ELSEVIER Journal of Accounting and Economics 19 (1995) 279–313

JOURNAL OF Accounting & Economics

Business unit innovation and the structure of executive compensation

Robert W. Holthausen*, David F. Larcker, Richard G. Sloan

Wharton School, University of Pennsylvania, Philadelphia, PA 19104-6365, USA

(Received May 1993; final version received July 1994)

Abstract

We examine whether the structure of compensation for the divisional CEO is related to subsequent innovative activity within the division, and whether the divisional CEO's compensation is structured as a function of the expected innovation opportunity set facing the division. Both the expected innovation opportunity set and the divisional executive's compensation contract are treated as endogenous variables by adopting a simultaneous equation approach. We find modest evidence that the proportion of total compensation tied to long-term components has a positive relation with future innovation, but no evidence that this proportion has a positive relation with the expected innovation opportunity set.

Key words: Management compensation; Divisional innovation; Divisional compensation contracts

JEL classifications: D29; G39; J33; O31

1. Introduction

There is a vast theoretical and empirical literature in economics that attempts to understand the factors leading to the generation of new knowledge or

*Corresponding author.

This paper has benefited from the comments of Kevin Murphy (the discussant of our paper), an anonymous referee, and participants of the 1993 Organizations, Incentives and Innovation Conference. The financial support of the Nomura Securities Company, Ernst & Young, LLP, and Goldman Sachs is also gratefully acknowledged.

SSDI 0165410194003 85 I

inventive activity in organizations. The basis of most existing empirical work follows from the classic discussion provided by Schumpeter (1942). In particular, prior research has provided extensive analysis of the role of firm size and market concentration as determinants of innovation. However, as discussed in the review by Cohen and Levin (1989), prior results do not exhibit convergence and are statistically fragile. Cohen and Levin suggest that researchers should move beyond the simple Schumpeterian hypotheses and begin to focus on the more fundamental determinants of technological progress or innovation.

The purpose of this paper is to provide an empirical analysis that considers some of the fundamental determinants of innovation. There are three important differences between our paper and prior work. First, with the exception of research considering line of business data (e.g., Scherer, 1984), prior empirical studies have used the firm (or even industry) as the unit of analysis. In contrast, we assume that most innovation decisions are made at the level of the business *unit*, and thus we use single profit centers (or divisions) as our unit of analysis. Implicit in our choice is the assumption that firm-level data is too aggregate to provide a reasonable examination of innovative activity. Second, we examine the role of compensation contracts for divisional managers in the production of innovation. In particular, we focus on the role of 'long-term' components of compensation in fostering innovation, since the payoffs associated with investing in innovation are not likely to be realized immediately. To our knowledge, the effect of compensation policies on innovative activity has not been previously examined.[1] Finally, we examine the relation between the compensation contract choice for the divisional manager and the outcome of innovation for the division using a simultaneous equation model. This approach allows *both* the innovation opportunity set and the compensation contract to be treated as *endogenous* (or choice) variables. By using a simultaneous equation approach, we can begin to address some of the difficulties associated with making inferences about the relation between executive compensation contracts and investment decisions when compensation is treated as exogenous (e.g., Larcker, 1983). Moreover, although some prior work has examined the relation between the investment opportunity set and the choice of executive compensation contracts, the investment opportunity set has been treated as an exogenous variable (e.g., Smith and Watts, 1992; Bizjak, Brickley, and Coles, 1993). Thus, our econometric approach enables us to relax the somewhat implausible assumptions of

[1]Galbraith and Merrill (1991) provide some analysis of the relation between research and development expenditures and various measures of compensation mix for 79 strategic business units. Specifically, they hypothesize a positive relation between the percentage of a manager's compensation that has a long-term orientation and research and development expenditures. Unfortunately, the research and development variable is measured as a *perceptual* variable (using a seven-point scale) that asks the respondent to evaluate the strategy of their business unit *relative* to their competitors. It is unclear how this variable relates to business unit innovation.

prior research regarding the exogenous nature of either the compensation structures or investment opportunity sets.

Using data obtained from a variety of confidential and nontraditional sources, we estimate our simultaneous equation model for divisions operating in a variety of different industries. We find modest evidence that increases in the division executive's proportion of total compensation which is based on long-term performance has a positive impact on the division's future innovation, but only when the long-term performance measures are based on accounting measures of performance. In addition, we find no evidence that a division's future innovation (or the expected investment opportunity set facing the division) has a positive relation with the degree to which the divisional executive's compensation contract has a long-term orientation.

The remainder of the paper is composed of five sections. Section 2 describes our model specification and develops a set of exploratory research hypotheses. Section 3 describes the sample, measures, and methodological approach used in examining the research hypotheses. The results obtained from estimating our system of equations for innovation and the compensation contract choice are discussed in Section 4. Section 5 contains some additional exploratory analysis using the level of pay, instead of the proportion of managerial compensation that is obtained from long-term contracts, as our measure of managerial incentives. Concluding remarks and a discussion of limitations are provided in Section 6.

2. Model specification and research hypotheses

We assume that the firm desires to maximize firm value and does that, at least in part, via the choice of managerial compensation contracts which affect managers' incentives to pursue innovation activities. The timeline for our model is as follows. At time period t, the firm (or perhaps the corporate CEO) forms expectations about the future innovation opportunity set facing each division and chooses the contract to properly motivate each division manager with regard to innovation activities. Thus, the choice of the contract is based on the *expectation* of the division's innovation opportunity set and a variety of exogenous division-specific and firm-specific factors affecting the compensation contract (discussed below). At time period $t + 1$, labor and capital inputs are consumed in the division as part of the innovation process, and the results from the innovation process become known to the division and the firm. At some later period (denoted as time $t + 2$), the division may take actions to protect the ownership of their innovation (e.g., apply for patents that are granted by the governmental patent office). Thus, the division's innovation becomes observable to other firms at $t + 2$. Finally, any profits earned from these innovations will be a function of market structure and firm-specific characteristics which restrict other firms or suppliers from appropriating returns from innovation. Thus, the ultimate amount of innovation depends on the form of the contract chosen to motivate the manager and a variety of exogenous firm-specific and market structure factors (also discussed below). Fig. 1 provides a general depiction of the structural model envisioned in this analysis.

2.1. Determinants of innovation

The industrial organization literature has developed and empirically examined many models for the innovation behavior of firms. In general, these models analyze the role of market structure and firm-specific characteristics on the incentives of firms to engage in innovation. We expand on the existing literature by also including the managerial compensation contract as an additional determinant of innovation. Based upon this prior literature, we assume that the innovation process can be characterized in the following form:

$$innovation_{t+2} = f(compensation\ contract_t,\ market\ structure_t,\ firm\ factors_t).$$

In the standard agency model, the compensation contract is used to motivate the agent to provide effort, which in our setting refers to innovation activity at the divisional level. For a firm involved in risky innovation, it may be difficult for the principal to monitor the actions of the agent because there are few informative signals concerning agent performance until the outcome of the innovation investment is observed at some future date. Since the outcome from

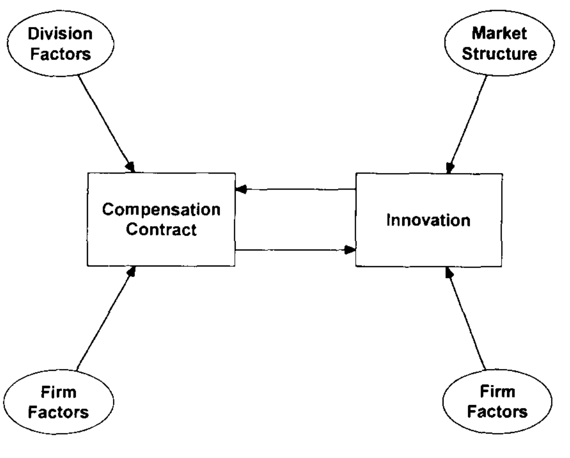

Fig. 1. Structural model for business unit innovation indicating the endogenous treatment of both the structure of the compensation contract and the extent of innovation. The structural model allows the choice of the compensation contract to be determined by the business unit's innovation opportunity set, division factors, and firm factors. The subsequent amount of innovation is affected by the compensation contract choice, market structure, and firm factors.

an agent's action choice can only be observed with a considerable lag, it seems desirable for the principal to structure the agent's compensation to incorporate a deferred or long-term component.[2] Thus, we hypothesize that innovation will have a positive relation with the *compensation contract* (or more specifically with the proportion of a manager's total compensation that is derived from long-term contracts).[3] As discussed below, the choice of the compensation contract is also treated as an *endogenous* variable in the model and we discuss its determinants in Section 2.2.[4]

The impact of *market structure* on innovation has been the focus of many prior studies (see the review by Cohen and Levin, 1989). One key market structure variable is the extent of market power exhibited by the firm engaged in innovative activity. In order for innovation to take place, firms must have some expectation that they will be able to capture (at least some of) the economic rents arising from their innovation. The market structure measures employed in prior work are typically proxies for the extent of imperfect competition in the firm's product market. These studies generally rely on Schumpeter (1942) to hypothesize a positive relation between market power and innovation. However, it can also be the case that the existence of market power shields the firm from competitive pressures, which reduces the incentive for the firm to engage in innovation (e.g., Phillips, 1965; Scherer, 1980). This alternative scenario suggests that market power should have a negative relation with innovation. Thus, the sign of the relation between *market power* and innovation is ambiguous from a theoretical perspective.

---

[2]From an institutional perspective, Clinch (1991) finds that 'high-tech' firms exhibit a higher incidence of stock options (i.e., long-term, market-based compensation arrangements) than 'non-high-tech' firms. Similarly, Balkin and Gomez-Mejia (1985) observe that 'high-tech' firms are more likely to use stock options and restricted stock for key scientists and engineers than 'traditional' firms. Finally, Smith and Watts (1992) find that the existence of executive stock option plans is increasing in the firm's growth opportunities.

