Insurer Ownership Structure and Executive Compensation as Strategic Complements

Leslie M. Marx, David Mayers*, and Clifford W. Smith, Jr.

Wm. E. Simon Graduate School of Business Administration
University of Rochester
Rochester, NY 14627

*A. Gary Anderson Graduate School of Management
University or California-Riverside
Riverside, CA 92521

March 20, 1998

Abstract

We examine theories of insurance companies' choices of ownership structure and executive compensation, focusing on the impact of a firm's lines of business in determining these policy choices. Using results on strategic complementarities, we identify the requirements for the theory to have testable implications for reduced-form regression coefficients. Obtaining testable implications for structural-equation regression coefficients requires less of the theory, but requires more from the data since an instrumental variables approach is required. Thus, our analysis highlights a tradeoff between theory and statistical methods and identifies the minimal requirements for a theory to have testable implications for regression coefficients.

1. Introduction

Much progress has been made in the study of insurance companies' choices of organizational form and incentive structures. In order to further our understanding, we require better-developed theories as well as more powerful empirical validation. In this paper, we examine the requirements for a theory of an insurance company's strategic choices to have empirically testable implications for regression and correlation coefficients. We also suggest directions for future theoretical and empirical research on the structure of the insurance industry.

In recent years, research on strategic complementarities has led to a richer understanding of the requirements for monotonic comparative statics and of their implications for empirical work. These ideas have not been applied specifically to the choice of organizational form in the insurance industry. Yet, as we show in this paper, they are immediately applicable to questions of insurance companies' strategic choices and have important implications for research in the area. In this paper, we show how results on strategic complementarities can be used in studying basic policy choices made by insurance companies, in particular, their choices of ownership structure and executive compensation.

To provide unambiguous signs of correlation and reduced-form regression coefficients, a theory of insurance companies' strategic choices must imply monotone comparative statics. Without a monotone relation between type variables and choice variables, the theory does not produce unambiguous sign predictions using reduced-form regression methods. While the regression can estimate the average relation in the data, the theory is not falsifiable in the sense that either a positive or a negative observed relation would be consistent with the theory. Even if the theory does not imply monotone comparative statics, there can still be testable implications for structural-equation coefficients, but then one must impose more structure on the estimation process and require more of the data since an instrumental variables approach must be used

The requirements for monotone comparative statics are readily satisfied in models with a single choice variable, but insurance companies have a large number of strategic variables, including organizational form and components of executive compensation. When firms jointly establish several policies, additional care is required in developing theory and in undertaking empirical work to analyze these choices. Results on strategic complementarities provide a productive method of structuring the problem. By applying these results to questions of ownership structure and executive compensation in the insurance industry, we are better able to interpret existing results, identify weaknesses in existing theory, and propose additional empirical tests.

In this paper, we discuss whether the extant theory justifies the assumptions necessary for a monotone relation to exist between insurance companies' choices of ownership structure and executive compensation and the level of discretion required for insurance companies' lines of business. In Section 2, we discuss how the framework of strategic complementarities can be applied to issues in the insurance industry by examining the impact of a firm's lines of business on its choices of ownership structure and executive compensation. In Section 3, we discuss implications for empirical work and propose tests of the theory. In Section 4, we conclude.

2. Strategic Complementarities in Insurance

Different lines of business within the insurance industry vary in the levels of managerial discretion that they require. For example, we expect managerial discretion should be less important in lines of insurance for which more loss data are available, the variance of losses is lower (Lamm-Tenant and Starks, 1992; Doherty and Dionne, 1993), screening is less valuable (Hansmann, 1985; Smith and Stutzer, 1990), and the claims are expected to be administered within a more stable legal environment. Because of the differences in the required levels of discretion, insurance firms in different lines of business choose different ownership structures and compensation policies. We analyze how these different features interact with one another and with an insurance firm’s lines of business.

