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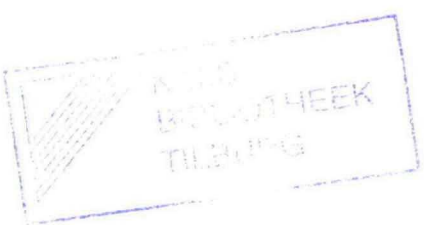

AN EMPIRICAL TEST OF HOLMSTRÖM'S PRINCIPAL-AGENT MODEL THAT TAKES TAX AND SIGNALLY HYPOTHESES EXPLICITLY INTO ACCOUNT

Harry Barkema
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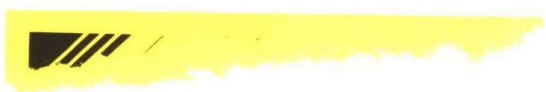

AN EMPIRICAL TEST OF HOLMSTRöM'S PRINCIPAL-AGENT MODEL THAT TAKES TAX AND SIGNALLING HYPOTHESES EXPLICITLY INTO ACCOUNT

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Comments welcome

AN EMPIRICAL TEST OF HOLMSTRÖM'S PRINCIPAL-AGENT MODEL THAT TAKES TAX AND SIGNALLING HYPOTHESES EXPLICITLY INTO ACCOUNT

Harry Barkema[1]

Abstract

During the last two decades, economists have grown increasingly interested in the theory of the firm. Much interest has focused on the economics of bonus schemes in a principal-agent setting. However the empirical validity of this theory is not well established. A number of studies have documented evidence that is consistent with this theory. However this evidence is also consistent with tax and signalling hypotheses.

In this paper I test two hypotheses that are both derived from Holmström's 1979 'standard' principal-agent model: that a reciprocal relation exists between the agents' expected bonus and effort; 2) that agents for whom performance variables are available with higher signal-to-noise ratio's, earn higher bonuses associated with these variables. The agency hypotheses are tested against data about managers of high technology firms in the Netherlands. An empirical model is tested that takes simultanously and separately into account effects suggested by tax and signalling hypotheses. The agency hypotheses are corroborated by the data.

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1. Introduction

During the last two decades, economists have grown increasingly interested in the theory of the firm. Much of the interest has focused on the economics of bonus schemes in a principal-agent setting (Ross, 1973, Harris and Raviv, 1976, 1978, Holmström, 1979, 1982, etc.). Until now, however, the empirical validity of this theory has not been well established.

The theory implies that agents are motivated by their bonuses, and that bonuses are based on the agents' effort. Some studies have documented evidence that is consistent with these hypotheses.[1] This evidence is, however, also consistent with tax and signalling hypotheses, hence it cannot unambiguously be attributed to agency hypotheses (Miller and Scholes, 1982, Warner, 1985, Raviv, 1985, Brickley, Bhagat and Lease, 1985, and Bhagat, Brickley and Lease, 1985).

Additionally, in practice bonus schemes seem less important than one might have believed given the abundant literature on this subject. Annual changes in the value of shares owned by top managers tend to be much larger than the value of the change in even their salary and bonus combined (Benston, 1985, Murphy, 1985, Jensen and Murphy, 1988).[2] Also the labour market, where promotions substantially increase the manager's salary and status, is likely to be a major source of incentives.[3] Finally, in the world 'as we know it' (in the words of Frank Knight) a large portion of managerial income seems to be, at least in the short run, independent of performance. Egalitarian pay systems, seniority based pay systems and holiday bonuses abound (Baker, Jensen and Murphy, 1988), in the U.S. and even more so in Europe and Japan. Because bonuses seem to be relatively unimportant in practice, and because bonus schemes and their documented effects can also be explained by tax and signalling hypotheses, the question arises whether the principal-agent theory on bonus schemes has any empirical validity at all.

It is the purpose of this study to test for this validity such that tax and signalling effects are explicitly controlled. Two hypotheses are tested that are both derived from Holmström's 1979 'standard' principal-agent model: 1) that a reciprocal relation exists between the agent's expected bonus and effort; 2) that agents for whom performance variables

are available with higher signal-to-noise ratio's, face higher bonuses associated with these variables. The hypotheses are tested against data about top level managers of high-technology firms in the Netherlands. An empirical model (a system of equations) is tested that takes simultanously and separately into account effects suggested by agency hypotheses and effects suggested by tax and signalling hypotheses. It is found that even if tax and signalling effects are statistically controlled, agency hypotheses are still corroborated by the data.

This study is organized as follows. The agency hypotheses are discussed in section 2. The data set is discussed in section 3, and a simple test that reveals evidence consistent with the agency hypotheses is presented in section 4. In section 5 it is shown that tax and signalling hypotheses can also explain the documented results. The test that separates agency effects from tax and signalling effects is presented in section 6. The paper ends with a summary and some suggestions for further research.