[3]The use of long-term compensation arrangements is constrained by the risk premium demanded by the agent and the consumption requirements of the agent. Thus, we would not expect to see the compensation contract to be solely a function of long-term accounting or stock market performance. In addition, our discussion presumes the existence of a hidden action problem with respect to the division manager's choice of action. If there is no hidden action problem or costless and perfect monitoring is available, the optimal compensation contract, of course, will be a fixed salary.

[4]Under fairly restrictive conditions, it is possible to use a sequence of annual plans to provide long-run incentives (see Fudenberg, Holmstrom, and Milgrom, 1990). One such condition is that there can be no information asymmetries between the principal and the agent which could arise from the agent receiving information that the principal does not receive or from the agent taking actions which are not observed by the principal. This condition is not likely to hold in the innovation process. Despite that, we also empirically examined the relation between innovation and compensation structure defined as the proportion of total compensation arising from the sum of short-term annual bonus plans and all forms of long-term compensation. The results are very similar to those reported for the proportion of total compensation arising from long-term compensation.

There are a variety of other market structure variables that can affect the extent to which the market exhibits imperfect competition, and consequently, a firm's ability to capture the rents from innovation. In particular, there are likely to be barriers to entry for any given product market. For example, high levels of capital investment, research and development, and advertising may be required for production and sale of a product, and these expenditures will serve as barriers to entry for potential competitors. However, similar to the reasoning for market power, the sign of the relation between *barriers to entry* and innovation is ambiguous from a theoretical perspective.

Although the rents from innovation may be captured by competitors in the product market, it is also possible that suppliers of factor inputs appropriate some of these economic rents. For example, Acs and Audretsch (1987) argue that unions can capture some of the rents via increases in wage rates. This would suggest a negative relation between the extent of *worker unionization* and innovation.

Another market (or perhaps product) characteristic that can have a pronounced impact on innovation is the life-cycle for the products produced by a firm (e.g., Acs and Audretsch, 1987; Cohen and Levin, 1989). At an early point in the product life-cycle (where a standardized product has not evolved), there are substantial potential rents to innovation activities. In contrast, once a firm's product is mature (where the market exhibits an accepted standardized product), there are much lower economic rents to innovation. This would suggest a negative relation between the point on the *product life-cycle* and innovation.

In terms of firm factors, Schumpeter (1942) argues that firm size should have a positive influence on innovation, or that scale economies are necessary for innovation. Although this hypothesis has been examined extensively, the theoretical basis of the claim by Schumpeter is unclear. One common explanation is that large firms have an advantage in securing the financial capital necessary for undertaking risky innovation. However, this explanation requires that the capital markets are imperfect. Nevertheless, it has become commonplace in the industrial organization literature to hypothesize a positive relation between firm size and innovation. In contrast, Holmstrom (1989) argues that large firms are primarily engaged in production and marketing activities. Further, centralized decision-making and the adoption of bureaucratic procedures are common in large firms, because they are necessary to control the employee managers. However, this organizational structure will tend to inhibit innovation that is inherently individualistic in character. Thus, the sign of the relation between *firm size* and innovation is ambiguous from a theoretical perspective.

Finally, the extent of diversification in the operations of the firm has been argued to be another potentially important firm characteristic for understanding innovation. For example, Nelson (1959) argues that higher diversification encourages innovation because there are more opportunities to use any knowledge generated from the innovation process (or the firm can more easily exploit the outcomes from innovation conducted in any single division). However, there is considerable theoretical and empirical debate concerning the motivation for a firm to diversify. One possible explanation is that diversification is simply a manifestation of an agency problem where the manager reduces his personal risk by diversifying the firm's operations. This possibility would suggest that diversified firms would be less likely to engage in risky innovation. Thus, again, the sign of the relation between *diversification* and innovation is ambiguous from a theoretical perspective.

2.2. Determinants of the compensation contract

There is also a developing literature on the theoretical and empirical determinants for the choice of executive compensation contracts (e.g., Lambert and Larcker, 1987; Smith and Watts, 1992; Sloan, 1993; Bizjak, Brickley, and Coles, 1993). In general, these models consider the role of the investment opportunity set (or for our setting, the innovation opportunity set), division factors, and firm factors. However, much of the prior empirical work on the choice of compensation contracts has focused attention on the corporate CEO, rather than on the compensation contracts for divisional executives. Based upon this prior literature, we assume that the compensation contract choice can be characterized in the following form:

$$compensation\ contract_t = f(innovation_{t+2}, firm\ factors_t, division\ factors_t).$$

As discussed in Section 2.1, innovation is treated as an endogenous variable. However, in theory, it is a key determinant of the compensation contract selected for divisional managers. Specifically, firms confronting a substantial innovation opportunity set will attempt to provide managers with greater incentives to invest in innovation. Similarly, Smith and Watts (1992) and Bizjak, Brickley, and Coles (1993) argue that as firms' growth opportunities increase, their CEOs' compensation will be weighted more heavily toward long-run compensation. As discussed above, we hypothesize that an agent can be motivated to supply effort for innovation by increasing the proportion of their total compensation that is tied to long-term performance. Moreover, if division managers have private information which indicates the division is facing a highly valuable innovation opportunity set, they will attempt to structure more of their compensation using long-term performance payoffs. Thus, we hypothesize that the *innovation opportunity set* for a division will have a positive relation with the compensation contract (or the proportion of a manager's total compensation that is derived from long-term contracts).[5]

[5]This hypothesis is based upon the assumption that, on average, actual innovation observed at time $t + 2$ is equal to the innovation expected by the firm or division at time t (or the time at which the compensation contract choice is made). As long as firms and managers have rational expectations, on average, actual innovation observed at time $t + 2$, should be equal to the expected innovation at time period t.

As discussed in Lambert and Larcker (1987) and Sloan (1993), the choice of performance measure and the weight applied to the measure in the compensation contract is affected by the *noise* inherent in the performance evaluation metric. In particular, holding the sensitivity of the performance signal constant with respect to effort, the weight placed on a performance measure should vary inversely with the noise in the measure. The long-term compensation contracts for a divisional manager can be based upon either the stock return for the entire firm or the multi-year accounting performance for the division.[6] We hypothesize that the compensation contract (or the proportion of a manager's total compensation that is derived from long-term contracts) will have a negative relation with the noise in the stock market and accounting performance measures.

The results in Baiman, Larcker, and Rajan (1995) also suggest two additional variables that may affect the choice of compensation contracts for divisional managers. In their model, the agent (e.g., divisional manager) is always informed about some productivity parameter in his division, whereas the principal (e.g., corporate CEO) may not be informed about the division's productivity parameter. In their model, an informed CEO is considered to have expertise. Baiman, Larcker, and Rajan observe that an expert principal tends to allocate fewer tasks to the agent, but also imposes more compensation risk on the agent. This occurs because an expert principal can use his superior information to select appropriate actions on behalf of the business unit. However, for the tasks allocated to the manager, the manager is asked to exert more effort, which requires more compensation risk to be imposed on the manager. Thus, we hypothesize that the compensation contract (or the proportion of a manager's total compensation that is derived from long-term arrangements) will have a positive relation with the expertise of the corporate CEO.

Baiman, Larcker, and Rajan also observe that more compensation risk is imposed on the agent with increases in the potential payoff from the agent's business unit. This occurs because the principal desires to increase the level of agent effort in business units with high potential payoffs. As with most agency models, in order to motivate the agent to provide more effort, it is necessary to impose more risk in the compensation contract. Since larger divisions have a more pronounced impact on the residual payoff to the principal, we hypothesize that the compensation contract (or the proportion of a manager's total

[6]It is also possible that the firm will use nonfinancial performance goals to assess performance (i.e., the creation of a product or a technology is rewarded, not whether the stock price or accounting earnings increased). Moreover, performance can be rewarded by subsequent promotion and salary increases as opposed to being rewarded explicitly through a long-term performance plan.

compensation that is derived from long-term contracts) will have a positive relation with *relative division size*.[7]

Finally, firm size is also likely to be a determinant of the proportion of total compensation that is determined by long-term components. If it becomes more difficult to monitor the actions of executives as the size of the firm increases, we would anticipate that more contingent compensation would be imposed on division managers in larger organizations. Prior studies have also documented that larger firms tend to utilize more long-term compensation contracts for their CEOs (e.g., Sibson, 1991). Since the design of business unit compensation contracts tends to be (at least partially) a function of the contract chosen for the CEO,[8] we suspect that firm size will be a determinant of the contracts for the business unit manager. Thus, *firm size* is expected to have a positive relation with the extent of the manager's compensation derived from long-term components.

2.3. System of equations

Obviously, our discussion of innovation and compensation contract equations has not examined an explicit optimization model that completely incorporates the supply and demand for innovation or the costs and benefits regarding the choice of a compensation contract. We view our models as heuristic depictions that capture some of the important determinants of innovation and compensation contracts. Moreover, our discussion is generally consistent with the prior empirical literature that has examined innovation and compensation contracts as endogenous variables. Given the above analysis, we use the following *nonrecursive* system as the basis for our empirical study:

$$\begin{aligned} \textit{innovation}_{t+2} = f(&\textit{compensation contract}_t, \textit{market power}_t, \textit{barriers to} \\ &\textit{entry}_t, \textit{worker unionization}_t, \textit{product life-cycle}_t, \\ &\textit{firm size}_t, \textit{firm diversification}_t), \end{aligned}$$

$$\begin{aligned} \textit{compensation contract}_t = g(&\textit{innovation}_{t+2}, \textit{noise in performance measures}_t, \\ &\textit{expertise of the corporate CEO}_t, \textit{relative division} \\ &\textit{size}_t, \textit{firm size}_t). \end{aligned}$$

There are two useful features of this system of equations. First, we allow *both* the innovation opportunity set and the compensation contract to be *endogenous*

[7]It is also possible to motivate this hypothesis by assuming that it is inherently more difficult to monitor the actions of larger organizations or divisions. Rather than relying on inadequate monitoring to mitigate the hidden action problem, the board of directors can impose more compensation risk on the managers.