There are different ownership structures in the insurance industry, including mutuals and stocks. Mayers and Smith (1981) suggest that stock ownership is more appropriate for firms whose lines of business require higher levels of managerial discretion. When other policy choices of an insurance company are considered in addition to the ownership structure, the interaction among the policy choices must be considered as well as their interactions with the lines of business. A change in a firm’s lines of business can induce other changes due to complementarities among the policy variables. The analysis of this class of problems can be accomplished by using results on strategic complementarities. Applying these results, we derive a clearer understanding of the policy issues faced by the insurance firms and can analyze how packages of policy variables change with insurance firms' lines of business.

2.1. Lines of business, ownership structure, and executive compensation

We view a firm as maximizing its value with respect to its choices of ownership structure, which can be mutual or stock, $o \in \{o_m, o_s\}$, the level of executive compensation, $c_1 \in \Re$, and the sensitivity of compensation to changes in firm value, $c_2 \in [0,1]$. In the maximization problem, a firm takes as given its lines of business, which we classify as requiring either low discretion or high discretion $d \in \{d_{lo}, d_{hi}\}$. For example, in lines in which information is less available, more managerial discretion is required to establish corporate policy and administer the business.[1] Thus, a firm's maximization problem can be written as follows:

$$\max_{o \in \{o_m, o_s\}, c \in \Re \times [0,1]} V(o, c; d). \tag{1}$$

Using a differential approach to this problem, we express a Taylor-series expansion of the firm's value function:

$$\begin{aligned} V = {} & a_1 o + a_2 o^2 + a_3 c_1 + a_4 c_1^2 + a_5 c_2 + a_6 c_2^2 + a_7 o \cdot c_1 + a_8 o \cdot c_2 + a_9 c_1 \cdot c_2 \\ & + a_{10} o \cdot d + a_{11} c_1 \cdot d + a_{12} c_2 \cdot d + \ldots \end{aligned} \tag{2}$$

[1] Authorized discretion can be limited by concentrating the business by lines of business. Other mechanisms that limit managerial discretion include charter restrictions on investments, limitations on dividends, concentration of the business by geographic area, regulatory oversight, and policy loans. We take a firm's required discretion as exogenous.

The first-order conditions with respect to o, c_1, and c_2 allow us to write each choice variable as a function of the other choice variables and the level of discretion:

$$\begin{aligned} o &= \alpha_0 + \alpha_1 d + \alpha_2 c_1 + \alpha_3 c_2 \\ c_1 &= \beta_0 + \beta_1 d + \qquad\quad \beta_3 c_2 + \beta_4 o \\ c_2 &= \gamma_0 + \gamma_1 d + \gamma_2 c_1 + \qquad\quad \gamma_4 o, \end{aligned} \tag{3}$$

where

$$\alpha_0 = \frac{a_1}{-2a_2},\ \alpha_1 = \frac{a_{10}}{-2a_2},\ \alpha_2 = \frac{a_7}{-2a_2},\ \alpha_3 = \frac{a_8}{-2a_2}$$
$$\beta_0 = \frac{a_3}{-2a_4},\ \beta_1 = \frac{a_{11}}{-2a_4},\ \beta_3 = \frac{a_9}{-2a_4},\ \beta_4 = \frac{a_7}{-2a_4}$$
$$\gamma_0 = \frac{a_5}{-2a_6},\ \gamma_1 = \frac{a_{12}}{-2a_6},\ \gamma_2 = \frac{a_9}{-2a_6},\ \gamma_4 = \frac{a_8}{-2a_6}.$$

And the second-order conditions with respect to o, c_1, and c_2 require a set of inequalities constraints. In particular, the second-order condition is that the matrix

$$\begin{vmatrix} 2a_2 & a_7 & a_8 \\ a_7 & 2a_4 & a_9 \\ a_8 & a_a & 2a_6 \end{vmatrix}$$

be negative semi-definite, which implies that

$$0 \geq a_2, a_4, a_6$$
$$0 \leq 4a_2a_4 - a_7^2,\ 4a_2a_6 - a_8^2, 4a_4a_6 - a_9^2$$
$$0 \leq 2a_2a_9 - a_7a_8,\ -2a_4a_8 + a_7a_9,\ 2a_6a_7 - a_8a_9$$
$$0 \geq 8a_2a_4a_6 - 2a_6a_7^2 - 2a_4a_8^2 + 2a_7a_8a_9 - 2a_2a_9^2.$$

