Executive Compensation and Tournament Theory: Empirical Tests on Danish Data

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This article adds to the empirical literature on tournament theory as a theory of executive compensation. I test several propositions of tournament models on a rich data set containing information about 2,600 executives in 210 Danish firms during a 4-year period. I ask, Are pay differentials between job levels consistent with relative compensation? Is pay dispersion between levels higher in noisy environments? Is the dispersion affected by the number of tournament participants? Is average pay lower in firms with more compressed pay structures? Does wider pay dispersion enhance firm performance? Most of the predictions gain support in the data.

I. Introduction

My intention in this article is to test some predictions that have emerged in the theory of tournaments as a theory of pay structures of firms and to add to the small empirical literature on this subject. The database comes from a major Danish consulting firm and contains fairly detailed

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information about managers, their jobs, their compensation, and the firms in which they are employed.

The present study is one of very few in four respects. First, it uses actual data on executives; second, the basis of our analysis is more general as the data are from over 260 firms (and not from a case study of a single firm); and third, it is one of the first investigations of managerial pay structures on data from outside the United States. Finally, it attempts to test for several aspects of tournament theory on the same data set, whereas most previous studies, save Main, O'Reilly, and Wade (1993), have examined whether facts square with only one or two predictions for each data set.

I focus on the following aspects of tournaments. Are pay differentials between job levels, controlling for individual and firm characteristics, consistent with relative compensation? Is the prize in the tournament affected by the number of participants? Is the pay dispersion between job levels greater in noisy business environments? Does a wider spread in pay enhance firm performance? Are there differences between firms in this respect? Is the average pay lower in firms with more compressed pay structures? Common to these questions is the focus on the pay structure within firms. This distinguishes tournament models from some other theories of pay like human capital, agency, and learning models, which are mainly concerned with individual pay that is not compared to that of others.

As stressed by two recent surveys on pay and promotion dynamics within firms, Gibbons (1996) and Prendergast (1996), the literature is characterized by the theoretical models being set up to explain a few stylized facts and by the empirical work being tests of whether certain outcomes in the data are compatible with theory. Both authors conclude with pleas for more theoretical work aiming at explanations of broader patterns of evidence and for empirical work that is helpful in distinguishing between alternative theories.

As for empirical verification of theories, an alternative approach is to consider multiple predictions from a given theory and to test them on the same data set. This is the approach adopted here. Although one or two of the individual predictions may also be given an alternative, possibly equally plausible, explanation, the strategy of testing several predictions on the same data set provides us with a sharper test of the tournament theory against the alternatives since the latter do not yield the same combination of predictions. One of the virtues of tournament theory is that it encompasses several predictions that each may be explained by a different, alternative theory, and this property of the theory is put to a test here.

This article proceeds as follows. In Section II some basic theoretical notions and earlier work are briefly discussed. The data to be used in the empirical analysis are described in the third section. Two sections of tests follow next. Section IV is concerned with shape of the pay and job-level relationship, and Section V reports some tests of other aspects of tournaments. In the final section some concluding remarks are offered.

II. Theory and Existing Work

To illustrate some points, I provide a simple model that follows the one set out in Lazear and Rosen (1981). There are two identical players, denoted j and k. The game has a fixed prize to the winner, W_1, and the loser receives another fixed prize, W_2. The winner is the player who produces the largest output. The players' output (performance),

$$q_i = \mu_i + \varepsilon_i, \quad i = j, k, \tag{1}$$

depends on the player's effort level (action), μ, and a random component (as, e.g., luck) denoted by ε. The disutility of effort is described by the cost of effort function $C = C(\mu)$, and it is assumed that both C' and C'' are positive.

The probability that j wins W_1 depends positively on how much effort he puts forth (μ_1) and negatively on the actions of the other player (μ_k). In addition, the probability of winning is also affected by the distribution of ε. The expected utility of the jth player is

$$\begin{aligned} P(W_1 - C(\mu_j)) + (1 - P)(W_2 - C(\mu_j)) \\ = P(W_1 - W_2) + W_2 - C(\mu_j), \end{aligned} \tag{2}$$

where P is the probability of winning.

The probability that j wins is then

$$\begin{aligned} \text{prob}(q_j > q_k) &= \text{prob}((\varepsilon_k - \varepsilon_j) < (\mu_j - \mu_k)) \\ &= \text{prob}((\mu_j - \mu_k) > \zeta)) \\ &= G(\mu_j - \mu_k), \end{aligned} \tag{3}$$

where $\zeta = \varepsilon_k - \varepsilon_j$; $\zeta \sim g(\zeta)$, G = the cumulative density function of ζ, and $E(\zeta) = 0$.