2. The agency hypotheses

Suppose a publicly owned firm with a board of directors and multiple managers.[4] [5] The board is assumed to be sufficiently motivated to select a value maximizing pay package for managers. Board members may be motivated because they own shares of the firm, because of proxy fights or takeover threats (possibly resulting in a removal of incumbent directors), or because their performance as a director affects their reputation and hence their income in other occupations: as a director or as a manager at another firm (Manne, 1965, Fama, 1980, Fama and Jensen, 1983a, b, Jensen and Ruback, 1983).

The board is assumed to administer bonuses to managers based on two performance variables: 1) the firm's accounting earnings;[6] 2) the manager's effort as monitored by the board. Holmström's 1979 'standard' agency model provides a framework for evaluating properties of any two generic variables that are relevant for the evaluation of an agent's performance.[7] If some additional constraints are placed on the utility function of the manager and on the probability functions (see Lambert and Larcker,

1987), it can be derived that the bonus is an increasing function of the signal-to-noise ratio's d_a and d_m of the performance variables 'accounting earnings' and 'managerial effort as monitored by the board', where:

$d_a = s(a|e) / var(a|e)$, and $d_m = s(m|e) / var(m|e)$,

$s(.|e)$ is the conditional sensitivity of the mean of the signal to the manager's effort and var $(.|e)$ is the variance of the signal given the manager's effort, that is: its noise.

Now suppose a manager about whose effort information is more readily available and monitoring reveals less noisy information than in case of other managers, that is, a manager with a relatively high d_m. Examples seem marketing managers and sales managers, whose effort may immediately be reflected by advertisement campaigns, changes in the market share of a product, and so on. On the other hand, information about effort seems less readily available in case of e.g. R&D managers, since the value of research activities may become clear only (many) years later, or in case of personnel managers, whose effort to maintain and increase the quality of the labour force is even hard to measure in a long term context. Since marketing managers and sales managers are expected to have relatively high d_m's, we expect relatively high bonuses for these managers.

A second implication from Holmström's model concerns the reciprocal relation between the agent's effort and his expected bonus. On the one hand, a higher level of effort is predicted to lead to a higher expected bonus. On the other hand, higher expected bonuses are predicted to induce higher levels of effort. The latter implication, combined with the earlier derived prediction that marketing and sales managers face relatively high expected bonuses, leads to the prediction that these managers select relatively high levels of effort.

The hypotheses about variations in bonuses and effort across managers allow for a test of Holmström's principal-agent model in the next section. Apart from that, the hypotheses are also interesting in their own right. Theory about how bonuses and effort vary across functional managers within firms complements theory derived elsewhere that explains how pay packages vary across hierarchical levels (Smith and Watts, 1982) and across firms (Lewellen and Loderer and Martin, 1987, Lambert and Larcker, 1987).

3. The data set

Data were obtained from a survey among top level managers in the high technology sector, held in the Netherlands in 1984 (Dijkstra, 1985).[8] The data concern managers at the two highest levels of their firms. The following types of jobs were distinguished in the survey: general management, marketing, finance and administration, personnel, automatization, education and training, production, research and development, sales, purchases, and technical services.

The survey was carried out by means of questionnaires, with a follow-up by telephone if questionnaires were not returned in time. Eventually, 248 managers responded from 50 firms, which accounts for 20% of the number of firms approached. Since the non-response rate is quite high (80 %), tests were carried out to check for response bias, e.g. a chi-square test was carried out with respect to the types of industries that responded, such as electro-technical firms, computer firms, chemical firms, engineering firms, and so on. No significant score was found. Nevertheless empirical results that are derived from this data set should be interpreted with care.

4. A simple test of the agency hypotheses

In this section a simple test is performed with respect to the predicted variations in bonus and effort across management functions. More specifically, marketing managers are compared to other managers at the same hierarchical level. The analysis of a rather homogenous group: marketing managers, allows later on in this study the identification and subsequent statistical control of other hypotheses that may also explain the bonuses and levels of effort documented in the present section, apart from tax and signalling hypotheses.[9]

Given the data acquired by the survey, the theoretical variable 'effort' is operationalized in a simple way: by the number of hours devoted to work per week. (Later I will deal explicitly with flaws of this indicator.) The bonus is defined in the survey in terms of the manager's bonus

dependent on past year's performance, measured at the corporate, divisional or the individual level.

For 'marketing managers' and 'other managers' (that is: other managers than marketing managers at the hierarchical level directly below general management), the mean bonus and the mean number of hours devoted to work per week are presented in the first two colums of table 1.[10]

	marketing managers	other managers	mark.-other	t-value
bonus	19.6	5.7	13.9	2.8**
hours	49.2	46.1	3.1	2.0*

Table 2. Sample statistics about managers in the high technology sector. Bonuses in thousands of Dfl.