Solving the first-order conditions for the three choice variables gives the following reduced-form equations:

$$
\begin{aligned}
o &= \pi_{10} + \pi_{11} d \\
c_1 &= \pi_{20} + \pi_{21} d \qquad (4) \\
c_2 &= \pi_{30} + \pi_{31} d,
\end{aligned}
$$

where

$$\pi_{11} = \frac{4a_4a_6a_{10} - 2a_6a_7a_{11} - 2a_4a_8a_{12} + a_7a_9a_{12} + a_8a_9a_{11} - a_9^2a_{10}}{-8a_2a_4a_6 + 2a_6a_7^2 + 2a_4a_8^2 - 2a_7a_8a_9 + 2a_2a_9^2}$$

$$\pi_{21} = \frac{4a_4a_6a_{11} - 2a_6a_7a_{10} - 2a_2a_9a_{12} + a_7a_8a_{12} + a_8a_9a_{10} - a_8^2a_{11}}{-8a_2a_4a_6 + 2a_6a_7^2 + 2a_4a_8^2 - 2a_7a_8a_9 + 2a_2a_9^2}$$

$$\pi_{31} = \frac{4a_2a_4a_{12} - 2a_4a_8a_{10} - 2a_2a_9a_{11} + a_7a_8a_{11} + a_7a_9a_{10} - a_7^2a_{12}}{-8a_2a_4a_6 + 2a_6a_7^2 + 2a_4a_8^2 - 2a_7a_8a_9 + 2a_2a_9^2}.$$

Note that the second-order conditions imply that the denominators in the expressions for π_{11}, π_{21}, and π_{31} are positive.

This approach to the problem highlights several problems. First, variables such as ownership structure are naturally discrete, so aspects of this approach are potentially inappropriate. Second, assuming the necessary differentiability and convexity, we can consider whether the value function (2), the structural equations (3), and the reduced-form equations (4) can be estimated empirically. Estimation of the value function is difficult without good measures of firm value and a fully specified functional form for firm value. While the reduced-formed equations in (4) can be consistently estimated using OLS, the structural equations in (3) cannot be estimated consistently with OLS since the equations contain endogenous right-hand-side variables. Finally, the coefficients in (3) are not identified and, consequently, cannot be estimated without imposing additional restrictions on the problem.

Since empirical work based on the value function or the structural equations must confront potentially difficult estimation issues, to date, empirical work has avoided the estimation of structural equations. Therefore, we initially examine the theoretical predictions that can be made with respect to the reduced-form coefficients. The analysis in Mayers and Smith (1981, 1992) has clear implications for the signs of the coefficients in the value function. And, given the second-order condition, they also have direct implications for the signs of the coefficients in the structural equations. Yet, the reduced-form coefficients are composites of the underlying parameters in the value function. Even though the second-order condition allows us to sign the denominator, we require a theory that allows us to sign the numerators in order to have testable predictions about the signs of the reduced-form coefficients. Although estimation of the reduced form poses fewer statistical problems, this method places greater demands on the theory to yield unambiguous sign predictions for the estimated coefficients. We describe these conditions and the more general ideas of strategic complementarities below.

Strategic complementarities. To impose additional structure while addressing the discreteness issue, we draw from the literature on strategic complementarities. The standard definition of complements in a production process states that two inputs are *complements* if a decrease in the price of one causes an increase in the use of the other. Milgrom and Roberts (1990) extend this term beyond its traditional usage to describe relations among groups of activities. They define activities to be *strategic complements* if doing more of one increases the marginal profitability of the others. The Milgrom and Roberts analysis highlights the fact that assumptions of differentiability and convexity are not necessary for problems that have other structures. In particular, they show that, in a problem with a lattice structure, having complementarities among the variables is sufficient for the monotonicity of a firm's choice variables in its exogenous characteristics. Extending the work of Milgrom and Roberts, Milgrom and Shannon (1994) define two conditions — quasi-supermodularity and the single-crossing property — and show that these conditions are necessary and sufficient for a firm's optimal policy choices to depend monotonically on characteristics of the firm.