[8]Empirical support for this proposition is provided by Fisher and Govindarajan (1991) and Baiman, Larcker, and Rajan (1995).

variables. Second, although the market structure and firm characteristics in the innovation equation do not directly affect the choice of compensation contract, these variables have an indirect effect on the choice of the compensation contract through their impact on the innovation opportunity set.

3. Sample, measures, aggregation issues, and econometric issues

3.1. Sample

The sample for our study represents the intersection of firms with data available from a variety of sources. In particular, we obtain our compensation data from the confidential compensation files of a major U.S. human resource consulting firm, patent data from Chi Research Inc., accounting data for business segments from the 1988 Business Information Compustat and accounting data for the overall firm from the 1992 Compustat files. More specific information on the data files is provided when we discuss each measure used in our analysis. In order for a division to be included in our sample, we must have (at least) compensation data for the division from the compensation survey and patent data that matches the three-digit SIC code of the division.

3.2. Measures

Innovation. The generation of new knowledge or inventive activity in organizations is a construct that is difficult to directly measure. Much of the prior industrial organization work uses an *input* into the innovation process (i.e., expenditures on research and development or the number of employees engaged in research and development) as the measure for innovation. Holding aside the problems concerning the ability of firms to exercise considerable discretion in accounting for research and development expenditures, the most obvious limitation is that research and development expenditures do not provide any information about the success of the innovation process. In particular, research and development inputs do not provide any indication about the *output* of commercially viable innovations or inventions. Further, we know of no source of divisional research and development expenditures.

An alternative measure for innovation that has an output orientation can be constructed from patent data (e.g., Griliches, 1990).[9] Obviously, the number of

[9] As reviewed by Griliches (1990), prior research generally finds a very strong positive *cross-sectional* association between the level of research and development and the number of patents generated, with R-squares typically on the order of 0.9. Moreover, this cross-sectional correlation is not just due to size differences (Bound, Cummins, Griliches, Hall, and Jaffe, 1984). However, the *time-series* correlation between patent counts and research and development is somewhat less impressive with R-squares typically around 0.3.

patents is a noisy measure of the value of innovation because it assumes that all patents are equally valuable. Nevertheless, patent counts are one measure of innovation that is commonly used in the industrial organization literature. Moreover, the prior literature has found some evidence that patent counts are associated with changes in firm value, subsequent firm profits, sales growth, and the formation of new firms manufacturing related products (Cohen and Levin, 1989; Griliches, 1990).

Our innovation data were obtained from the database on patents constructed by Chi Research Inc.[10] This database consists of the number of patents granted, the number of citations to prior patents, and a variety of other patent statistics for approximately 1,100 actively patenting firms. For each of our sample firms, we collect data (where available) on the total number of patents granted during the five-year period from 1987 to 1991 in each three-digit SIC code. Although the database does not report patent counts for each division within a firm, we can match the patent data for a firm to its divisions using three-digit SIC codes. We deflate the patent count for a firm's three-digit SIC code, by total sales (in millions) for all divisions of the firm with the same three-digit SIC code, in order to control for cross-sectional differences in the size of the divisions generating the patents. Divisional sales is the sales reported from the confidential compensation data base from the same year the compensation data is collected (where sales are expressed in millions of 1990 dollars). The resulting innovation measure (denoted as *innov*) is a measure of patents per million dollars of sales from a firm's three-digit SIC code.[11] Since we aggregate patent data across all divisions of a firm with the same three-digit SIC code, the key assumption in our

[10]For some institutional discussion of these data, see Buderi (1992).

[11]Researchers have attempted to incorporate the differential values of an entity's patents by computing the number of citations in patent applications by other firms to previous patents by the entity (using the methods developed in bibliometrics). Patent citations differ from citations in journals because the patent examiner, not the patent applicant, is responsible for choosing the citations to previous patents and the citations represent a limitation on the scope of property rights established in a patent. Interestingly, Trajtenberg (1990), using computer tomography scanner patent and associated profit data, verifies that an index computed from patents weighted by citations exhibits a positive correlation with the value of a patent. To estimate citation-weighted patent counts, we multiply patent counts by the average citation index over the five-year time period from 1987 to 1991. The citation index for year t measures the average number of times patents granted between year $t-5$ and year $t-1$ *are cited in new patents granted in year t*. Chi Research Inc. normalizes this index by the average number of citations per patent received by all firms in the same three-digit product group. Thus, a citation index of one implies a firm's patents are cited at the average level of other patents granted in the same product group, and an index of 1.2 would imply that firm's patents are cited 20% more frequently. Like the patent count data, data on the citation index for each firm is collected by three-digit product groups. Multiplying the citation index by the number of patents granted to a division provides a measure of patents weighted by citations. We estimated, but do not report results based on citation-weighted patent counts because its correlation with patent counts is 0.97.

matching procedure is that patents associated with a specific three-digit SIC code arose from a division of the firm with the same three-digit SIC code. We refer to the divisions of a firm which share the same three-digit SIC code as a product group.

Compensation Contract. Our analysis considers two different measures of the compensation contract. The first measure, denoted *long-term/total*, is computed by taking the ratio of expected long-term compensation (or the sum of the valuations for stock options, performance plans, restricted stock, and phantom stock) to total expected compensation for the divisional CEO of each division of a company. This measure is similar to that used in prior work (e.g., Lewellen, Loderer, and Martin, 1987) and management consulting practice (see the discussion in Lambert and Larcker, 1985). The second measure, denoted *long-term-acctg/total*, is calculated by taking the ratio of expected long-term compensation based on accounting performance (or the sum of the valuations for performance units, performance shares, and phantom stock plans that are based on changes in book value) to total compensation for the divisional CEO. With the exception that the payout from performance share plans is partially a function of the stock price (although accounting numbers are used to determine whether the performance shares are 'earned out'), this measure excludes the price-based contingent performance. We use this second measure because the compensation risk imposed on the business unit manager can be tied directly to business unit performances, whereas price-based compensation can only be based on overall firm performance.

Both measures for the ratio of long-term compensation to total compensation are based on expected values of the long-term components granted to a divisional CEO in a given year under the assumption that performance targets are met. Hence, the measures are *ex ante* assessments of the value of long-term compensation granted to an executive in a given year and are not ex post outcomes of the payouts under these plans. This *ex ante* assessment is the variable of interest, because we are interested in the structure of the compensation granted to the executive, and not the *ex post* source of compensation actually earned from observed performance.

Our compensation data are obtained from the confidential compensation data files of a major U.S. human resource consulting firm. These data were collected during mid-year 1982, 1983, and 1984 via mail survey (with follow-up telephone conversations to verify the accuracy of responses). The compensation data consist of base salary, target annual bonus,[12] and the grant parameters for long-term compensation arrangements (i.e., stock option, performance

[12]The target annual bonus is the expected percentage of salary that will be paid to the executive if the short-term performance targets are met. This variable is sometimes not available, in which case we substitute the actual bonus paid. On average, actual bonuses are very close to target bonuses (see Holthausen, Larcker, and Sloan, 1995).

unit/share, restricted stock, and phantom stock plans). We use data on the divisional CEO, or the manager with the highest authority in a single profit center. The divisional CEO has business unit responsibility for sales, marketing, engineering, manufacturing, and research and development activities.[13]

Our incentive measures require a valuation of the value of long-term components of compensation *granted* to the divisional CEO in any given year. The long-term components of compensation can be tied to either the stock price established by the security market (i.e., stock options and restricted stock) or multi-year measures of accounting performance (i.e., performance units, performance share plans, and phantom stock plans). We value total compensation as the sum of annual salary, annual bonus, and an expected value for stock options, performance plans, restricted stock, and phantom stock. The expected value of stock options is computed by multiplying the number of stock options granted by 25% of the exercise price at the date of grant.[14] The expected value of performance plans and phantom stock is computed by multiplying the number of performance units, performance shares, or phantom shares by their respective target values (or payout per unit or share if the assigned performance goals are met). Finally, the expected value of restricted stock is computed by multiplying the number of restricted shares by the price per share at the date of grant.

Timing Issues for Innovation and Compensation. Despite our attempt to accurately measure innovation and the structure of the compensation contract, the timing of the data collection suggest a possible limitation. In particular, the compensation data are associated with the time period from 1982 to 1984, whereas the patent data are associated with the time period from 1987 to 1991. The observation that our compensation data are computed before the innovation data is consistent with the structural model developed in Section 2.

[13]We also investigated the same system of equations using the divisional research and development (R&D) manager. The divisional R&D manager is responsible for all applied R&D and design and development engineering. The tasks of this manager include investigating practical applications of scientific theories, as well as the application of existing engineering and scientific theory to the design and development of new products. Results using the divisional R&D manager did not find a statistically significant relation between the form of the compensation contract and innovation.

[14]We acknowledge that this option valuation is somewhat crude. However, it is very unclear (in theory) how to value multi-year components of long-term compensation. For example, the options could have been valued using the Black–Scholes method. Holding aside the applicability of Black–Scholes for executive stock options (see Lambert, Larcker, and Verrecchia, 1991, for a discussion of this point), we do not have a similar (sophisticated) model for valuing performance plans or phantom stock. In an attempt to assess the sensitivity of our results to our method of valuing stock options, we also estimated our results by valuing the options at 50% of the exercise price (the approximate value that would be assigned to stock options with a ten-year life for typical risk-free rate estimates and variance parameters observed for large firms) and by valuing at the exercise price of the grant date. These adjustments in the compensation computation had no substantive impact on our results.

However, an important issue is whether the approximate five-year time lag between the compensation contract data and the innovation data is appropriate. Ravenscraft and Scherer (1982) find that the lag between returns and research and development expenditures is approximately four to six years, and thus the time lag between our compensation contract and innovation data seems reasonable. Alternatively, if compensation contracts and innovation activity are reasonably constant through time, the exact timing of the innovation measure becomes less critical.