* : significant at 0.05 level (one-sided test)
** : ,, 0.01 ,,

The third column reports differences in the bonus and hours of work between marketing managers and other managers. In the fourth column, the t-values of these differences are given. Because the distribution of variables deviates from normality, standard deviations (on which the t-values are based) were calculated by means of Jackknifing. This procedure usually yields estimators that approximate Student's t-distribution (Gray and Schucany, 1972, Mosteller and Tukey, 1977).

The following conclusions can be drawn from the table. Marketing managers earn significantly higher bonuses than other managers ($t = 2.8$). Additionally, marketing managers devote significantly more hours per week to work ($t = 2.0$). Both results are consistent with the agency hypotheses formulated earlier.

We end this section with a possible criticism against the test presented above. (Other criticisms are dealt with later in the study). Lewellen, Loderer and Martin (1987) and Lambert and Larcker (1987) predict variations in compensation schemes across firms and industries. Now although 'high technology' indicates some homogeneity in terms of firms and industries, it still entails electro-technical firms, computer firms, chemical firms, engineering firms, and so on (see section 3). This diversity, combined with the rather high non-response rate of the survey, could in theory have a disturbing effect on the empirical results presented above. The following example illustrates the point. Suppose marketing managers from an industry that is dominated by large firms are overrepresented in the sample. Suppose also that larger gains result from motivating a manager of a larger firm than of a smaller firm. In that case, higher bonuses are expected for marketing managers.

Therefore, as a check, means were recalculated for a more homogeneous sample that only contained computer firms and electro-technical firms. Only very small changes in sample statistics were found for the remaining marketing managers (26) and other managers (105): mean bonuses turned out to be 21.9 and 6.5, and hours devoted to work 50.1 and 47.4, respectively.[11]

5. Tax and signalling hypotheses that could also explain the documented results

The empirical regularities documented in the previous section are consistent with the agency hypotheses formulated earlier. However, as I will show below, other non-mutually exclusive hypotheses are also consistent with the documented evidence: a tax hypothesis and a signalling hypothesis. Moreover, the higher bonuses and levels of effort of marketing managers could be explained based on job specific characteristics.

5.1. A signalling hypothesis.

A signalling hypothesis assumes that managers, even if they select first best levels of effort, may possess inside information or 'good news'

that they want to signal to the market. One way to convince the market of the truth of the signal, is by adopting incentive schemes that reward the manager in case the good news is true. To give an example: a manager may accept restricted stock of the firm in which he is employed, thus signalling to the market that he expects a favorable outcome of investment projects (Leland and Pyle, 1977). Also, if the debt capacity of a firm is a signal of its health, the manager may accept a scheme that rewards him for debt increases, and (severely) punishes him in case the debt forces the firm into bankruptcy (Ross, 1977).

As a result the documented positive reaction of shareholders on the adoption of executive compensation plans (Brickley, Bhagat and Lease, 1985, Tehranian and Waegelein, 1985) and the resulting existence of a relation between executive compensation and firm performance (Larcker, 1983, Murphy, 1985, Coughlan and Schmidt, 1985, Benston, 1985, Jensen and Murphy, 1988) can also be explained in terms of signalling hypotheses. The evidence does not necessarily support the agency hypotheses.

At first sight, the evidence documented in the previous section appears less vulnerable to this criticism. Although the signalling hypothesis is capable of explaining the adoption and existence of schemes that award a bonus to the manager, it is not immediately obvious that the hypothesis can explain the documented variations in bonuses across managers.

However assume that marketing managers earn higher reservation wages than other managers. Earlier it was assumed that the utility functions of managers belong to the power class of utility functions (that exhibit decreasing absolute risk aversion and constant proportional risk aversion). The two assumptions combined imply that cet. par. less disutility is induced by a risky bonus on marketing managers. As a result it is expected to be cheaper to signal by means of marketing managers, which may explain their higher bonuses.

In fact the mean total income of marketing managers and 'other managers' of computer and electro-technical firms (the more homogenous sample) turn out to be f 138.700,- and f 99.100,- respectively. This is consistent with the assumption that marketing managers earn higher reservation wages than other managers and hence with the signalling hypothesis formulated above.

According to Raviv a signalling hypothesis is especially relevant in the high technology sector: 'It could well be that different hypotheses are applicable in different environments. For example, when we discuss high technology firms it can be conjectured that information signalling is crucial in designing the entrepreneur's contract. In other environments the motivation of workers might be the dominant reason for a compensation-incentive contract.' (Raviv, 1985).