Each of the players maximizes (3) by choosing the effort level. The conditions for optimum (assuming an interior solution) are

$$\left.\begin{aligned} (W_1 - W_2)\delta P/\delta\mu_i - \delta C/\delta\mu_i = 0 \\ \text{and} \qquad \\ (W_1 - W_2)\delta^2 P/\delta\mu_i^2 - \delta^2 C/\delta\mu_i^2 < 0, \end{aligned}\right\} \quad i = j, k. \tag{4}$$

If both players are maximizing (3) taking the other player's action as given, then using (3),

$$\begin{aligned}\delta P/\delta\mu_j &= \delta G(\mu_j - \mu_k)/\delta\mu_j \\ &= g(\mu_j - \mu_k),\end{aligned}$$

which after substitution into (4) gives player j's best reaction function;

$$(W_1 - W_2)g(\mu_j - \mu_k) = \delta C/\delta\mu_j.$$

Of course, given the assumption of identical players, both chooses the same effort level, and player k's reaction function is symmetric. In Nash equilibrium, $\mu_j = \mu_k$, and the outcome of the game is random (i.e., $P = 0.5$). Thus,

$$(W_1 - W_2)g(0) - \delta C_i/\delta\mu_i = 0. \tag{5}$$

Given the labor supply characterized by (5), firms maximize profits per worker (which here is equal to the number of job slots). It can easily be seen (by Lazear and Rosen 1981) that the average wage necessary to attract employees to the firm and the optimal wage spread are

$$(W_1 + W_2)/2 = C(\mu) \tag{6}$$

and

$$W_1 - W_2 = 1/g(0), \tag{7}$$

respectively.

Equation (5) has two implications. First, the equilibrium level of effort is increasing in the spread between the winning and the losing prize. The levels of the prizes do not affect effort levels as long as prize differentials are unchanged. In the case where there are several positions within the firm, tournament theory predicts (see Rosen 1986) that there will be an increasing ratio of pay as the individuals move up along the corporate ladder. This is because the value of winning not only is the winner's prize at that level but also includes the value of the possibility to compete for larger prizes at higher levels. As a consequence, there is a convex relationship between pay and organisational level. Note, however, that at the final level there is no further prize to be won, and CEOs should, therefore, be given an extra prize. Thus, tournament theory predicts an extraordinarily large pay differential between the CEO and the managers at the level next below.

The second implication of (5)—and also an implication of (7)—is that, the greater is the importance of the random components in output (i.e., the smaller $g(0)$ becomes), the lower is the optimum level of effort for a given spread $W_1 - W_2$. Hence, in production environments in which contributions of luck or other random factors to output are important, firms use a larger wage spread in order to offset the effort reducing effect of randomness. As pointed out by Lazear (1995), this incentive role of salaries may be important in comparisons of payment structures across industries or countries.

In the model above, the players do not differ with respect to their abilities. However, if they do, it is no longer necessarily the case that the player who puts forth most effort wins the contest. If players know their own ability as well as that of the other players, the outcome may be a lower level of effort. The less able know they are less likely to win, and the able win by their innate ability (see Knoeber and Thurman [1994] for a discussion).

Another simplifying assumption was that the number of players was restricted to two. In fact, the number of players does matter in tournament models. With more players, the probability of winning clearly is smaller. It is less obvious, however, how the effect of effort on the probability of winning changes as the number of contestants increases. This is examined by McLaughlin (1988), who derives the following expressions for the optimal prize spread and effort, respectively, in a tournament with n contestants:

$$\Delta W^* = (\delta P(n)/\delta\mu)/((\delta P(n)/\delta\mu)^2 + SC''/4) \tag{8}$$

and

$$C'(\mu^*) = 1/(1 + SC''/4(\delta P(n)/\delta\mu)^2), \tag{9}$$

where $P(n)$ is the probability of winning in a n-contestant tournament, given that the other $n - 1$ contestants supply effort μ^*, S is the degree of risk aversion, and C'' is, as before, the curvature of the cost of effort.

We can see that, under risk neutrality ($S = 0$), the prize spread is increasing in tournament size, whereas effort is unaffected. The effect of a marginal increase in effort on the probability of winning decreases as n increases. Consequently, to induce effort, the prize spread has to be increased. As for the case with risk-averse contestants, effort decreases in n. The limiting result for the optimal prize spread is fragile: it goes to zero in the limit. However, the spread is increasing in the tournament size range, which is relevant for analyzing top managerial tournaments.