Market Structure. We measure market power using the four-firm concentration ratio for the industry of the division measured during the year corresponding to the compensation survey year. For example, in using compensation data for 1982, the four-firm concentration ratio is computed as the ratio of total sales for 1982 for the four firms with the greatest revenues to total industry revenues for 1982, which is based on the sum of the sales for all firms in the relevant three-digit SIC code on the annual industrial, research, and full coverage Compustat files in each year. The resulting variable is denoted as *cr4*. Market share is measured by computing the ratio of divisional revenues to the total revenues for all firms in the three-digit SIC code of the division. The market share measure is computed during the year corresponding to the compensation survey year. For example, in using compensation data for 1982, the market share is computed as the ratio of divisional sales for 1982 to total industry sales for 1982. The resulting variable is denoted as *mktshare*.

Barriers to entry are measured by computing the median capital expenditures to sales, research and development to sales, and advertising to sales ratios for all firms in the three-digit SIC code of the division, during the year corresponding to the compensation survey year. Rather than individually analyzing capital expenditure, research and development, and advertising intensity in the structural equation, we sum these three measures into an overall index for barriers to entry (denoted as *invest*).

We do not have a source of division-specific or firm-specific data on the percentage of employees that are unionized or covered by a collective bargaining agreement. As an alternative, we proxy for worker unionization using the results presented in Kokkelenberg and Sockell (1985) concerning their analysis of the Current Population Surveys. In particular, the average (over 1978 to 1980) percentage of unionized workers in the three-digit SIC code of the division is used as an estimate for the extent of unionization for the division. We assume that the unionization variable is reasonably stable over time. The resulting variable is denoted as *union*.

Product life-cycle was measured using the Chi Research Inc. database. Specifically, they compute the median age (in years) of U.S. patent references on front pages of a company's patents. In general, references to patents that are young (old) suggest that the firm is operating at an early (late) stage of the product life-cycle. We again match this patent data for a firm's product groups to our divisional data using three-digit SIC codes. Our measure of product life-cycle (denoted as *pattct*, where 'tct' refers to the Chi Research Inc. terminology of technical cycle time) is the average age of the patent references over the time period from 1987 to 1991, the period during which innovation is measured.

Firm and Division Factors. We measure the size of the total organization in terms of sales revenue in the fiscal year corresponding to the year when the compensation data was collected. For example, if the compensation data is from 1982, the sales revenue for the firm in fiscal 1982 is obtained from Compustat. In order to mitigate the influence of extreme observations, we take the natural logarithm of sales revenue (expressed in millions of 1990 dollars) and denote the resulting variable as *firmsize*. Similarly, we measure division size as the natural logarithm of divisional sales (expressed in millions of 1990 dollars) and denote the resulting variable *unitsize*. We measure the relative size of the division by computing the ratio of sales revenue for the division (which is obtained from the confidential compensation survey) to sales revenue for the firm and denote the resulting variable as *relsales*.

Firm diversification is measured using the distribution of sales revenue across the segments with different three-digit SIC codes reported by a firm on the 1988 Compustat Business Information files. For each firm, the share of revenue attributable to each segment is computed. These shares are then squared and summed to provide a Herfindahl-like index of diversification. A Herfindahl index of zero (one) implies that the firm is completely diversified (undiversified). The Herfindahl index is measured in the same year as the compensation survey is collected and the resulting variable is denoted as *hhi*.

Similar to Lambert and Larcker (1987), we measure the noise in performance measures using a time-series standard deviation. The noise in the market measure is computed from the annual standard deviation of common stock returns over the five-year period ending at the time the compensation data is collected. The resulting measure is denoted as *sdcret*. The noise in the accounting measure is computed from the standard deviation of the return on assets of the firm over the five-year period ending in the year of the compensation survey. The resulting measure is denoted as *sdcroa*.

The expertise of the corporate CEO was measured by comparing the two-digit SIC code of the overall corporation to the two-digit SIC code for the division in the year of the compensation survey. Similar to Baiman, Larcker, and Rajan (1995), we assume that CEO expertise is present when the corporate and divisional SIC codes are identical. We code this variable (denoted as *dsic*) as a one if the SIC codes *differ* and as a zero if the SIC codes are identical, and thus an increase in *dsic* is associated with a decrease in the expertise of the corporate CEO.

3.3. Aggregation issues

In order to mitigate dependence among the observations, we aggregate observations across divisions and across time. As discussed above, the innovation variable is measured as all patents in a company's product group (as defined by all divisions with the same three-digit SIC code) over the 1987 to 1991 period, deflated by total sales revenue across all divisions in that product group. Sales revenue, which is expressed in 1990 dollars, is obtained for the *same year* for which compensation data is collected. Thus, the innovation variable for a given year is aggregated across all divisions of a company in the same product group. However, for a given product group, we may have as many as three measures of innovation where the numerator is identical in all three measures and the denominator varies slightly with changes in sales revenue over time for the divisions (1982, 1983, and 1984). Thus, we also aggregate across the observations of a firm's product group by averaging the available observations over time, which results in a maximum of one observation for each product group of a firm. Our final sample consists of 299 observations from 116 different companies, with a median of two product groups per company.

Since we collapse the innovation variable into one observation for each firm-product group, we similarly aggregate the measures of compensation, market structure, firm factors, and division factors. In general terms, we first average across all divisions in the same product group for a given year, and then average across the available yearly observations for a product group to create a single observation for each required variable. For example, compensation data may be available for several divisions with the same three-digit SIC code and for several years. We first compute the average of the available observations across divisions in that product group for each year, and then average the available yearly means over time to create one compensation measure for each product group within a firm. Similar aggregation techniques are followed for the market structure, firm factors, and division factors.

3.4. Descriptive statistics

Descriptive statistics regarding the compensation of the divisional CEOs for the final sample are presented in Table 1. The mean (median) total compensation (measured in nominal 1990 dollars) for the aggregated observations is approximately $210,000 ($190,000). Although the median amount of *each* of the various forms of long-term compensation is zero for the divisional CEO, the median total long-term compensation is approximately $40,000. Approximately 65% of the divisional CEOs receive some type of long-term compensation. In general, to the extent there is long-term compensation for divisional CEOs, its most significant component comes in the form of stock options or performance units.

Table 1
Descriptive statistics on the estimated value of the components of divisional CEOs' compensation

Sample consists of 299 aggregated firm-product group observations. An aggregated firm-product group observation is formed by measuring observations at the *division-year level* and *averaging* observations for the same firm across divisions in the same three-digit SIC code (product-group) and then across years (from 1982 to 1984). All amounts are CPI adjusted to 1990 equivalent dollars.

	Mean	Std. dev.	Q1	Median	Q3
Salary	$158,070	$56,365	$120,254	$146,570	$179,470
Bonus	53,336	37,085	30,198	47,016	65,310
Total cash compensation	211,406	86,103	155,400	191,418	243,867
Performance shares	10,686	52,790	0	0	0
Performance units	25,190	69,788	0	0	18,795
Stock options	19,143	29,559	0	0	31,257
Restricted stock	4,172	17,473	0	0	0
Phantom stock	2,956	15,605	0	0	0
Total long-term compensation	62,147	94,120	0	39,971	79,118
Total compensation	273,553	156,718	178,842	239,449	310,961

Details concerning the computation of the value of the components of compensation are provided in the text.

The descriptive statistics for the variables used in the structural equation model for the sample of aggregated observations are presented in Table 2.[15] The median firm-product group in the sample is part of a firm with sales revenue of approximately four billion dollars (expressed in 1990 dollars) and about 25,000 employees. The median firm-product group has divisions with sales revenue of approximately 200 million dollars (expressed in 1990 dollars) and about 1,000 employees. The mean (median) innovation measure, number of patents for a product group divided by sales (in millions of 1990 dollars) is equal to 0.25 (0.057). The divisional CEOs of the firm-product groups have mean (median) *long-term/total* of approximately 16.5% (15.2%) and *long-term-accounting/total* of approximately 9.5% (0.0%).

The *relsales* variable indicates that the average (median) firm-product group has divisions which represent approximately 10% (6%) of corporate sales. The variable *dsic* indicates that the divisions are part of a company whose primary SIC code is not in the same two-digit SIC code approximately 48% of the time. The average standard deviation of return on assets, *sdcroa*, is less than 2% and the annual standard deviation of common stock returns, *sdcret*, is approximately 30%. The variable *pattct*, which measures the average age of patent references in the patents granted to the divisions of a firm-product group, indicates that the referenced patents, on average, have an age that exceeds 11 years.

The mean and median four-firm concentration ratios, *cr4*, are approximately 0.64 and the average market shares for the divisions in a product group are 3.2%. The average measure of barriers to entry (sum of capital expenditures, research and development, and advertising relative to sales in the divisions of the product groups is approximately 13%. Finally, the average percentage of unionized empolyees, *union*, exceeds 30%.

3.5. Econometric issues

For the nonrecursive system of equations developed in Section 2, it is well-known that ordinary least-squares (OLS) estimation will not provide consistent estimates of the coefficients in the structural equations. Therefore, we estimate our system using two-stage least-squares (2SLS) procedures. In the

[15]We impute missing values for the market structure, firm factor, and division factor variables for those observations with available data on the compensation and innovation variables. Without imputation, we would only have 188 observations, whereas with imputation we estimate the system with 299 observations. Our imputation procedure estimates the missing values using the stepwise multiple regression techniques outlined in Buck (1960), Beale and Little (1975), and Little (1992).

absence of misspecification, the resulting coefficient estimates are consistent, but not necessarily as efficient as full information estimates. However, there are two basic advantages associated with limited information 2SLS procedures relative to full information procedures. First, 2SLS estimation may be preferred to full information estimation techniques in small samples.[16] Second, the estimation results may be less affected by misspecification in the system, which will be very likely in the early stages of a research inquiry. For example, if the innovation equation is misspecified, but the compensation contract equation is correctly specified, the specification error will only affect the innovation equation when the system is estimated via 2SLS. However, the misspecification will affect both equations when the system is estimated via full information estimation techniques.