To sum up: the criticism to previous empirical studies on compensation schemes that observed regularities cannot only be explained in terms of agency hypotheses but also in terms of signalling hypotheses, applies also to the documented results of the previous section. Additional testing is therefore required that separates signalling effects from agency effects. This test is performed in section 6.

5.2. A tax hypothesis.

In their 1982 article, Miller and Scholes seek 'to distinguish schemes that seem intended mainly to share tax benefits from those, of greater interest to economists, that appear designed as incentives to make the real pie bigger'. They show that under the US tax system a variety of schemes, including various types of stock (restricted stock, phantom stock, performance shares), options (option stock, appreciation rights, stock purchase plans) and bonus plans are tax-advantageous. Hence the existence of these schemes cannot unambiguously be attributed to agency effects.

In the Netherlands, a different setting applies. To give an example: the personal tax rate on capital gains is zero. Nevertheless, as I will show below, a tax hypothesis cannot a priori be excluded as an explanation of the documented variations in bonuses.

Compare the following one-period settings A and B. In both settings the manager is entitled to a salary at the beginning of the period, of which he does not consume an amount v during the period. The personal and corporate tax rate are denoted by t_p and t_c, respectively.

A) the manager obtains v at the <u>beginning</u> of the period with the rest of his salary. The manager invests what is left of v after taxes in riskless

securities with interest rate r. If interest is tax exempt, the investment amounts at the end of the period to:

$$v(1 - t_p)(1 + r) \qquad (1)$$

Additional v yields at the end of the period:

$$v(1 - t_p)\{1 + r(1 - t_p)\} \qquad (2)$$

B) During the period the firm invests v in riskless securities, and pays v and interest to the manager at the end of the period, after a deduction that compensates the firm for the corporate tax increase due to the interest obtained. The payment is labeled 'bonus'.[12] The manager obtains at the end of the period:

$$v\{1 + r(1 - t_c)\}(1 - t_p) \qquad (3)$$

Let us compare the settings. In essence, the difference lies in the tax paid over interest during the period: 0, t_p and t_c under (1), (2) and (3), respectively. Hence (1) dominates (2) and (3) if t_p, $t_c > 0$. That is, as long as interest is tax-exempt, and the personal and corporate tax rate are positive, the manager prefers v with his salary. Furthermore, (3) dominates (2) if $t_c < t_p$. Thus if the tax-exempt amount is exhausted and the personal tax rate is higher than the corporate tax rate, the manager prefers a bonus.

In 1984 dutch managers typically faced a personal tax rate of 0.67 or 0.72 [13], while interest was tax exempt up to f 1200.-. Hence if $t_p = 0.67$ and $r = 0.05$, a manager prefers v up to f 72.000,- in the form of salary.[14] Since the 1984 corporate tax rate was 0.43, which is lower than the typical personal tax rate, managers prefer additional amounts of v in the form of a bonus.

Earlier I found that marketing managers earn on average higher total incomes than other managers. As a result, cet. par. (given equal amounts of consumption during the manager's working life, etc.), marketing managers are expected to defer more income, that is, to earn higher bonuses.

Thus a tax hypothesis cannot a priori be excluded as an explanation of the variations in bonuses documented earlier.

While a tax hypothesis cannot be excluded, some doubt can be raised about whether tax benefits are the sole explanation of bonus differentials:

A) Tax benefits from scheme (3) are small. In case of the average marketing manager, annual gains from deferring income are at best (3) - (2):

$$v\{1 + r(1 - t_c)\}(1 - t_p) - v(1 - t_p)\{1 + r(1 - t_p)\} =$$
$$19200\{1 + 0.05(1 - 0.43)\}(1 - 0.67) - 19200(1 - 0.67)\{1 + 0.05(1 - 0.67)\}$$
$$= f\ 80,-$$

For most other managers these gains are even smaller. These tax benefits are possibly smaller than the transaction costs of establishing an administering a bonus plan, and may thus be insufficient to explain dutch bonus plans in general and variations in bonuses in particular.

B) Gains from bonus plans arise because taxes are foregone for one year. However, at least in theory, larger gains may be reaped under alternative plans such as pension plans that defer payments for longer periods.

C) In practice a bonus is often paid if accounting earnings surpass a prepecified criterion. Miller and Scholes argue that this plan is essentially equal to options on a hypothetical common stock with pay-offs corresponding to the firm's accounting earnings. This plan is more attractive than a straight salary for a manager who invests savings in traded or home-made options, because under the plan any price appreciation of the hypothetical options over the exercise period is tax-exempt (Miller and Scholes, 1982). In the Netherlands, however, taxes on price appreciations are zero. Hence the Miller and Scholes 'tax-story' does not explain the existence of dutch plans that award a bonus conditional on accounting earnings.[15]

Thus it seems doubtful that the tax hypothesis is the sole explanation of the documented bonus differentials. Nevertheless a tax hypothesis cannot completely be excluded on theoretical grounds alone. Therefore, an

empirical test that separates agency effects from tax effects is carried out in paragraph 6.