The model sketched above also abstracts from the fact that senior management of a firm often acts as a team performing highly interdependent work and, so, compensation based on individual performance may be inappropriate because it leads to too harsh competition among the members in the management team. As stressed by Lazear (1989), pay compression may dominate tournament aspects in so-called hawkish firms in which the managers are especially good at uncooperative behavior. To see this, we allow for employees to behave strategically against their rivals by augmenting (1) with a "sabotage" parameter ϕ_i, which shows the harm $j(k)$ can inflict on $k(j)$:

$$q_j = \mu_j - \phi_k + \varepsilon_j \qquad \text{and} \qquad q_k = \mu_k - \phi_j + \varepsilon_k. \tag{10}$$

As sabotage requires effort, the cost of effort function now becomes: $C(\mu_i, \phi_i)$. Denoting the partials with C_1 and C_2 (both assumed to be positive), respectively, the first-order conditions to the employees' maximization problem are

$$\left.\begin{aligned} &(W_1 - W_2)\delta P/\delta\mu_i = C_1(\mu_i, \phi_i) \\ \text{and} \\ &(W_1 - W_2)\delta P/\delta\phi_i = C_2(\mu_i, \phi_i). \end{aligned}\right\} \tag{11}$$

From these we can see that, for a given wage spread, the effort is lower for players who can sabotage others (provided $C_{12} > 0$). The first-order conditions for the firm's maximization problem in case of absence and presence of strategical behavior, respectively, are

$$(1 - C_1)\delta\mu/\delta W_1 = 0, (1 - C_1)\delta\mu/\delta W_2 = 0, \tag{12}$$

$$\left.\begin{aligned} &(1 - C_1)\delta\mu/\delta W_1 - (1 + C_2)\delta\phi/\delta W_1 = 0, \\ \text{and} \\ &(1 - C_1)\delta\mu/\delta W_2 - (1 + C_2)\delta\phi/\delta W_2 = 0. \end{aligned}\right\} \tag{13}$$

Clearly, as C_2 is positive, equilibrium effort is higher in the case of players not behaving strategically against their competitors.

The empirical literature on tournament models is quite small. Strong evidence of tournament notions has above all been obtained from studies of sports (Ehrenberg and Bognanno 1990; Becker and Huselid 1992) and in controlled experiments (Bull, Schotter, and Weigelt 1987). Studies based on data on actual executives are thin on the ground, simply because data sets containing information about several managers per firm are hard to find.

Most of the studies have focused on the convexity of the pay structure. O'Reilly, Main, and Crystal (1988), Leonard (1990), and Main et al.

(1993), all using the same data set, have shown that differences in compensation between hierarchical levels are consistent with tournament theory. Similar results are obtained by Lambert, Larcker, and Weigelt (1993) and in two detailed studies of the personnel records of a single firm, Lazear (1992) and Baker, Gibbs, and Holmström (1994). In a recent study, Conyon (1995), using a large sample of British firms also isolates a convex pay and job-level relationship.

Additional evidence is somewhat more mixed, however. O'Reilly et al. (1988) find a negative relationship, and Main et al. (1993) a positive relationship, between the number of tournament participants and pay differentials. Main et al. (1993) also consider the effects of the pay structure on firm performance, finding evidence in support of tournaments. Drago and Garvey (1998) examine the effects of pay spread on the cooperative behavior of employees in a multitask setting. They find strong evidence of a tournament structure; strong promotion incentives were associated with reduced helping efforts and increased individual efforts. Knoeber and Thurman (1994) study the performance of broiler producers facing a tournament compensation structure. Their tests of predictions concerning the effects of prize level and prize differentials, the effects of ability, and the existence of handicap systems, all provide strong evidence in favor of tournament theory. As stated in the introduction, this article differs from previous work in that we test for several predictions of tournament theory on the same data set.

III. Data Description

The bulk of the data used in this article comes from an unbalanced panel containing information about approximately 2,600 managers in about 210 Danish firms (per year) during the 4-year period 1992–95. The data have been obtained from confidential files of a major Danish consulting firm and provide, in addition to annual compensation data, fairly detailed information about the individual characteristics of managers, their jobs, and the firms in which they are employed.