Using the Mayers and Smith (1981, 1992) models of policy choices in the insurance industry and the results on strategic complementarities, we derive testable empirical implications. Our analysis implies that greater levels of required discretion are complementary with stock ownership, higher levels of compensation, and higher sensitivity of compensation to changes in the value of the business. The theory also predicts that lower levels of required discretion are complementary with mutual ownership, lower levels of executive compensation, and less sensitivity of compensation to changes in the value of the firm.

We consider two policy choices faced by insurance firms, ownership structure and executive compensation. For ownership structure, we focus on two possibilities, mutuals and stocks, denoted by $o \in \{o_m, o_s\}$. We define an ordering on $\{o_m, o_s\}$ so that $o_s > o_m$. For management compensation, we consider both the level and sensitivity of compensation. Executive compensation policy can offer executives either low or high levels of expected compensation, as well as make executive compensation more or less sensitive to firm performance. For example, bonuses and stock options increase the sensitivity of executive compensation. We denote compensation by $c \in \Re \times [0,1]$, where the first component of *c* indicates the level of compensation and the second component of *c* indicates the sensitivity of compensation to changes in the value of the firm (a value of 0 indicates compensation is completely insensitive to changes in firm value). We define an ordering on $\Re \times [0,1]$ by specifying that $(c_1', c_2') \geq (c_1, c_2)$ if $c_1' \geq c_1$ and $c_2' \geq c_2$, and $(c_1', c_2') > (c_1, c_2)$ if, in addition, $(c_1', c_2') \neq (c_1, c_2)$.

We now argue that, for an insurance firm, firm value is quasi-supermodular and satisfies the single-crossing property. Once we establish these conditions, general results on strategic complementarities enable us to state a number of testable empirical implications. We then can test whether the implications of the theory hold and also can perform more direct tests of the underlying assumptions of quasi-supermodularity and single crossing.

2.2. Requirements for the single-crossing property

Ownership structure and lines of business as strategic complements. Formally, the value function satisfies the *single-crossing property* in ownership structure, given the lines of business,[2] if for all types of compensation,

$$V(o_s, c; d_{lo}) - V(o_m, c; d_{lo}) > [\geq]\, 0 \quad \text{implies that}$$

[2]This condition is called single crossing because if the choice variable is graphed against the type variable, the function crosses zero at most once and from below.

$$V(o_s, c; d_{hi}) - V(o_m, c; d_{hi}) > [\geq] 0. \tag{5}$$

Thus, for lines of business that require low levels of discretion, if firm value with a stock ownership is less than firm value with a mutual ownership, then the precedent of (5) is not satisfied and hence the condition as a whole is satisfied. We expect this single-crossing condition to be satisfied. To see why, note that stock companies have several control mechanisms that limit the dysfunctional exercise of managerial discretion. Some of these mechanisms are: (1) monitoring by capital markets, specifically by stock analysts, institutional investors, and other blockholders; (2) the threat of a takeover; and (3) the use of stock-based incentive compensation. These potentially important control mechanisms are infeasible in mutuals because mutuals do not have alienable, traded ownership claims. Thus, stocks should have a comparative advantage over mutuals in lines that require higher managerial discretion (Mayers and Smith, 1988 and 1994).