I end this section with the following expansions of the analysis. Suppose the opportunity set of the firm and the manager is expanded such that they are also allowed to invest in stock. Since capital gains are tax-exempt for dutch managers, the firm cannot reap tax benefits by realizing capital gains in stead of the manager.[16] [17] On the other hand, since dividends are taxed in the Netherlands at the personal tax rate with a tax-exempt amount (similar to interest), tax benefits can be reaped if the firm invests in stock and pays dividend to managers in the form of a bonus, after a deduction that compensates the firm for the corporate tax increase due to the dividend obtained.[18] Hence the fact that firms often own shares of other firms may (partly) be explained by a tax gimmick: bonus plans.

Furthermore, given the opportunity to reap tax benefits associated with dividends, the following clientele-effect is predicted. Firms will invest in high dividend, low capital gain stock, and pass this dividend on to managers at the corporate tax rate in the form of bonuses. Managers, on the other hand, who face a high personal tax rate, will specialize in low dividend, high capital gain stock. This frequency distribution of investor preferences will in turn attract a distribution of corporate payout ratios. Vice versa, each corporation will attract a clientele consisting of those preferring its particular payout ratio. In sum: bonus plans as tax gimmicks will induce a specialization in corporate payout ratios (a clientele effect).[19]

5.3. Two other hypotheses that may also explain the documented results.

Suppose the earlier hypothesized reciprocal relation between expected bonus and effort does apply, but not the signal-to-noise hypothesis on the basis of which I predicted higher bonuses for marketing managers. Then higher bonuses for marketing managers can nevertheless be predicted. Since marketing managers earn higher reservation wages (as mentioned above), less disutility is associated with subjecting these managers to risk, hence in equilibrium these managers are exptected to face higher expected

bonuses, associated with higher levels of effort. Hence the higher bonuses and hours of work of marketing managers do not necessarily corroborate the signal-to-noise hypothesis.

Finally, suppose the variable 'effort' is imperfectly operationalized by the variable 'hours of work'. Suppose, more specifically, that because marketing (and sales) managers 'have to' travel much outside normal working hours in order to attract clients, many nights 'have to' be spent in hotels, and so on, the reported number of hours of work is biased upwards in case of these managers. In that case, more hours of work are expected in case of marketing managers even if the agency hypotheses do not apply.

In the next section these two explanations will also be taken explicitly into account into the empirical tests.

6. A more sophisticated test of the agency hypotheses

In this section I present a more sophisticated test of the agency hypotheses that takes the non-mutually exclusive hypotheses presented in the previous section explicitly into account. An empirical model is specified and estimated that separates effects suggested by agency hypotheses from effects suggested by hypotheses of the previous section. The empirical model is tested against data about managers of computer firms and electro-technical firms.

I) Suppose the signalling hypothesis applies. Then it is expected to be cheaper to signal by means of marketing managers with higher reservation wages since less disutility is associated with risk than in case of other managers. This hypothesis is modelled in figure 1 as follows. In the figure 'type of manager' is a dummy variable, valued 1 in case of a marketing manager and 0 otherwise. The expectation that marketing managers earn higher incomes is captured by the positive effect from 'type of manager' on 'total income'. The hypothesis that higher incomes lead to higher bonuses is captured by the positive effect from 'total income' on 'bonus'. (Later I will discuss the reciprocal effect.)

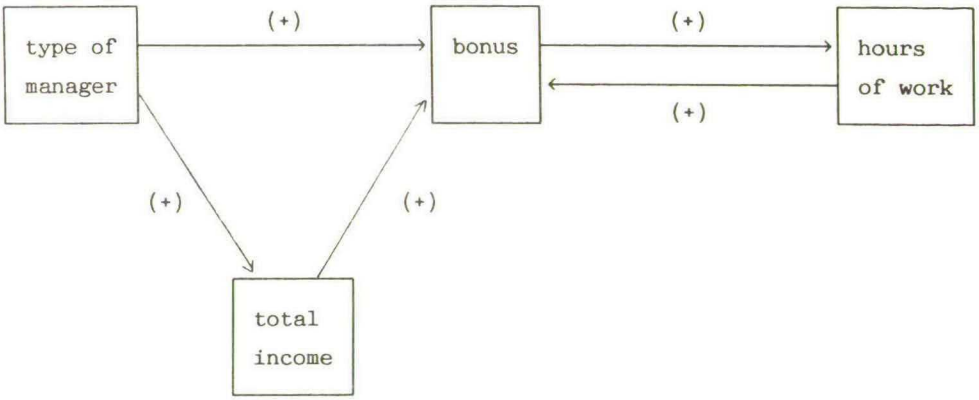

Figure 1. An empirical model that separates agency effects from other effects.