The compensation variable includes salary and bonus components as well as the employers' contributions to pension funds (all three are available as separate variables). A relatively small proportion—20%–25% of all managers and a third of the CEOs—are paid bonuses and/or commissions, and their average share of total compensation varies between 10% and 12% during the 4-year period. Stock options, deferred compensation (except contributions to pensions), and stock awards are not included. This omission is not likely to affect our results much, as all three forms of compensation are rare among Danish managers.

The renumeration data set has been augmented with further information on the firms regarding their performance (accounting profits, sales) in the 8-year period 1987–94. This information has been derived from an annual handbook of all Danish firms with an annual turnover exceeding 40 million Danish kroner in 1994 prices or more than 50 employees called *Greens—Børsens håndbog om dansk erhvervsliv.*

Three distinguishing features of Danish firms are worth pointing out here. First, most Danish firms are relatively small. To some extent, that is simply a natural consequence of the small size of the country and its population. However, the average size of firms in Denmark is small also relative to the other Nordic countries, and, in particular, the large Danish firms are much smaller than those in Finland, Norway, and Sweden. Second, the corporate governance system is generally of the Nordic-German type, in which mangers are monitored by representatives of banks, large shareholders, and closely related firms. Thus, it differs in particular from the Northern American system, which is characterized by boards made up mainly of "outsiders" representing the shareholders. Third, several Danish firms are closely held and are not publicly traded. Consequently, there is only a relatively small number of firms in the stock market. This applies also to the firms in my data set.[1]

The majority of the firms in this data set are medium-sized or large firms (in the Danish sense), and the data are, therefore, not representative of all Danish firms. However, the sample at my disposal is fairly representative of the medium-sized and large firms with respect to distribution across industries and geographical location.

IV. Pay and Job Levels

The first of the tests I carry out concerns the shape of the pay and organizational-level relationship. I test for whether differentials in pay between levels (defined in alternative ways) in corporate hierarchies are consistent with tournament models. To obtain estimates of the pay differences between adjacent organizational levels, I estimate compensation equations, both from single years and from a short panel (which allows us to account for fixed effects), of the following form:

$$W_{ijt} = \alpha_i + \beta X_{ijt} + \gamma L_{ijt} + \varepsilon_{ijt}, \tag{14}$$

where W is the logarithm of annual compensation, α_i are individual fixed effects, X is a vector of individual and firm characteristics, and L is a vector of job-level dummies. The vector X includes age, tenure in current position, educational level, industry, number of employees, number of subordinates, and (log of) sales (and year dummies in panel estimations). The vector L will be defined in three alternative ways below. Thus, the

[1] It should be noted, however, that the firms in the sample are not headed by owner-managers.

γ estimates are derived from a model that controls for individual traits (and individual-specific fixed effects) as well as some firm characteristics. This may be important as some part of the inter-level pay differences may reflect differences in these characteristics.

It is not self-evident how to define job levels in hierarchies. The data at my disposal contain information about jobs according to their function (production, sales, logistics, personnel, etc.), formal position as reported by the firm (CEO, vice-president, higher-level manager [*fagdirektør*], and lower-level manager [*fagchef*]), membership in the board or the top-management group, and responsibility level (see below). In none of these descriptions are job levels identified according to the pay connected to them.

In order to check the sensitivity of the results to the job-level definition adopted, I have used three alternative sets of levels (or positions) in the corporate hierarchy variables. The most detailed description, which, however, is available only for a portion of the whole sample, is a classification of positions into nine levels according to a job authorities evaluation system created by the consulting firm. The classification is based on grades (1–6) given to six factors: complexity of the problems to be solved, independence in decision making, reporting, responsibility, experience, and training requirements.

The second classification is a cruder version of the first one[2] and classifies the positions held into five different responsibility levels.[3] All jobs in the sample are covered by this classification. The third set of level dummies has been constructed from two pieces of information: the titles of positions as reported by the firms and board or top-management group membership. This gives us six levels: CEO, vice-president, a board member higher-level manager, a non–board member higher-level manager, a board or top-level group member lower-level manager and a nonmember lower-level manager. This classification is also available for all observations in the sample. To save space, below I report only results from using the third classification with six position levels. The estimates from using the other two classifications were quite similar to those reported here

[2] The two lowest levels in the cruder classification correspond largely to levels 1–4 in the more detailed classification, levels 3 and 4 to 5 and 6, and level 5 to levels 7 to 9.