Rather than relying on normal theory standard errors, we conduct our statistical tests using the bias-adjusted bootstrapped confidence intervals (Stine, 1989; Jeong and Maddala, 1993). Specifically, 2SLS parameter estimates were computed using 500 iterations with random resampling, and the resulting bias-adjusted confidence for each parameter were computed for conventional levels of statistical significance. This bootstrapping approach exhibits several advantages. First, it mitigates the bias associated with normal theory standard errors that arises because they ignore the sampling variation associated with an imputed observation. Second, it mitigates the potential bias in normal theory standard errors induced by the winsorization of the data.[17] Third, since we use a random resampling technique, the bootstrapping adjusts the confidence intervals for heteroskedasticity problems which would likely exist even if the missing data were not imputed. Fourth, the variables cannot be characterized as having a normal distribution (e.g., the incentive variables are frequently equal to zero), and bootstrapping should provide more reasonable confidence intervals with this type of data.[18] Finally, the finite sample properties of 2SLS are

[16] Challen and Hagger (1983) perform Monte Carlo simulations and indicate that 2SLS has more desirable small sample properties and is more robust to multicollinearity and specification problems than full information estimation techniques.

[17] Before estimation, we also winsorize the data at the first and 99th percentile because some of the variables have extreme observations. Although our subsequent results are based on winsorized data, this procedure (or winsorization at the 5th and 95th percentiles) had almost no impact on the results.

[18] Since values of the compensation and innovation variables cannot take on values below zero, the data is potentially censored, which could result in inconsistent parameter estimates. In order to provide some insight into whether our results are affected by this possibility, we also estimated a model where the innovation and compensation variables were indicator variables indicating innovation (or not) and existence of long-term compensation (or not). In addition, we estimated the model for only nonzero values of the variables. The results of these two sensitivity analyses were similar to those reported. However, in order to more completely address the problems induced by censored data, it would be necessary to incorporate a Tobit specification in the system of equations.

Table 2
Descriptive statistics on aggregated firm-product group characteristics

Sample consists of 299 aggregated firm-product group observations. With the exception of the innovation measure, aggregated firm-product group observations are formed by measuring observations at the division-year level (variable definitions at the division-year level are provided at the foot of the table) and averaging observations for the same firm across divisions in the same three-digit SIC code (product group) and then across years (from 1982 to 1984). Innovation is initially measured at the firm-product group level (see the definition at the foot of the table) and then averaged across years (from 1982 to 1984).

	Mean	Std. dev.	Q1	Median	Q3
Endogenous variables					
Innovation					
innov	0.250	0.535	0.010	0.057	0.210
Incentive					
lt/total	0.165	0.150	0.000	0.152	0.258
lt acc/total	0.095	0.141	0.000	0.000	0.179
ln(*total*)	12.388	0.443	12.088	12.361	12.637
Exogenous variables for innovation equation					
pattct	11.046	3.885	8.300	10.400	12.600
cr4	0.645	0.133	0.569	0.640	0.723
mktshare	0.032	0.056	0.004	0.011	0.035
firmsize	8.267	1.021	7.678	8.279	8.926
invest	0.128	0.070	0.085	0.109	0.147
union	0.317	0.142	0.248	0.308	0.435
hhi	0.483	0.196	0.347	0.467	0.562
Exogenous variables for incentive equation					
relsales	0.105	0.115	0.032	0.063	0.135
dsic	0.482	0.500	0	0	1.000
sdcret	0.293	0.119	0.214	0.283	0.354
sdcroa	0.019	0.016	0.009	0.015	0.024
firmsize	8.267	1.021	7.678	8.279	8.926

innov = total number of patents granted to each firm-product group (from 1987 to 1991), divided by the annual sales for divisions in the firm-product group.
lt/total = ratio of long-term compensation to total compensation for the divisional CEO.
lt acc/total = ratio of accounting-based long-term compensation (i.e., the sum of the value of compensation under performance share, performance unit, and phantom stock plans) to total compensation for the divisional CEO.
ln(*total*) = natural logarithm of total compensation for the divisional CEO.
relsales = ratio of divisional sales revenue to total firm sales revenue.
dsic = dummy variable coded as one if the division's two-digit SIC code is different from the overall corporation's two-digit SIC code and zero otherwise.
sdcret = standard deviation of the stock price of the corporation to which the division belongs.

Table 2 (continued)

sdcroa	= standard deviation of the return on assets for the corporation to which the division belongs.
pattct	= median age of the US patent references cited in the division's new patents.
cr4	= average four-firm concentration ratio computed for all firms in the division's three-digit SIC code.
mktshare	= ratio of divisional revenues to the total revenues of all firms in the division's three-digit SIC code.
firmsize	= natural log of sales revenue for the corporation to which the division belongs.
invest	= median ratio of the sum of capital expenditures, research and development expenditures, and advertising expenditures, to sales for all firms in the division's three-digit SIC code.
union	= average percentage of employees in the division's three-digit SIC code that are unionized.
hhi	= Herfindahl index based on the distribution of sales revenue across all product groups of the corporation to which the division belongs (higher values imply less diversification).

somewhat unclear, and therefore reliance on normal theory test statistics is questionable.

Despite the procedures used, there are six limitations inherent in our methodological approach. First, our observations will tend to exhibit some degree of positive cross-sectional dependence. As discussed previously, the median firm in our sample has two three-digit product groups in our analysis. If there is a firm-specific compensation strategy, this may induce correlation among the observations, and thus tend to deflate the standard errors for the parameter estimates.

Second, only the compensation contract and innovation variables are treated as endogenous. The market structure, firm factors, and divisional factors are assumed to be exogenous or predetermined variables. Obviously, identification considerations require each endogenous variable to be associated with some unique set of exogenous variables (or instruments). However, we acknowledge that in the 'long run' the firm can select the size of the organization, the extent of diversification, the product mix, and other important strategic variables. Thus, our market structure, firm factors, and divisional factors are not purely exogenous. Our estimation procedures assume that these variables are 'fixed' during the time period used to examine the nonrecursive relation between the compensation contract and innovation (i.e., firms are unable to substantially change the industry and attributes of their factor input and product markets).

Third, our variables are almost certainly measured with error, and this will tend to produce inconsistent estimates for the structural equation parameters and their standard errors. However, without more detailed knowledge of the correlation structure of the measurement error, it is difficult to determine the precise impact of these errors on our interpretation of the results.

Fourth, there is the distinct possibility that the system of equations is misspecified, because of correlated omitted variables and inappropriate zero restrictions on the coefficients between the exogenous instruments and the endogenous variables. For example, compensation contracts are likely to be chosen to address issues other than the innovation problem (e.g., other types of moral hazard problems). To the extent our analysis does not consider all of the determinants of the compensation contract, we face the possibility that our results are affected by unidentified correlated omitted variables.

Fifth, our instruments have relatively weak empirical associations with the endogenous variables. For example, the reduced form incentive equation exhibits an adjusted R^2 of approximately 10% and the reduced form innovation equation exhibits an adjusted R^2 of approximately 20%. Although it is common wisdom to assume that unacceptable instruments will cause the coefficient estimates to have extremely large sampling variance, recent work by Nelson and Startz (1990) suggests that this need not be the case. Thus, while our system is formally identified because each nonrecursive source has a unique set of instruments, the low adjusted R^2 of the reduced form equation can result in both low power and potential interpretation problems.

Finally, the relation between innovation and compensation structure is likely to be influenced by industry effects or the notion that different industries have quite different propensities to patent their innovations (Cohen and Levin, 1989). In principle, industry effects could be controlled by estimating a separate system of equations for each industrial grouping of the divisions. Unfortunately, we do not have sufficient sample size within the industrial groupings to reasonably pursue this industry-specific approach. We attempt to mitigate industry effects by including an indicator variable for any two-digit SIC code which represents at least 5% of the overall sample. For our sample, we include an indicator variable for chemicals (*grp28*), machinery (*grp35*), electrical (*grp36*), transportation equipment (*grp37*), and instrumentation (*grp38*). The remaining industries are represented by the intercept in the equation.

4. Results

The incentive equation in Table 3 indicates that the relation between *innov* (patent counts divided by divisional sales) and *long-term/total* (the proportion of long-term compensation in total compensation) is significantly negative ($p < 0.20$, two-tail). Thus, inconsistent with our hypothesis, we find weak evidence that increases in the innovation opportunities facing the division result in less reliance on long-term components of compensation. There is also evidence that *firmsize* has a positive relation with *long-term/total* ($p < 0.05$, two-tail). However, *relsales*, *dsic*, *sdcret*, *sdcroa*, and the industry indicator variables are all

Table 3

Two-stage least-squares estimation of the simultaneous relation between innovation and incentives for divisional CEOs

With the exception of the innovation measure, aggregated firm-product group observations are formed by measuring observations at the division-year level (variable definitions at the division-year level are provided at the foot of the table) and averaging observations for the same firm across divisions in the same three-digit SIC code (product group) and then across years (from 1982 to 1984). Innovation is initially measured at the firm-product group level (see the definition at the foot of the table) and then averaged across years (from 1982 to 1984). Incentives (denoted '*incent*') are measured using the *ratio of long-term compensation to total compensation.*

Incentive equation			Innovation equation		
Variable	Predicted sign	Coefficient	Variable	Predicted sign	Coefficient
intercept		– 0.230***	*intercept*		– 0.445
innov	(+)	– 0.120*	*incent*	(+)	– 0.362
relsales	(+)	0.011	*pattct*	(–)	– 0.012
dsic	(–)	0.001	*cr4*	(?)	– 0.045
sdcret	(–)	0.003	*mktshare*	(?)	– 2.000
sdcroa	(–)	– 0.034	*firmsize*	(?)	0.132***
firmsize	(+)	0.052***	*invest*	(?)	0.124
grp28	(?)	– 0.032	*union*	(–)	– 0.358*
grp35	(?)	– 0.025	*hhi*	(?)	– 0.224
grp36	(?)	0.026	*grp28*	(?)	– 0.061
grp37	(?)	– 0.040	*grp35*	(?)	0.058
grp38	(?)	0.045	*grp36*	(?)	0.415**
			grp37	(?)	– 0.090
			grp38	(?)	0.297***
Adjusted R^2 = 5.87%			Adjusted R^2 = 20.83%		

Asterisks indicate: Significantly different from zero at the 5% (***), 10% (**), and 20% (*) levels (two-tailed test using bias-adjusted bootstrapped confidence intervals).

innov = total number of patents granted to each firm-product group (from 1987 to 1991), divided by the annual sales for divisions in the firm-product group.
incent = ratio of long-term compensation to total compensation for the divisional CEO.
relsales = ratio of divisional sales revenue to total firm sales revenue.
dsic = dummy variable coded as one if the division's two-digit SIC code is different from the overall corporation's two-digit SIC code and zero otherwise.
sdcret = standard deviation of the stock price of the corporation to which the division belongs.
sdcroa = standard deviation of the return on assets for the corporation to which the division belongs.
pattct = median age of the US patent references cited in the division's new patents.
cr4 = average four-firm concentration ratio computed for all firms in the division's three-digit SIC code.
mktshare = ratio of divisional revenues to the total revenues of all firms in the division's three-digit SIC code.
firmsize = natural log of sales revenue for the corporation to which the division belongs.
invest = median ratio of the sum of capital expenditures, research and development expenditures, and advertising expenditures to sales for all firms in the division's three-digit SIC code.