Executive compensation and lines of business as strategic complements. The value function satisfies the *single-crossing property* in executive compensation given the lines of business if for all ownership structures and $c'' > c'$,

$$\begin{aligned} &V(o, c''; d_{lo}) - V(o, c'; d_{lo}) > [\geq] 0 \text{ implies that} \\ &V(o, c''; d_{hi}) - V(o, c'; d_{hi}) > [\geq] 0. \end{aligned} \tag{6}$$

Thus, if firm value with high levels of expected compensation and high sensitivity to performance is less than firm value with lower expected compensation and/or less sensitivity to performance for lines of business that require low levels of discretion, then the precedent of (6) is not satisfied and hence the condition as a whole is satisfied. We expect this single-crossing condition to be satisfied. Executives of firms operating in lines that require high discretion have greater affects on value from exercising discretion in their decisions and hence have a higher value of the marginal product. A competitive market for executives implies that they receive a higher level of compensation. Moreover, with greater discretion, the compensation package must place greater weight on incentive compensation, rewarding managers more on the consequences of their actions rather than attempting to monitor the actions themselves and reward executives on their chosen actions.

Set of choice variables and lines of business as strategic complements. We require the single-crossing property to hold for the *set* of choice variables given the lines of business. In order for this to hold, it is sufficient that, for all $(o'', c'') > (o', c')$,

$$V(o'', c''; d_{lo}) < V(o', c'; d_{lo}). \tag{7}$$

This says that an increase in one or more of the choice variables (e.g., a move to stock ownership, an increase in compensation, or an increase in the sensitivity of compensation) decreases value for a low-discretion firm.

We expect (7) to hold. This is because in a common stock insurance company there is a conflict of interest between stockholders and policyholders over dividend policy, financing policy, and investment policy. In a mutual this conflict is naturally controlled by merging the two parties.[3] However, this merger results in less effective control of the conflict

[3]The stockholder and policyholder conflict in a stock insurance company is partially controlled through mechanisms that restrict managerial discretion in certain dimensions. Thus, policies that control managerial

of interest between owners and executives over effort, payout policy, and risk-management activities. This conflict is partially controlled through outsider participation on the board of directors who monitor the executives (Mayers, Shivdasani, and Smith, 1997). Outside directors can adopt the lower level of compensation sensitivity appropriate for control of the owner-manager conflict in a mutual.

Thus, when required discretion is low, firm value is higher with mutual ownership. The source of the value increase is the internalization of the owner-policyholder conflict. There are also value increases from an appropriate selection of compensation policies. These gains (from offering a lower level of compensation and making compensation less sensitive to performance) are derived from the lower level of required managerial discretion and do not depend on the ownership choice.

2.3. Requirements for quasi-supermodularity

With both ownership structure and executive compensation as choice variables, the single-crossing property is not sufficient to generate monotone comparative-static results and thus would not be sufficient to imply an unambiguous sign for the coefficients in a reduced-form regression. For instance, the value-maximizing choices would not be monotonic if there were a sufficiently non-monotonic interaction among the policy variables. When there are multiple choice variables, we require an additional condition to restrict the interaction among choice variables, either quasi-supermodularity or supermodularity. Quasi-supermodularity

---

discretion are complementary with stock-based ownership structure.

is necessary and sufficient to ensure monotone statics; supermodularity is sufficient. If the value function is quasi-supermodular or supermodular, changes in the choice variables are mutually reinforcing, so the optimal policy variables are nondecreasing in the level of discretion required for the lines of business.

Quasi-supermodularity requires that, if an increase in some policy variables increases value, then an increase in those policy variables also increases value when the other policy variables are increased, i.e., for all levels of discretion and for $c'' > c'$,

$$V(o_s, c'; d) - V(o_m, c'; d) > [\geq]\, 0 \text{ implies that}$$
$$V(o_s, c''; d) - V(o_m, c''; d) > [\geq]\, 0. \tag{8}$$

If for high discretion, both differences are positive, and for low discretion, the first difference, the precedent, is negative, then this condition holds. Thus, for quasi-supermodularity to hold, it is sufficient that for all $(o'', c'') > (o', c')$,[4]

$$V(o'', c''; d_{lo}) < V(o', c'; d_{lo}), \tag{9}$$

and for all $(o'', c'') > (o', c')$,[5]

$$V(o'', c''; d_{hi}) \geq V(o', c'; d_{hi}). \tag{10}$$

Conditions (9) and (10) state that larger values of the choice variables decrease the value of a low-discretion firm but increase the value of a high-discretion firm. The more choice variables that are chosen appropriately, the higher is the firm's value, where for a high-

[4]Note that (9), which is part of the sufficient conditions for quasi-supermodularity, is equivalent to (7), which is a sufficient condition for single crossing.