[3] The jobs are classified into three main responsibility levels: the tactical level, the strategical level, and the policy level, which is the highest one. For the two lowest responsibility levels, a further distinction is made on the basis of whether the position involves making propositions or decisions. Thus, e.g., a position at the lower strategical level involves making propositions regarding principal strategies and plans for the firm, whereas a person in the position at the higher strategical level has the authority to make those decisions.

Table 1
Mean Pay (Base Salary plus Bonus) by Levels in Corporate Hierarchy

Level/Position	*N*	Total Pay	Difference (%)
Lower-level manager, no membership	729	483.1	
Lower-level manager, board or top-level group	714	524.9	+12.4
Higher-level manager, no membership	90	844.8	+60.9
Higher-level manager, top-level group	311	728.6	−13.7
Higher-level manager, board member	160	835.1	+14.6
Vice-president	64	903.1	+8.1
CEO	180	1,250.0	+38.4

(and are set out in a longer version of this article, which is available from me on request.)

I begin by looking at the basic data on pay. The average pay (base salary plus bonus) for each level and the proportional pay differences between adjacent levels, starting from the lowest, are presented in table 1.[4] The figures are from 1994, but the corresponding figures from the other 3 years are very similar. Irrespective of which one of the level classifications are used, the same pattern emerges. As one moves up the corporate hierarchy, the pay differences increase.[5] Clearly, these simple averages look quite consistent with a tournament structure of pay. So, let us turn to consider whether this also remains to be the case when we control for individual and firm characteristics.

In tables 2 and 3, the estimates from equation (7) are shown. The coefficients are those of level dummies in estimations in which the dependent variable, total pay, is in logs and the (omitted) reference category is the lowest job level in the data set. In table 2 the estimates of job-level pay differences by year are presented. As in some previous studies (see, e.g., Leonard 1990; Lazear 1992; and Baker et al. 1994), job levels turn out be a very important determinant of pay. Thus, in regressions with just one set of explanatory variables included at a time, the human capital variables explain about 20% of the variance, whereas job level dummies explain about 60%. Adding the job-level dummies to a specification with standard human capital variables, industry dummies, and firm characteristics significantly

[4] The results presented are all based on the broadest compensation variable that includes bonuses and commissions. The picture remains largely unaltered when we look at base salary only.

[5] However, there is one odd feature. For some reason, the rather small group of higher-level managers who are neither board members nor members of top management groups in the firms earn more than their colleagues who are members of these bodies. (This unexpected result is found for each year in the sample.)

Table 2
Estimated Pay Differences (log Differentials)

Position*	1992	1993	1994	1995
Lower-level manager, board or top-level group	.121	.103	.110	.125
	(.012)	(.011)	(.011)	(.010)
Higher-level manager, no membership	.399	.413	.420	.437
	(.023)	(.024)	(.024)	(.025)
Higher-level manager, top-level group	.324	.319	.340	.337
	(.014)	(.015)	(.014)	(.016)
Higher-level manager, member of board	.489	.464	.480	.475
	(.021)	(.019)	(.020)	(.018)
Vice president	.628	.629	.620	.695
	(.021)	(.020)	(.020)	(.021)
CEO	.989	.951	1.031	1.011
	(.022)	(.022)	(.025)	(.026)
Adjusted R^2	.699	.724	.719	.701
Number of observations	2,289	2,248	2,502	2,111

NOTE.—Standard errors are in parentheses.
* Omitted category: lower-level manager with no membership. Other regressors included were age, tenure in current position, level of education, industry, number of employees in the firm, the number of subordinates, and log of sales.

improves the explanatory power of the model. As can be seen from the table, the pay differences are relatively stable across years.

The estimates can be used to calculate the increase in reward from moving from one level to the next holding individual traits and firm characteristics constant. Thus, from the results for 1995 in table 2,[6] we

Table 3
Fixed-Effects Estimation Results

Positions	Estimation Results
Lower-level manager, board/top member	.101 (.010)
Higher-level manager, no membership	.375 (.025)
Higher-level manager, top-level group	.327 (.015)
Higher-level manager, board member	.472 (.020)
Vice president	.607 (.030)
CEO	.923 (.020)
Adjusted R^2	.774
Hausman's test ($\chi^2(2)$)	7.25
Number of observations	9,150

NOTE.—Standard errors are in parentheses.

[6] Again, the results from the other years were quite similar. Note also that the decrease in rewards between the third and the fourth level may be due to relatively few observations for the group of higher-level managers who are neither board nor top-management group members.

find that increases in rewards, beginning from the lowest level, are 13.3, 36.6, −9.5, 14.8, 24.6 and 37.1%. The corresponding figures from table 3 are 10.6, 31.6, −4.7, 15.6, 14.5, and 37.2%. The last figure is an estimate of the change in reward of moving from a vice-president to CEO position.