Table 3 (continued)

union	= average percentage of employees in the division's three-digit SIC code that are unionized.
hhi	= Herfindahl index based on the distribution of sales revenue across all product groups of the corporation to which the division belongs (higher values imply less diversification).
grp28	= product group indicator variable taking the value of one if the observation belongs to the chemicals product group and zero otherwise.
grp35	= product group indicator variable taking the value of one if the observation belongs to the machinery product group and zero otherwise.
grp36	= product group indicator variable taking the value of one if the observation belongs to the electrical product group and zero otherwise.
grp37	= product group indicator variable taking the value of one if the observation belongs to the transportation equipment product group and zero otherwise.
grp38	= product group indicator variable taking the value of one if the observation belongs to the instrumentation product group and zero otherwise.

statistically insignificant at conventional levels ($p > 0.20$, two- tail). Finally, this incentive equation exhibits a very modest R^2 of 5.8%.

For the innovation equation of Table 3, there is no evidence that *innovation* has a positive relation with *long-term/total*. However, we observe that subsequent innovation has a positive relation with *firmsize* ($p < 0.05$, two-tail), a negative relation with *union* ($p < 0.20$, two-tail), and a positive relation with the indicator variable for the electrical industry ($p < 0.10$, two-tail) and the instrumentation industry ($p < 0.05$, two-tail). The R^2 of the innovation equation is 20.8%.

The results where *long-term-acctg/total* is used as the incentive variable are presented in Table 4. As discussed in Section 3, the advantage of this incentive variable relative to *long-term/total* is that the long-term performance measure can be based exclusively on divisional performance. Since the median division in the sample accounts for only about 6% of corporate revenues, this incentive variable may more directly measure the divisional CEO's performance. Hence, it is possible that *long-term-acctg/total* is a better measure for the compensation structure for the divisional CEO than *long-term/total*. In the incentive equation of Table 4, there is no evidence that the expected innovation opportunity set is related to the choice of the compensation contract as measured by *long-term-acctg/total*. As in Table 3, there is evidence that *long-term-acctg/total* has a positive relation with *firmsize* ($p <$ 0.05, two-tail), and *relsales*, *dsic*, *sdcret*, and *sdcroa* are still unrelated to *long-term-acctg/total*.[19] Three of the industry

[19]When using *long-term-acctg/total* as the incentive variable, the expected sign on *sdcret* becomes positive. That is, holding *sdcroa* constant, we would expect that the compensation contract would place more weight on accounting measures with increases in the noise of market measures of performance (*sdcret*).

Table 4
Two-stage least-squares estimation of the simultaneous relation between innovation and incentives for divisional CEOs

Sample consists of 299 aggregated firm-product group observations. With the exception of the innovation measure, aggregated firm-product group observations are formed by measuring observations at the division-year level (variable definitions at the division-year level are provided at the foot of the table) and averaging observations for the same firm across divisions in the same three-digit SIC code (product group) and then across years (from 1982 to 1984). Innovation is initially measured at the firm-product group level (see the definition at the foot of the table) and then averaged across years (from 1982 to 1984). Incentives (denoted '*incent*') are measured using the *ratio of accounting-based long-term compensation to total compensation.*

Incentive equation			Innovation equation		
Variable	Predicted sign	Coefficient	Varible	Predicted sign	Coefficient
intercept		− 0.095	*intercept*		− 0.911***
innov	(+)	− 0.065	*incent*	(+)	3.216***
relsales	(+)	0.018	*pattct*	(−)	− 0.007
dsic	(−)	0.005	*cr4*	(?)	− 0.080
sdcret	(+)	0.044	*mktshare*	(?)	− 3.612***
sdcroa	(−)	− 0.351	*firmsize*	(?)	0.098*
firmsize	(+)	0.028***	*invest*	(?)	− 0.264*
grp28	(?)	− 0.062***	*union*	(−)	− 0.052
grp35	(?)	− 0.051*	*hhi*	(?)	0.168*
grp36	(?)	− 0.030	*grp28*	(?)	0.209***
grp37	(?)	− 0.050*	*grp35*	(?)	0.238***
grp38	(?)	− 0.011	*grp36*	(?)	0.669***
			grp37	(?)	− 0.045
			grp38	(?)	0.449***
Adjusted R^2 = 3.03%			Adusted R^2 = 10.93%		

Asterisks indicate: Significantly different from zero at the 5% (***), 10% (**), and 20% (*) levels (two-tailed test using bias-adjusted bootstrapped confidence intervals).

innov = total number of patents granted to each firm-product group (from 1987 to 1991), divided by the annual sales for divisions in the firm-product group.
incent = ratio of accounting-based long-term compensation (i.e., the sum of the value of compensation under performance share, performance unit, and phantom stock plans) to total compensation for the divisional CEO.
relsales = ratio of divisional sales revenue to total firm sales revenue.
dsic = dummy variable coded as one if the division's two-digit SIC code is different from the overall corporation's two-digit SIC code and zero otherwise.
sdcret = standard deviation of the stock price of the corporation to which the division belongs.
sdcroa = standard deviation of the return on assets for the corporation to which the division belongs.
pattct = median age of the US patent references cited in the division's new patents.
cr4 = average four-firm concentration ratio computed for all firms in the division's three-digit SIC code.

Table 4 (continued)

mktshare	= ratio of divisional revenues to the total revenues of all firms in the division's three-digit SIC code.
firmsize	= natural log of sales revenue for the corporation to which the division belongs.
invest	= median ratio of the sum of capital expenditures, research and development expenditures, and advertising expenditures to sales for all firms in the division's three-digit SIC code.
union	= average percentage of employees in the division's three-digit SIC code that are unionized.
hhi	= Herfindahl index based on the distribution of sales revenue across all product groups of the corporation to which the division belongs (higher values imply less diversification).
grp28	= product group indicator variable taking the value of one if the observation belongs to the chemicals product group and zero otherwise.
grp35	= product group indicator variable taking the value of one if the observation belongs to the machinery product group and zero otherwise.
grp36	= product group indicator variable taking the value of one if the observation belongs to the electrical product group and zero otherwise.
grp37	= product group indicator variable taking the value of one if the observation belongs to the transportation equipment product group and zero otherwise.
grp38	= product group indicator variable taking the value of one if the observation belongs to the instrumentation product group and zero otherwise.

indicator variables are also statistically significant at conventional levels. The incentive equation again exhibits a very modest R^2 of 3.03%.

In the innovation equation, there is now evidence that the subsequent amount of innovation has a positive relation with *long-term-acctg/total* ($p < 0.05$, two-tail). In addition, many of the other variables in the innovation equation also have a statistically significant effect on the degree of patenting activity. In particular, both *invest* ($p < 0.20$, two-tail) and *mktshare* ($p < 0.05$, two tail) have a statistically negative coefficient. These results indicate that divisions innovate less when they have greater market share in their three-digit SIC industry, and when there are greater barriers to entry. The significantly positive coefficient on *hhi* ($p < 0.20$, two-tail) suggests that subsequent innovation of a division is greater if it is a part of a less diversified firm. Similar to the results in Table 3, *firmsize* has a positive relation with innovation ($p < 0.20$, two-tail), while *pattct* and *cr4* are statistically insignificant at conventional levels. The R^2 of the innovation equation is 10.9%.

The results in Tables 3 and 4 provide only modest evidence that subsequent innovation is an increasing function of the proportion of total compensation which is long-term. Moreover, this result is obtained only when we consider that proportion of long-term compensation that is based on accounting performance. This result implies that if the *exogenous* determinants of the divisional CEO's proportion of total compensation derived from accounting-based long-term components changed so as to cause that proportion to increase, we should expect to observe an increase in subsequent innovation for the division, holding the other determinants of innovation constant. Further, there is also very weak evidence (in Table 3, but not in Table 4) that increases in the innovation opportunity set result in firms compensating their division managers with less long-term compensation.[20] It is difficult to provide an economic justification for this result, as it implies that if the *exogenous* determinants of innovation were to change such that the expected innovation opportunity set increases, we would expect that the proportion of long-term compensation to total compensation would decline for divisional CEOs (holding the other determinants of the compensation structure constant). If firms with more innovation tend to be high-growth firms or firms with greater investment opportunity sets, this result is inconsistent with the empirical evidence in Smith and Watts (1992) and Bizjak, Brickley, and Coles (1993).[21]

With regard to the exogenous variables in the incentive equations, the significant positive coefficient on firm size is consistent with larger organizations attempting to use more long-term compensation incentives to substitute for monitoring, as the costs of monitoring increase with firm size. The lack of cross-sectional relation with the two noise variables, *sdcret* and *sdcroa*, is inconsistent with the time-series evidence in Lambert and Larcker (1987) and Sloan (1993), who find that increases in the noise associated with a performance signal reduce the weight placed on that performance metric in the compensation contract. Finally the lack of significance associated with *dsic* and *relsales* is inconsistent with Baiman, Larcker, and Rajan (1995), although they concentrate on explanations for the importance of the annual bonus component of compensation. However, it is difficult to make comparisons between our paper and the prior work in the incentive area, because the focus of our study and our methodological approach differ considerably from the existing literature.