[5]More precisely, the quasi-supermodularity condition is: for all (o'', c'') and (o', c'), $V(o'', c'') > [\geq]$ $V(min(o'', o'), min(c'', c'))$ implies that $V(max(o'', o'), max(c'', c')) > [\geq]\, V(o', c')$.

discretion firm, choosing appropriately means choosing higher values, and for a low-discretion firm, choosing appropriately means choosing lower values. These quasi-supermodularity conditions are expected to hold.

3. Implications for Empirical Tests

Now we appeal to the mathematics of complementarities, which state that if firm value satisfies the single-crossing property in the choice variables given the firm characteristics and if firm value is quasi-supermodular in the choice variables, then the optimizing choice variables are nondecreasing (as a group) in the firm characteristics (see Milgrom and Shannon, 1994, Theorem 4).

Since we have argued that quasi-supermodularity and the single-crossing property hold in our problem, then the choice variables, ownership structure and compensation, are nondecreasing functions of the level of discretion required for the firm's lines of business. These conditions imply that higher levels of the firm's characteristics are associated with higher values of the choice variables. In our case, firms whose lines of business require greater discretion are associated with stock rather than mutual ownership, higher levels of executive compensation, and greater sensitivity of compensation to changes in firm value. Thus, our theory implies that firms whose lines of business require higher discretion are more likely to be stock companies that pay higher levels of compensation and make pay more sensitive to firm value. Firms whose lines of business require less discretion are more likely to be mutuals that offer lower levels of compensation and make pay less sensitive to firm performance.

A direct test of the theory would be to test whether the single-crossing property and quasi-supermodularity hold. But, these conditions are written in terms of the value function, which is difficult to estimate.[6] Since we generally cannot observe the value function, we focus on other implications of the theory. The primary implications of the theory are monotonicity results, but together with our assumptions on the functional form of the value function, we can derive implications for measures of the *linear* relation between the variables, such as correlation and regression coefficients.

These implications can be tested using correlation coefficients or regression analysis. We now examine these tests in more detail.

3.1. Correlation tests

The assumptions of quasi-supermodularity and the single-crossing property imply that ownership structure, compensation policy, and the discretion required for a firm's lines of business have positive pairwise relations. This can be tested using standard tests based on correlation coefficients.[7] The ordinal nature of our assumptions implies that the results are unchanged by monotone transformations of the variables, which suggest that tests based on rank correlation coefficients, e.g., Spearman and Kendall, are also appropriate. Since some

[6]See Athey and Stern (1996, Sec. 6.3) and Schwert (1981) for estimation issues when a measure of firm value is available.

[7]Note that having no correlation may only mean that there is no *linear* relation between the variables.

of our variables are discrete, chi-square tests for independence in 2×2 based on contingency tables can also be used, and may be more appropriate.[8] Finally, our assumptions also imply that conditional correlation coefficients between ownership structure and compensation policy are positive (see Arora, 1996).

3.2. Regression tests

Reduced forms. In the reduced-form equations, we avoid identification problems and the need for instruments, but we lose any opportunity to identify the underlying structural parameters. The reduced-form equations in (4) have only exogeneous variables on the right-hand side. Thus, these equations can be estimated consistently using ordinary-least-squares.[9] The quasi-supermodularity and single-crossing conditions imply that π_{11}, π_{21}, and π_{31} are positive (i.e., firms with lines of business that require greater discretion have "higher" ownership structure, higher levels of compensation, and more sensitive compensation).