A comparison of these figures with those in table 1 shows that, in general, controlling for individual and firm characteristics gives rise to a slight reduction in the pay differences between job levels. A further decrease occurs as I cater for heterogeneities (like differences in ability discussed above) by an individual fixed-effects specification. The results set out in table 3 confirm this. The changes are rather small, however, and do not change the qualitative picture observed earlier.

The key result of the econometric exercises is that the pay difference increases as one moves up in the hierarchy. This increase in spread at higher levels in the hierarchies is consistent with tournament theory. However, I have not been able to isolate an extraordinarily large increase in the reward at the very top of the hierarchy as suggested by rank-order tournament models.

To summarize, the convexity of the relationship between pay and levels in hierarchy documented above is consistent with the operation of tournaments based on relative performance. It also fits well in with the results of an earlier study using the same data, Eriksson and Lausten (1996), which found only a weak pay-for-performance relationship. It may well be that executive pay has little to do with the absolute performance of the CEO or other senior managers and that instead the increasing pay differences act as an incentive to provide greater effort.

Although a widening pay gap through the corporate hierarchy is a key prediction of tournament models, the pattern observed does not imply tournament theory as other economic theories (see Rosen 1992) as well as sociological theories (see O'Reilly et al. 1988) also predict a convex pay and job level relationship. Thus, for example, provided superiors' decisions affect directly the productivity of lower-level employees, sorting of more able persons into higher-level positions will lead to higher marginal productivity of people at higher levels. A convex pay structure may also arise in task assignment models; see, for example, Waldman (1984). The assignment of an employee to new tasks signals information about his productivity or ability and thus explains the large wage increases on promotion. There is, however, some evidence in the analysis above suggesting that pay is not likely to equal marginal product, namely, the fact that pay is largely attached to job levels and considerably less to individual characteristics reflecting human capital levels.

V. Other Aspects of Tournament Theory

The aim in this section is to try to test some other predictions of tournament theory than the shape of pay-job level relationship. I analyze two types of aspects. First, I investigate whether interfirm differences in pay dispersion are affected by the factors suggested by tournament models. I test for two predictions specific to tournament models, namely, that reward differences are affected by the number of tournament participants and that pay differences between job levels are higher in noisy or risky environments. I also examine whether average pay is lower in firms with more compressed pay structures. Second, I carry out a simple test of a key prediction concerning the efficiency of tournament pay structures, namely, that a wider pay dispersion enhances the economic performance of firms.

In investigating these aspects of tournament models, the units of observations are firms and their managerial pay structures.[7] The sample analyzed below consists of those firms for which I have observations on a minimum of five employees (one of which is the CEO) and complete records on firm performance for the period 1987–94 and on managerial compensation for all 4 years 1992–95. These restrictions reduces the sample to 111 firms.

McLaughlin's (1988) analysis suggests as a test of the presence of tournaments testing for the existence of a positive relationship between CEO pay and (given the average pay of the tournament participants) the number of contestants. Of course, in order to carry out such a test, the participants in the tournament have to be identified. One obvious candidate group is the vice-presidents. However, as many of the companies in the data set do not have formal vice-president positions, I have, following O'Reilly et al. (1988), decided to use the managers that are reported by the firms to have significant responsibilities—that is, the managers whose jobs are classified as being at the policy level—as the group of contestants. The dependent variable is the log difference between the CEO pay and the average pay of the other tournament participants.

The results from estimations on data for 1992 and 1994 are presented in table 4 (see also table 5 below). The estimates do suggest that, controlling for firm size, a greater number of contestants increases the winning prize, as predicted by tournament models. The magnitude of the effect is rather modest, however.

As was shown in Section II, a prediction emanating from tournament models is a larger spread in pay in firms operating in noisy or risky environments to compensate for the relatively greater importance of random factors. Consequently, we expect firms in industries where demand or cost conditions vary a lot to have a steeper pay-job level hierarchy.

[7] One further test could be whether tournament structures are observed in the firms that according to the theory are more likely to adopt them, namely, firms in which measurement costs, the firm-specific human capital element, and the probability of detecting sabotage or collusion are high. However, because of the great demands on the data, such tests are extremely difficult to perform.