II) Suppose the tax hypothesis applies. Then I expect that marketing managers, due to higher incomes, defer more income to enjoy tax benefits. The first part of this hypothesis: that marketing managers earn higher incomes, is (also) captured by the effect from 'type of manager' on 'total income'. The second part: that managers with higher incomes defer more income, is (also) captured by the effect from 'total income' on 'bonus'.
III) Suppose the reciprocal relation between expected bonus and effort applies but not the signal-to-noise hypothesis. Then again higher bonuses of marketing managers are expected due to their higher incomes. This is the third hypothesis covered by the effect from 'type of manager' via 'total income' on 'bonus'. (Later I will deal with problems due to imperfections in the operationalization of effort.)

After these other, non-mutually exclusive hypotheses have been explicitly taken into account into the model, I still expect, based on the signal-to-noise hypothesis, that marketing managers earn higher bonuses. This hypothesis is modelled by the positive direct effect from 'type of manager' on 'bonus'. Furthermore, I expect a reciprocal relation between expected bonuses and effort. This relation is modelled by the reciprocal relation between 'bonus' and 'hours of work'.

The model of figure 1 was estimated by means of LISREL, a flexible framework for econometric analysis. LISREL allows e.g. the simultanous estimation of multiple equations, hence reciprocal relations can explicitly be taken into account (Jöreskog and Sörbom, 1981, Jöreskog and Wold, 1981, Barkema and Folmer, 1982, 1983, see also Lambert and Larcker, 1987).

The model of figure 1 is represented in equation (4), where y_1 = total income; y_2 = the bonus; y_3 = hours of work; x_1 = type of manager; b_{ij} = the effect of variable y_j on variable y_i; g_{ij} = the effect from variable x_i on variable y_i; and z_i = the error associated with equation i.

$$\begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} = \begin{bmatrix} 0 & 0 & 0 \\ b_{21} & 0 & b_{23} \\ 0 & b_{32} & 0 \end{bmatrix} \begin{bmatrix} y_1 \\ y_2 \\ y_3 \end{bmatrix} + \begin{bmatrix} g_{11} \\ g_{21} \\ 0 \end{bmatrix} \begin{bmatrix} x_1 \end{bmatrix} + \begin{bmatrix} z_1 \\ z_2 \\ z_3 \end{bmatrix} \qquad (4)$$

The model represented in (4) was estimated by means of the Unweighted Least Squares (ULS)-procedure. This procedure does not require distributional assumptions about variables. The estimates are presented in table 2.[20]

coefficient	b_{21}	b_{32}	b_2	g_{11}	g_{21}
estimate	0.48	0.27	0.20	0.38	0.15

Table 2. LISREL-estimates of the model of (4).

For ease of exposition, the estimates of table 2 are presented in figure 2 in a format similar to figure 1. T-values were calculated by means of Jackknifing and are given within brackets.

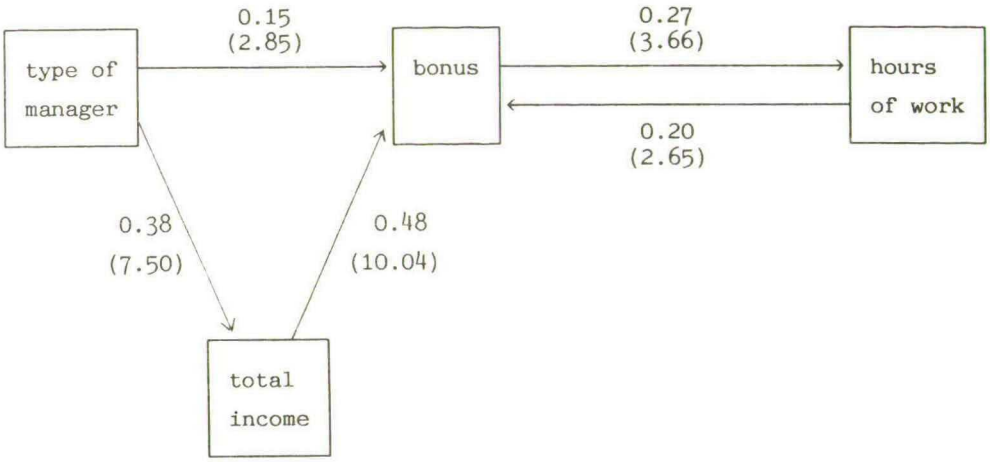

Figure 2. LISREL-estimates with respect to (4).

The following conclusions can be drawn from figure 2. Consistent with earlier findings, It is found that marketing managers earn significantly higher incomes than other managers at the same management level ($t = 7.50$). In line with the higher total incomes, marketing managers earn significantly higher bonuses ($t = 10.03$). The last result is consistent with at least one of the 'alternative' hypotheses derived earlier (a tax hypothesis, a signalling hypothesis, and so on).