It is important to note that a theory of the insurance industry can only restrict the sign of the reduced-form coefficients if the theory implies that the value function satisfies quasi-supermodularity and single crossing. For example, suppose the theory suggests that the single-crossing property is satisfied but that quasi-supermodularity is not. Then an increase

[8] See, e.g. Kanji (1995).

[9] If ownership structure is predetermined when compensation policy is chosen, then the ownership structure variable should be placed on the right-hand side in the two compensation policy equations.

in the discretion required for a firm's lines of business would cause optimal ownership structure to increase, and the increase in ownership structure would cause the optimal compensation policy to decrease. Thus, the coefficient on the discretion required for a firm's lines of business in a reduced-form regression could be either positive or negative. Unless a theory implies both quasi-supermodularity and single crossing, the theory does not have a testable prediction about the signs of the coefficients on the discretion variables in the reduced-form regressions. With the assumptions, the theory predicts positive signs for these coefficients. Thus, the theory we developed in the previous section potentially can be rejected by applying OLS to the reduced-form equations.

Structural equations. As discussed previously, we can consider estimating the structural equations (3). The single-crossing property (together with the second-order conditions and the linearity implicit in using a quadratic Taylor-series approximation) implies that α_1, β_1, and γ_1 are non-negative (i.e., the requirement of greater discretion results in stock ("higher") ownership structure, higher levels of compensation, and more sensitive compensation). Quasi-supermodularity implies that α_2 and γ_2 are positive (i.e., higher levels of compensation result in stock ownership and more sensitive compensation), that α_3 and β_3 are positive (i.e., more sensitive compensation results in stock ownership and higher levels of compensation), and that β_4 and γ_4 are positive (i.e., stock ownership results in higher levels of compensation and more sensitive compensation). Unfortunately, ordinary-least-squares regressions based on these equations generally will yield biased and inconsistent estimated coefficients since the equations include endogenous right-hand-side variables.

The coefficients in the structural equations can be identified if we have appropriate identifying variables or additional identifying assumptions. For example, if good instruments are available for ownership structure, the level of compensation, and the sensitivity of compensation, then the coefficients can be identified using an instrumental variables approach. For example, in a two-stage least-squares approach, in the first stage, ownership structure, the level of compensation, and the sensitivity of compensation are regressed on all of the exogenous variables in the system (the discretion required for the lines of business plus all the instruments). Then, in the second stage, the predicted values from the first-stage regressions are used as instruments for the endogenous variables in the estimation of the structural equations.

Predetermined variables. Although one might reasonably view ownership structure as predetermined when a firm chooses its compensation policy, this assumption does not solve all the problems associated with estimating the structural equations. Assuming that ownership structure is determined before the compensation policy variables, the relevant equation for ownership structure is the reduced-form equation, $o = \alpha_0 + \alpha_1 d$, but the equation for c_1 still contains the endogenous right-hand-side variable c_2, and the equation for c_2 still contains the endogenous right-hand-side variable c_1.[10]

If ownership structure really is chosen after a firm's lines of business are determined, but prior to its choice of compensation policy, then our theory can be adjusted to show that

[10]In addition to the problem with having endogenous right-hand-side variables, it is only appropriate to have predetermined variables on the right-hand side if they are uncorrelated with the current error term.

the single-crossing property and quasi-supermodularity hold when the two components of compensation policy are the choice variables and when the type variables that describe a firm are ownership structure and the required level of discretion. Then the implication is that β_1, β_3, β_4, γ_1, γ_2, and γ_4 are positive, but this version of the theory has no implication for the coefficients on discretion in $o = \alpha_0 + \alpha_1 d + \alpha_2 c_1 + \alpha_3 c_2$ or $o = \pi_{10} + \pi_{11} d$.[11] Negative values for α_1 (estimated using, say, an instrumental-variables approach) or π_{11}, might cause one to reject the theory in the previous section, but those negative values would not cause one to reject this different version of the theory, which assumes that ownership structure is predetermined.

Summary. The implications of our theory for the coefficients in these regression are summarized in the following table.