Table 4
Test of the Effect of the Number of Contestants

	Dependent Variable: log CEO Pay − log Average Managerial Pay	
	1992	1994
Constant	.175 (.039)	.187 (.052)
Number of contestants	.018 (.006)	.017 (.005)
Firm size (log sales)	.0002 (.0001)	.0002 (.0001)
R^2	.102	.097

NOTE.—Standard errors are in parentheses.

The main problem with attempting to test this hypothesis is, of course, to find a variable that accurately captures differences in firms' (industries') demand or cost conditions. We have used two alternative pieces of information. The data set provides information about the sales of the firms in the period 1987–94. From these series I have for each firm calculated the coefficient of variation of (deflated) sales.[8] These coefficients of variation is the first proxy measure of a noisy environment. The other measure is derived in a similar fashion, but now I make use of industry-level information. Coefficients of variation were calculated from the Industrial Statistics, produced by Statistics Denmark, for the 1987–93 period for volume of production for each of the two-digit level industries the firms in the sample are operating in.[9] I tried two alternative dependent variables: the coefficient of variation of total pay and the CEO-contestants differential constructed for the test above. A drawback of the coefficient of variation variable is that it may be affected by differences in the number of managerial positions in firms.

According to the estimation results set out in table 5, there is indeed a positive and statistically significant relationship between the variability of the sales (production) of the firm (industry) and the intrafirm pay dispersion. An increase in the "noise" as measured by an increase in the coefficient of variation of firm sales by 1 SE increases the coefficient of variation of pay by about 3 percentage points. This is a relatively modest effect, as the standard deviation of the dependent variable is 10 percentage points. Naturally, in interpreting the results, one should keep in mind that the coefficient of variance measures can at best only be crude proxies

[8] The firms that have had changes in sales owing to acquisitions of other firms or sales of the parts of the firm had to be discarded.

[9] Some firms operate in several industries. I have assigned them to the industries reported by themselves as their main industry.

Table 5
Test of the Effect of a Noisy Business Environment on Spread of Pay, 1994

	Dependent Variable			
	CV of Pay		CEO-Contestants Difference	
	(1)	(2)	(3)	(4)
Constant	.311 (.054)	.295 (.059)	.122 (.034)	.111 (.033)
Firm size (log sales)			.0002 (.0001)	.0002 (.0001)
CV of firm sales	.011 (.005)		.014 (.008)	
CV of industry output		.015 (.003)		.016 (.005)
Number of contestants			.015 (.008)	.012 (.004)
Adjusted R^2	.064	.072	.121	.134

NOTE.—Standard errors are in parentheses. CV = coefficient of variation.

for interfirm differences in noise due to production uncertainty, luck, measurement error, or other factors beyond the managers' control.

The results of the two tests carried out so far clearly provide some additional support for the notion of rank-order tournaments. The reward differences are larger the more important are random factors for the development of the performance of the firm and the more competitors are participating in the tournament. The above analysis has, however, been concerned with what things look like, and not whether they also work. So, let us now turn to consider the consequences of the pay structure on firm performance.

As is plain from the equilibrium in (5), the wider the pay dispersion, the higher the level of effort put forth. However, as discussed by Lazear (1989; 1995), there may also be incentive motives for firms to adopt a more compressed pay structure.[10] In order to attract (the right) people to participate in a tournament, the spread cannot be "too big." Moreover, if the cooperation of the managers is essential for the success of the firm, rewarding them according to their individual achievements may not be a good idea. Not all firms benefit from their top managers acting as a team, however.[11] For those firms for which cooperation is less important—

[10] See also Milgrom and Roberts (1990) for a related analysis of employees engaging in costly rent-seeking behavior when the potential from redistribution of compensation is large.

[11] As pointed out by Lazear (1995), an alternative to pay compression as a means of reducing anticooperative behavior of managers is to set up the structure

"hawkish" firms, in Lazear's terminology—wider pay gaps may enhance performance, whereas this is not the case in "dovish" firms. Clearly, the main difficulty in testing the hypothesis of the performance-enhancing effects of pay dispersion is finding a variable or indicator that enables us to distinguish between "hawkish" and "dovish" firms. I follow Main et al. (1993) in using an executive team interdependency indicator, constructed as the proportion of profit center heads of the total number of managers, which is interacted with our measures of pay dispersion. Teams with a low (high) proportion of managers with profit center head titles are considered teams with a high (low) degree of interdependence. The industrial politics hypothesis predicts that the lower the degree of managerial team interdependence, the higher the productivity-enhancing effect of pay dispersion. Thus, the interaction between pay dispersion and team interdependence should be positive.

