)}{\partial \beta_1}\right|_{\beta_1^R, 0} &= 0. \end{aligned}$$

Again condition (15) holds and, hence, we must have that

$$\left.\frac{\partial S\left(\beta_1, \beta_2^R, \gamma\right)}{\partial \gamma}\right|_{\beta_1^R, 0} = -\kappa^2 \left(1 - \beta_1^R\right) \leq 0,$$

but this is the case if and only if $\beta_1^R \geq 1$ which is analogous to θ_2 beeing larger than a cut-off value as we have shown in claim (iii) of Corollary 1. ■

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