However even if effects suggested by these hypotheses are statistically controlled, marketing managers still earn significantly higher bonuses than other managers ($t = 2.85$), which corroborates the signal-to-noise hypothesis. In addition, both effects from 'bonus' on 'hours of work' and from 'hours of work' on 'bonus' are significant ($t = 3.66$ and $t = 2.65$), which corroborates the hypothesized reciprocal relation between expected bonus and effort.

Also other models could be tested, e.g. that check for operationalization errors (e.g. the operationalization of effort by means of 'hours of work'), or that explicitly recognize a reciprocal relation between 'bonus income' and 'total income'. Additional tests reveal that the explicit treatment of these aspects in empirical models strenghtens rather than weakens the conclusions formulated above.[21]

7. Summary and conclusions

In this paper I tested two implications from Holmström's 'standard' 1979 principal-agent model: 1) that a reciprocal relation exists between the agents' expected bonus and effort; 2) that agents for whom performance variables are available with higher signal-to-noise ratio's, earn higher bonuses associated with these variables. Hypotheses were tested against data about managers from high-technology firms in the Netherlands. It was found that even if tax and signalling effects are statistically controlled, the agency hypotheses are still corroborated by the data.

The hypotheses derived and tested in this paper about variations in bonuses and effort across managers are also interesting in themselves. The explanation of the complex pattern of compensation schemes within firms and the various managerial decisions induced by these contracts, provides an important challenge to economists interested in developing the theory of the firm.

Furthermore, more work needs to be done to test various implications of principal-agent theory. In this respect more ingenuity might be shown than using traditional techniques and data sets of the theory of finance (such as event studies and COMPUSTAT, respectively, see the empirical studies mentioned earlier); e.g. because data sets that are appropriate for testing hypotheses about capital markets are not necessarily the best to test implications about individual compensation schemes and behaviour. In my opinion, the extra costs in terms of time and money needed to acquire alternative data will often be justified by the gains in terms of decreased ambiguity of test results, e.g. because (some) specification errors associated with tax and signalling effects are avoided. Also, more relevant data sets may exist 'out there', e.g. gathered by consultancy firms, than is generally known by researchers in agency theory.

Finally, in addition to tests against US data, gains may be associated with the use of non-US data. First, because it may broaden the empirical base of agency theory. Secondly, because in economics laboratory experiments are of limited use, experiments by 'Nature', such as variations in institutional settings over time and over space and the consequences of these variations, provide a rich source of data. Especially the latter type of variations (across space, e.g. across countries) has hardly been

exploited until now in testing implications of agency theory about compensation schemes and associated behaviour.

Footnotes

1. Larcker (1983) documents a positive relation between performance plan adoption and corporate capital investment, Murphy (1985), Coughlan and Schmidt (1985), Benston (1985), and Jensen and Murphy (1988) find that executive compensation correlates positively with corporate performance, Tehranian and Waegelein (1985), and Brickley, Bhagat and Lease (1985) measure positive abnormal stock returns after the announcement of the adoption of short and long term executive compensation plans.

2. Jensen and Murphy (1988) find that the median CEO of Fortune top 500 manufacturing firms faces a change in all pay and stock related wealth of 197.6 cents per 1000 dollars of change in shareholder wealth. Of these 197.6 cents, 160.5 cents are a change in wealth related to stock ownership, 14.5 cents a change in the value of stock options and 23.1 cents a change in total compensation and the present value of the change in salary and bonus. Of these 23.1 cents, only 2.0 cents is a change in this year's and next year's salary and bonus.

3. Murphy (1985) reports that promotions of U.S. top managers tend to increase their total salary by 7.7 % - 42.9 % annually. These promotions typically represent systematic increases in salary, contrary to bonuses that tend to be incidental.

4. A board may exist (that is, enhance firm value) if costs are associated with the specification and enforcement of contracts between shareholders and managers. Shareholders could also motivate managers by means of e.g. restricted stock. However in that case a paretean improvement may result from the installation of a board that monitors managerial effort and administers rewards accordingly (see Jensen and Meckling, 1986, for proofs for more restricted settings that monitoring is valuable, see Harris and Raviv, 1976, 1978, and Holmström, 1979). In addition, gains may result from the screening of projects initiated by management and the subsequent rejection of bad projects (Sah and Stiglitz, 1985, 1986).

5. A firm with multiple managers may exist (that is, enhance firm value) if one manager affects another manager's output in a positive way (Alchian and Demsetz, 1972), in case of mutual monitoring (Fama, 1980, Fama and Jensen, 1983), or if managers are influenced by a common, external source such as the state of the economy. In the latter case the output of one manager provides information about the output of other managers, and gains are associated with the joint evaluation of managers (Holmström, 1982).