As was pointed out earlier, most of the firms in the data set are not publicly held. Hence, one cannot rely on stock market indicators as measures of firm performance, and I use accounting profits information instead. The performance of the firms is measured as a 3-year average of profits divided by sales.[12] Once again, I use two alternative pay dispersion measures for which I calculate 4-year averages. Additional explanatory variables included were firm size (measured by the 4-year average of the number of employees), industry dummies, and the average pay of the managers in the firm.

What do I find? First of all, I find a weak positive relationship between firm performance and average pay. As for the pay dispersion variables, these also carry positive coefficients; a significant one for the CEO-contestants difference and an almost significant one for the coefficient of variation variable. The empirical effect of a 1 SE increase in the pay dispersion variables is of the magnitude 4%–5%. The team interdependency variable as well as the interaction terms never differed significantly from zero. Thus, the industrial politics argument for pay compression in managerial teams is not supported by the analysis.

Regressions of the average log of pay on pay dispersion controlling for firm size and industry show, consistent with tournament theory, a lower

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of the firm in such a way that the consequences of competitive behavior to the firm are minimized.

[12] I have also tried two alternative performance measures. The first was the rate of return on the firm's own capital as reported by *Greens.* Unfortunately, this has one major drawback, namely, that the firm's own capital is measured at the end of the year. The estimates obtained were similar as those in table 6, but they were less precisely estimated. The other measure used was a crude index based on the performance of profits during the 8-year period 1987–94. Again, the results were quite similar to those reported above.

Table 6
Tests of Effects of Pay Spread on Firm Performance and Average Pay

	Dependent Variable			
	log Profits/Sales		log of Average Pay	
	(1)	(2)	(3)	(4)
Constant	3.092	3.151	6.420	6.398
	(.54)	(.57)	(.391)	(.362)
Number of employees			.0004	.0004
			(.0002)	(.0003)
Log average pay	.031	.032		
	(.011)	(.010)		
CV of pay	.241		.392	
	(.145)		(.200)	
CEO-contestants difference		.151		.204
		(.060)		(.096)
Interdependency indicator	.051	.039	.111	.125
	(.060)	(.064)	(.407)	(.750)
Interaction (interdependency and pay spread)	−.005	.010	.113	.179
	(.015)	(.020)	(.222)	(.451)
Adjusted R^2	.313	.345	.648	.662

NOTE.—Standard errors are in parentheses. CV = coefficient of variation.

average pay in firms with less pay dispersion (see table 6). But, again, I failed to find a significant coefficient for the interdependency variable and the interaction term. It should be noted that one possible reason I have drawn two blanks on these variables is that the estimates are downward biased because of measurement errors in the interdependency indicator. In future work, I hope to improve the analysis by explicitly accounting for differences in the organizational structure of the firms, that is, distinguishing between multidivisional firms, firms with a headquarter-subsidiaries structure, firms that are part of a concern, and so on. This is potentially important, as firms with different organizational structures may differ with respect to how they are affected by competition among their managerial employees.

VI. Concluding Remarks

In this article I have investigated some aspects of tournament theory using a data set on Danish executives. I find that there is a stable convex relation between pay and job levels and that this is relatively robust with respect to differences in how job levels are defined. The larger the number of managers considered to have significant responsibilities in the firm, the larger is the wage spread. Thus, the prediction of tournament models that there is a positive relationship between the number of participants and the prize of the tournament is supported. Another prediction gaining support is a larger pay dispersion in firms characterized by more variable business conditions.

A key implication of tournament theory, which differs considerably from theories of efficiency wages and fairness, is that managerial pay differentials provide useful incentives to improve corporate performance. This study adds to the very small literature on the effect of promotions and pay structures on performance some evidence of a larger managerial pay spread being associated with better performance of firms. There do not seem to be any differences, with regard to the effects of pay dispersion on firm performance, between firms with managerial teams that are more interdependent and those in which they are not. However, it must be noted that these results are tentative, as they may be affected by the problems of measuring accurately the interdependency of managers and/or firm performance.

In summary, I conclude that almost all of my findings are consistent with tournament models. Although some of the individual findings may also be explained by alternative theories, the combination of findings provides fairly strong evidence in favor of tournament theory. This is important in view of the weak link observed between firm performance and individual managers' pay, as it suggests that looking at individual wages without recognition of the structure they are part of may be misleading.

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