With regard to the exogenous variables in the innovation equation, the positive coefficient on *firmsize* is consistent with Schumpeter (1942) who argues that scale is needed for innovation, but is inconsistent with the argument by Holmstrom (1989) that larger firms have organizational structures which will inhibit innovation. The other exogenous variables which were statistically significant at conventional levels in the innovation equation, were only significant in either Table 3 or 4. The negative coefficients on *invest* and *mktshare*

[20]We conducted Hausman tests to determine whether *innov* and *incent* should be treated as endogenous variables. We are unable to reject the null hypothesis that *innov* and *incent* can be treated as exogenous variables. However, since the instruments explain a relatively low amount of the variation in the endogenous variables, we suspect that the power of the Hausman tests is relatively low.

[21]Smith and Watts (1992) find that firms are more likely to grant stock options to their CEOs as their market-to-book ratios increase. Bizjak, Brickley, and Coles (1993) conclude from their empirical work that high-growth firms place less emphasis on current performance relative to future performance in managerial compensation plans than low-growth firms.

indicate that there is less incentive to innovate when barriers to entry are high or when the firm has considerable market power. As such, the results on barriers to entry and market share are consistent with the arguments of Phillips (1965) and Scherer (1980), and inconsistent with Schumpeter (1942). The significant negative coefficient on *union* suggests that unions can capture some of the rents associated with innovation and therefore highly unionized firms are less likely to innovate which is consistent with Acs and Audretsch (1987). The positive coefficient on *hhi* indicates that less diversified firms exhibit higher levels of innovation, which is inconsistent with Nelson (1959). However, this result is generally consistent with recent arguments about the importance of competitive focus for understanding firm performance (e.g., Porter, 1987). Further, there is no observed relation between innovation and *cr4* nor *pattct*, which suggests that neither the industry's concentration ratio nor the life-cycle of the product affects the amount of innovation.

5. Level of total compensation as the incentive variable

The rationale for investigating the compensation variables in the previous section is based on the hypothesis that increasing the proportion of total compensation arising from long-term components will provide a division manager with a greater incentive to invest in innovative activities whose payoffs are not immediate. However, an alternative hypothesis is that managers who excel at fostering innovation are granted subsequent promotions or are granted subsequent increases in salary. That is, rather than varying the 'mix' of long-term components in the managerial compensation package, firms motivate managers via substantial promotion opportunities and commensurate increases in compensation. While we cannot test that hypothesis directly, we can provide an exploratory test of a variant of this hypothesis using our data.

Assume that some individuals have proven to be successful at fostering innovation in the past, and that those individuals earn higher equilibrium wages relative to those who have no proven record of fostering innovation. When a division faces a greater expected innovation opportunity set, the firm would tend to hire division managers who can foster innovation (assuming that the firm can capture some of the gains associated with the innovation). Thus, the level of *total compensation* of the divisional executive should be increasing in the expected innovation opportunity set. Moreover, greater subsequent innovation should be expected in those organizations which employ higher-paid divisional executives who are capable of fostering innovation.[22]

---

[22]The argument here is similar to that in Smith and Watts (1992) who argue that firms with greater growth opportunities will employ higher-quality managers and pay them more than firms with limited growth opportunities. Smith and Watts (1992) treat growth opportunities as exogenous and

Given this scenario, we examine another system of equations where the natural logarithm of the level of total compensation is used as the incentive variable, and several changes are made to the exogenous determinants for incentive equation. In particular, we substitute *unitsize* for *firmsize* in the incentive equation, as divisional size is expected to have a positive relation with level of pay (i.e., pay is an increasing function of job complexity). The noise measures, *sdcroa* and *sdcret*, are expected to have a positive relation with the level of pay because managers will demand greater wages from more risky employers. *Relsales* is expected to have a positive relation with the level of pay as the CEO is likely to hire higher-quality managers for a division that is relatively important to the total firm. The relation between the level of compensation and *dsic* is ambiguous. If the CEO desires to hire a high-quality manager for divisions where the CEO lacks expertise regarding the operation of the division, this would tend to increase the divisional manager's compensation. However, a less expert CEO will also tend to impose less compensation risk on the divisional manager, and this will lead to decreased levels of pay. Hence, the relation between level of pay and CEO expertise is unclear.

The results from estimating the system of equations using the level of compensation variable as the incentive variable are presented in Table 5. The incentive equation provides some evidence that divisional CEOs of business units facing greater expected innovation opportunity sets receive higher levels of total compensation ($p < 0.05$, two-tail). This result is consistent with the findings of Smith and Watts (1992). As documented in many prior studies, total compensation also exhibits a positive elasticity of approximately 0.30 with *unitsize* ($p < 0.05$, two-tail). Total compensation has an unexpected negative relation with *relsales* ($p < 0.20$, two-tail), which implies that divisional CEOs are paid more if the division is less important to the overall firm (holding *unitsize* constant). Total compensation is also negatively related to *sdcroa* ($p < 0.20$, two-tail) implying more risky firms exhibit lower pay levels, which is also counter-intuitive. Finally, the variable *dsic* has a statistically positive relation with the level of pay ($p < 0.20$, two-tail), indicating that managers of divisions which differ from the company's primary SIC code earn higher levels of compensation.

Unexpectedly, we find evidence that *incent* (*total compensation*) has a negative relation with subsequent innovation ($p < 0.05$, two-tail). It is difficult to provide an economic rationale for the result that higher-paid divisional CEOs produce

document that CEO salaries are increasing in growth opportunities. An alternative rationale for why the level of pay may affect innovative activity is that if a divisional CEO is paid an amount which exceeds his next best alternative, the divisional CEO will be motivated to work harder in order to avoid losing that superior position. Thus, the level of pay may affect the effort level of the divisional CEO and innovative activity.

Table 5

Two-stage least squares estimation of the simultaneous relation between innovation and incentives for divisional CEOs

Sample consists of 299 aggregated firm-product group observations. With the exception of the innovation measure, aggregated firm-product group observations are formed by measuring observations at the division-year level (variable definitions at the division-year level are provided at the foot of the table) and averaging observations for the same firm across divisions in the same three-digit SIC code (product-group) and then across years (from 1982 to 1984). Innovation is initially measured at the firm-product group level (see the definition at the foot of the table) and then averaged across years (from 1982 to 1984). Incentives (denoted '*incent*') are measured using the log of the level of total compensation.

Incentive equation			Innovation equation		
Varible	Predicted sign	Coefficient	Variable	Predicted sign	Coefficent
intercept		10.738***	*intercept*		8.623***
innov	(+)	0.246***	*incent*	(+)	− 0.813***
relsales	(+)	− 0.344*	*pattct*	(−)	− 0.012**
dsic	(?)	0.061*	*cr4*	(?)	− 0.376
sdcret	(+)	− 0.105	*mktshare*	(?)	0.071
sdcroa	(+)	− 1.628*	*firmsize*	(?)	0.281***
unitsize	(+)	0.304***	*invest*	(?)	− 0.153
grp28	(?)	0.036	*union*	(−)	− 0.694***
grp35	(?)	0.011	*hhi*	(?)	− 0.154
grp36	(?)	− 0.039	*grp28*	(?)	− 0.041
grp37	(?)	0.023	*grp35*	(?)	0.016
grp38	(?)	0.130**	*grp36*	(?)	0.305***
			grp37	(?)	− 0.034
			grp38	(?)	0.297***
Adjusted R^2 = 54.80%			Adjusted R^2 = 21.71%		

Asterisks indicate: Significantly different from zero at the 5% (***), 10% (**), and 20% (*) levels (two-tailed test using bias-adjusted bootstrapped confidence intervals).

innov = total number of patents granted to each firm-product group (from 1987 to 1991), divided by the annual sales for divisions in the firm-product group.

incent = the natural logarithm of total compensation for the divisional CEO.

relsales = ratio of divisional sales revenue to total firm sales revenue.

dsic = dummy variable coded as one if the division's two-digit SIC code is different from the overall corporation's two-digit SIC code and zero otherwise.

sdcret = standard deviation of the stock price of the corporation to which the division belongs.

sdcroa = standard deviation of the return on assets for the corporation to which the division belongs.

pattct = median age of the US patent references cited in the division's new patents.

cr4 = average four-firm concentration ratio computed for all firms in the division's three-digit SIC code.

mktshare = ratio of divisional revenues to the total revenues of all firms in the division's three-digit SIC code.

firmsize = natural log of sales revenue for the corporation to which the division belongs.

Table 5 (continued)

unitsize	= natural log of sales revenue for the division.
invest	= median ratio of the sum of capital expenditures, research and development expenditures, and advertising expenditures to sales for all firms in the division's three-digit SIC code.
union	= average percentage of employees in the division's three-digit SIC code that are unionized.
hhi	= Herfindahl index based on the distribution of sales revenue across all product groups of the corporation to which the division belongs (higher values imply less diversification).
grp28	= product group indicator variable taking the value of one if the observation belongs to the chemicals product group and zero otherwise.
grp35	= product group indicator variable taking the value of one if the observation belongs to the machinery product group and zero otherwise.
grp36	= product group indicator variable taking the value of one if the observation belongs to the electrical product group and zero otherwise.
grp37	= product group indicator variable taking the value of one if the observation belongs to the transportation equipment product group and zero otherwise.
grp38	= product group indicator variable taking the value of one if the observation belongs to the instrumentation product group and zero otherwise.

less subsequent innovation. Thus, the expectations of more innovation from employing higher-quality division managers are not realized in this sample. As seen in previous tables, *union* has a statistically negative relation with subsequent innovation ($p < 0.05$, two-tail), and *firmsize* is positively related to subsequent innovation ($p < 0.05$, two-tail). Finally, *pattct* is statistically *negative* ($p < 0.10$, two-tail), which implies that firms engage in more innovation in the early stages of a product's life cycle, consistent with Acs and Audretsch (1987) and Cohen and Levin (1989).