Table 1: Summary of Implications For Empirical Tests

Equations	**Estimation technique**	**Implications of the theory***
Reduced-form equations	OLS	qsm, scp and soc $\Rightarrow$ $\pi_{11}, \pi_{21}, \pi_{31} \geq 0$
Structural equations	Instrumental variables techniques (e.g., 2SLS)	scp and soc $\Rightarrow$ $\alpha_1, \beta_1, \gamma_1 \geq 0$ qsm and soc$\Rightarrow$ $\alpha_2, \alpha_3, \beta_3, \beta_4, \gamma_2, \gamma_4 \geq 0$

*qsm is quasi-supermodularity; scp is single-crossing property; soc is second-order condition.

[11] Note that a regression based on $o = \alpha_0 + \alpha_1 d + \alpha_2 c_1 + \alpha_3 c_2$ is particularly problematic if o is predetermined since then o "causes" c_1 and c_2, but we are treating c_1 and c_2 as exogenous. For a discussion of the issue of causality, see, for example, Sims (1972).

4. Conclusion

The approach to firm policy taken in this paper allows us to obtain results on how variation in firms' lines of business affect the package of policy variables they choose. We expect firms whose lines of business require high managerial discretion to tend to be stock companies and have high executive compensation that is sensitive to changes in firm value. And we expect firms whose lines of business require low managerial discretion to tend to be mutuals and have low compensation that is relatively insensitive to changes in firm value.

References

Arora, A. (1996), "Testing for Complementarities in Reduced-Form Regressions: A Note," *Economic Letters* **50**, 51-55.

Athey, S. and S. Stern (1996), "An Empirical Framework for Testing Theories About Complementarity in Organizational Design," Working paper, MIT.

Doherty, N. and G. Dionne (1993), "Insurance with Undiversifiable Risk: Contract Structure and Organization Form of Insurance Firms," *Journal of Risk and Uncertainty* **6**, 187-203.

Hansmann, H. (1985), "The Organization of Insurance Companies: Mutual versus Stock," *Journal of Law, Economics, and Organization* **1**, 125-154.

Kanji, G.K., (1995), *100 Statistical Tests* (London: Sage).

Lamm-Tennant, J. and L.T. Starks (1993), "Stock versus Mutual Ownership Structures: The Risk Implications," *Journal of Business* **66**, 29-46.

Mayers, D., A. Shivdasani, and C.W. Smith, Jr. (1997), "Board Composition in the Life Insurance Industry," *Journal of Business* **70**, 33-63.

Mayers, D. and C.W. Smith, Jr. (1981), "Contractual Provisions, Organizational Structure, and Conflict Control in Insurance Markets, *Journal of Business*, **54**, 407-434.

Mayers, D. and C.W. Smith, Jr. (1988), "Ownership Structure Across Lines of Property Casualty Insurance," *Journal of Law and Economics* **31**, 351-378.

Mayers, D. and C.W. Smith, Jr. (1992), "Executive Compensation in the Life Insurance Industry," *Journal of Business* **65**, 51-74.

Mayers, D. and C.W. Smith, Jr. (1994), "Managerial Discretion, Regulation, and Stock Insurer Ownership Structure," *Journal of Risk and Insurance* **61**, 638-655.

Milgrom, P. and J. Roberts (1990), "Rationalizability, Learning, and Equilibrium in Games with Strategic Complementarities," *Econometrica* **58**, 1255-1277.

Milgrom, P. and C. Shannon (1994), "Monotone Comparative Statics," *Econometrica* **62**, 157-180.

Schwert, G. William (1981), "Using Financial Data to Measure Effects of Regulation," *Journal of Law and Economics* **24**, 121-158.

Sims, C. (1972), "Money, Income, and Causality" *Economic Review* **62**, 540-555.

Smith, B. and M. Stutzer (1990), "Adverse Selection, Aggregate Uncertainty, and the Role for Mutual Insurance Contracts," *Journal of Business* **63**, 493-511.