6. A similar analysis follows if other performance measures at the level of the firm are selected such as stock market return.

7. Given the generality of the model, it provides little guidance regarding the functional form of the relation between the manager's bonus and the performance variables. Empirical implications can be derived if some additional structure is placed on the model, e.g. if it is assumed that the utility functions of agents belong to the power class of utility functions.

8. High technology firms were defined in terms of expenditures for R&D (above industry average), OESO-specialization coefficients, etc., see Dijkstra (1985).

9. This homogeneity concerns e.g. the specific segment of the labour market and the associated reservation wage (which, as I will argue later, may also affect the size of the bonus). The group 'marketing managers' is, however, less homogenous than it appears at first sight. Most firms have managers that are responsible for more than one management function. In this respect, 75 % of the marketing managers in the data set are also responsible for sales.

10. Our analysis is in terms of expected bonus incomes, where the data concern ex post information. So additionally, we assume that expected values of variables are unbiased estimates of realized values. If this assumption is unrealistic, the empirical analysis might fail to corroborate the agency hypotheses even if they are valid.

11. Another potential criticism concerns the fact that 75 % of the marketing managers are also responsible for sales. In theory, the results for marketing managers might be 'driven' by the sales function of these managers. In itself, higher bonuses associated with sales are consistent with the theory of the previous section. However we should be careful in interpreting these results with respect to the marketing function in particular.

12. Hence the bonus is a 'tax gimmick': a possibly unwritten contract between the firm and the manager intended to reap tax benefits.

13. In fact these figures concern the manager's marginal tax rate. Formula (1) - (3) are easily extended such that the dutch tax system, where the marginal tax rate increases with personal income, is modelled more realistically. However since the additional realism does not change the outcome of the analysis, this complication is avoided.

14. Table 2 shows that the average marketing manager got a bonus of f 19.600,- at the end of the period. Given neutrality in terms of firm value, this amounts at the beginning of the period to $19.600 / \{1 + r(1 - t)\}$. If t is 0.43 and $r = 0.05$, v is about f 19.200,-. In a multi-period setting, suppose a manager invests v, and only v, in riskless securities. Then the total investment in bonds and accumulated interest surpasses f 72.000,- within 4 years.

15. On the other hand, in a world with transaction costs, the costs of installing and administering a bonus plan by the firm may be smaller than the buying of traded options or making home-made options by managers. Thus a transaction cost-hypothesis cannot a priori be excluded as an explanation of this type of bonus plan, and hence for the higher bonuses of marketing managers.

16. Except if payments are made under a pension plan and taxes are lower after retirement. In practice, such payments are constrained under dutch tax laws.

17. In fact capital gains can even increase corporate taxes if the firm sells the stock and the resulting gains are reported on the income statement. On the other hand, if stock sales result in a capital loss, this may decrease corporate taxes.

18. This will only be used after the tax exempt amount of dividend is exhausted (similar to interest).

19. This clientele effect can also be predicted for the US setting, since it applies if the personal tax rate on capital gains is lower than the personal tax rate on dividend.

20. In calculating correlation coefficients, missing data were handled by pairwise deletion of observations. Of course the empirical models estimated by LISREL could also have been estimated by e.g. 2SLS. However since these estimates are virtually identical, they are omitted here.

21. Suppose that 'hours of work' is indeed biased upwards in case of marketing managers due to operationalization error. This hypothesis is tested by specifying in figure 1 a direct effect from 'type of manager' on 'hours of work' (g_{31}) which is then expected to be positive. For reasons of identification, b_{23} is specified to be 0. ULS-estimates turn out to be:

coefficient	b_{21}	b_{32}	g_{11}	g_{21}	g_{31}
estimate	0.48	0.40	0.38	0.17	-0.02

Hence g_{31} is negative (-0.02). The coefficient is however insignificant ($t \stackrel{=}{}^{31}$ -0.36), so the hypothesized operationalization error is not corroborated by the data.
Furthermore, a reciprocal effect can be hypothesized from 'bonus' on 'total income', because total income = salary + bonus + other elements. Therefore the model just described was reestimated (without g_{31} which was not empirically corroborated) with a two-way relation between 'total income' and 'bonus'. ULS-estimates turn out to be:

coefficient	b_{21}	b_{12}	b_{32}	g_{11}	g_{21}
estimate	0.22	0.27	0.39	0.36	0.24

Both b_{21} and b_{12} (the two-way relation between 'total income' and 'bonus') represent substantial values and are significant. In addition the effect from 'type of manager' on 'bonus' (g_{21}) increases substantially, so the evidence in favour of the signal-to-noise hypothesis becomes even more pronounced.

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