6. Concluding remarks

In this paper, we examine whether the proportion of total compensation arising from long-term components is related to the expected innovation opportunity set and whether the extent of subsequent innovative activity is related to this characteristic of the manager's compensation contract. One unique feature of our analysis is that we conduct our tests using divisional (or business unit) data for the compensation contract and innovation. In addition, we allow both the innovation opportunity set and the compensation contract to be endogenous variables using a nonrecursive system of equations.

Although our results are mixed, there is modest evidence that increases in the long-term component of the divisional CEO's compensation (especially that part which is accounting-based and can be tied directly to the division's performance) has a positive relation with future innovation by the division. The appropriate interpretation of this result is that if the exogenous variables affecting the proportion of total compensation tied to accounting-based long-term components shift so as to cause that proportion to increase, we should expect a positive effect on the division's future innovation. However, it would not be appropriate to conclude that an increase in the proportion of compensation tied to long-term components (which was not supported by a shift in the exogenous factors) should be expected to produce an increase in subsequent innovation by the firm. Further, we find no evidence that the proportion of total compensation arising from accounting-related long-term components is a function of the expected innovation opportunity set facing the division. However, we find a weak, but unexpected negative relation between the innovative opportunity set and the proportion of total compensation from all long-term compensation vehicles.

In order to relate our analysis to other recent work which has examined the compensation paid to CEOs (e.g., Smith and Watts, 1992), we also investigated the relation between the level of total compensation and innovative activities. The results of that investigation are quite different from the structural models based on the proportion of compensation arising from long-term components. In particular, we find evidence that total compensation is increasing in the expected innovation opportunity set, but that subsequent innovation is smaller in divisions with more highly paid divisional CEOs. The negative relation between innovation and compensation in the innovation equation is an unexpected result, for which an economic rationale is lacking.

Despite the absence of strong results and the inherent limitations of our empirical analysis, we believe the paper provides several significant insights relative to the prior literature. First, it empirically models innovative activity at the divisional level and uses divisional data to examine the determinants of innovation. Second, it extends the work on innovation beyond market structure and firm-wide characteristics (such as size and degree of diversification) to consider the effect of compensation structure on innovation. Finally, it treats both incentives and innovation as endogenous and estimates the effects of expected innovation on the choice of the compensation contract, as well as the effect of the choice of the compensation contract on subsequent innovation.

There are several possible reasons for the lack of strong results consistent with our predictions. First, the theories used to motivate our predictions may not be descriptive enough to capture the problems faced in practice in designing compensation contracts. Second, because we are restricted to using firms which actively patent innovations, perhaps our tests lack power because we have not sampled both innovative and noninnovative firms. This could lead to a lack of variation in both the innovation variable and in the compensation variable. Third, our tests assume that the innovation problem is the only issue considered by the designers of the compensation contract. If there are other potential agency problems which the contract is designed to mitigate, our tests may be less powerful because we have not controlled for these influences. Fourth, our measures may contain too much measurement error to detect the effects we try to document. In particular, the literature on innovation has debated the efficacy of a variety of different innovation measures, such as research and development expenditures, patent counts, and citation-weighted patent counts. Further, the appropriate time lag between the measurement of the compensation plan and the subsequent innovative activity is subject to question.

Cohen and Levin (1989) conclude that the extant literature on the effects of firm size and market structure on innovation has yielded statistically fragile and nonconvergent results. In their review, they call for researchers to move beyond the simple Schumpeterian hypotheses and focus on other determinants of innovation. While our analysis represents an early attempt to include the compensation structure at the divisional level as a fundamental determinant of innovation, our results do not substantially alter Cohen and Levin's conclusion regarding the nonconvergence of the results. At this time, we do not have a clear understanding of the factors which affect innovation, and subsequent research will be necessary to provide insights into this important organizational issue.

References

Acs, Zoltan J. and David B. Audretsch, 1987, Innovation, market structure, and firm size, Review of Economics and Statistics 69, 567–574.

Anderson, T.W., 1957, Maximum likelihood estimates for a multivariate normal distribution when some observations are missing, Journal of the American Statistical Association 52, 200–203.

Baiman, Stanley, David F. Larcker, and Madhav V. Rajan, 1995, Organizational design for business units, Journal of Accounting Research, forthcoming.

Balkin, David B. and Luis R. Gomez-Mejia, 1985, Compensation practices in high-technology industries, Personnel Administrator 30, 111–123.

Beale, E. and R. Little, 1975, Missing values in multivariate analysis, Journal of the Royal Statistical Society 37, 129–145.

Bizjak, J., J. Brickley, and J. Coles, 1993, Stock-based incentive compensation and investment behavior, Journal of Accounting and Economics 16, 349–372.

Bound, J., C. Cummins, Z. Griliches, B. Hall, and A. Jaffe, 1984, Who does R&D and who patents?, in: Z. Griliches, ed., R&D, patents, and productivity (University of Chicago Press for the National Bureau of Economic Research, Chicago, IL) 21–54.

Buck, S., 1960, A method of estimation of missing values in multivariate data suitable for use with an electronic computer, Journal of the Royal Statistical Society 22 B, 302–306.

Buderi, Robert, 1992, Global innovation: Who's in the lead?, Business Week, August 3.

Challen, D.W. and A.J. Hagger, 1983, Macroeconomic systems: Construction, validation and application (St. Martins Press, New York, NY).

Clinch, Greg, 1991, Employee compensation and firms' research and development activity, Journal of Accounting Research 29, 59–78.

Cohen, Wesley M. and Richard C. Levin, 1989, Empirical studies of innovation and market structure, in: R. Schmalensee and R.D. Willig, eds., Handbook of industrial organization (Elsevier Science, Amsterdam) 1059–1107.

Fisher, J. and V. Govindarajan, 1991, CEO and profit center manager compensation as a social comparison: An examination of owner and manager controlled firms, Unpublished paper (Amos Tuck School of Business Administration, Dartmouth College, Hanover, NH).

Fudenberg, D., B. Holmstrom, and P. Milgrom, 1990, Short-term contracts and long-term agency relationships, Journal of Economic Theory 51, 1–31.

Galbraith, Craig S. and Gregory B. Merrill, 1991, The effect of compensation program and structure on SBU competitive strategy: A study of technology-intensive firms, Strategic Management Journal 12, 353–370.

Griliches, Zvi, 1990, Patent statistics as economic indicators: A survey, Journal of Economic Literature 28, 1661–1707.

Jeong, J. and G. Maddala, 1993, A perspective on application of bootstrap methods in econometrics, in: Handbook of statistics: Econometrics (Elsevier Science, Amsterdam).

Holmstrom, Bengt, 1989, Agency costs and innovation, Journal of Economic Behavior and Organization 12, 305–327.

Holthausen, Robert W., David F. Larcker, and Richard G. Sloan, 1995, Annual bonus schemes and the manipulation of earnings, Journal of Accounting and Economics 19, 29–74.

Kokkelenberg, Edward C. and Donna R. Sockell, 1985, Union membership in the united states, 1973–1981, Industrial and Labor Relations Review 38, 497–543.

Lambert, Richard A. and David F. Larcker, 1985, Executive compensation, corporate decision-making and shareholder wealth: A review of the evidence, Midland Corporate Finance Journal 2, 6–22.

Lambert, Richard A. and David F. Larcker, 1987, An analysis of the use of accounting and market measures of performance in executive compensation contracts, Journal of Accounting Research 25, Suppl., 85–125.

Lambert, Richard A., David F. Larcker, and Robert E. Verrecchia, 1991, Portfolio considerations in the valuation of executive compensation, Journal of Accounting Research 29, 129–149.

Larcker, David F., 1983, The association between performance plan adoption and corporate capital investment, Journal of Accounting and Economics 5, 3–30.

Lewellen, W., C. Loderer, and K. Martin, 1987, Executive compensation and executive incentive problems: An empirical analysis, Journal of Accounting and Economics 9, 287–310.

Little, Roderick J., 1992, Regression with missing X's: A review, Journal of the American Statistical Association 87, 1227–1237.

Nelson, R.R., 1959, The simple economics of basic scientific research, Journal of Political Economy 67, 297–306.

Nelson, C. and R. Startz, 1990, The distribution of the instrumental variables estimator and its t-ratio when the instrument is a poor one, Journal of Business 63, S125–S140.

Office of Technology Assessment and Forecast, 1976, U.S. Department of Commerce, Patent, and Trademark Office: Sixth report (U.S. Government Printing Office, Washington, DC).

Phillips, A., 1965, Market structure, innovation, and investment, in: W. Alderson, B. Terpstra, and J. Shapiro, eds., Patents and progress: The sources and impact of advancing technology (Irwin, Homewood, IL) 37–58.

Porter, M., 1987, From competitive advantage to corporate strategy, Harvard Business Review 65, 43–59.

Ravenscraft, D. and F.M. Scherer, 1982, The lag structure of returns to research and development, Applied Economics 14, 603–620.

Schumpeter, Joseph A., 1942, Capitalism, socialism and democracy (Harper, New York NY).

Scherer, F.M., 1980, Industrial market structure and economic performance (Rand McNally, Chicago, IL).

Scherer, F.M., 1984, Innovation and growth: Schumpeterian perspectives (MIT Press, Cambridge, MA).

Sibson and Company, Inc., 1990, 1990 annual executive compensation report (Princeton, NJ).

Sibson and Company, Inc., 1991, Trends and issues in rewarding executive performance: 1991 annual report (Princeton, NJ).

Sloan, Richard G., 1993, An examination of the role of accounting earnings in top executive compensation contracts, Journal of Accounting and Economics 16, 55–100.

Smith, Clifford W. and Ross L. Watts, 1992, The investment opportunity set and corporate financing, dividend, and compensation policies, Journal of Financial Economics 32, 263–292.

Stine, Robert, 1989, An introduction to bootstrapping methods: Examples and ideas, Sociological Methods and Research 18, 243–291.

Trajtenberg, M., 1990, A penny for your quotes: Patent citations and the value of innovations, Rand Journal of Economics 21, 172–187.