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The Role of Performance Measure Noise in Mediating the Relation between Task Complexity and Outsourcing

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ABSTRACT: This paper examines the effect of task complexity on a firm's decision to outsource and the mediating role of performance measure noise. Using insights from agency and transaction cost economics theories, we predict that task complexity reduces the extent of outsourcing of the task. We further predict that one reason for the negative relation between task complexity and outsourcing is that task complexity increases the noise in performance measures. Noisy performance measures introduce problems in incentive contracting with external vendors and, hence, decrease the extent of outsourcing. Data from 305 inpatient and 1,255 ancillary and outpatient departments of for-profit hospitals provide support for our prediction that performance measure noise mediates the relation between task complexity and outsourcing.

Keywords: task complexity; incentive contracting; outsourcing; hospitals.

Data Availability: Data used in this study are publicly available from the Office of Statewide Health Planning and Development, Sacramento, California.

INTRODUCTION

In any owner-manager relationship, three types of decisions are involved: assignment of decision rights, performance measurement, and incentive compensation (Brickley et al. 2006; Milgrom and Roberts 1992). Three important factors that influence these decisions are task complexity, performance measure characteristics, and managers' degree of risk aversion. The latter

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two variables, performance measure characteristics and risk aversion, have received attention from analytical and empirical researchers. Analytical researchers predict a negative relation between performance measure noise and incentive compensation in the presence of risk-averse agents (Banker and Datar 1989; Feltham and Xie 1994).

Accounting research has paid relatively less attention to the third aspect of organizational architecture, i.e., task complexity. Analytical researchers define as a complex task one for which the optimal course of action is difficult to determine (Prendergast 2002). The difficulty arises because complex tasks have uncertain or unknown alternatives, lack clear means to end connections, and involve subtasks that must be coordinated for a successful outcome (Holmström and Milgrom 1991; March and Simon 1958). From a contracting perspective, complex tasks have components that are less easily measured, which adds noise to performance measures. Agency theory predicts that noisy performance measures increase the risk to managers, and as a result, incentives are muted when tasks are complex (Prendergast 1999). The moral hazard and monitoring problems that attend the use of muted incentives with external vendors render the outsourcing of complex tasks less likely. Complex tasks are thus more likely to be kept in-house and monitored using other control mechanisms such as input monitoring.

Transaction cost economics (TCE) makes a similar prediction about contracting in the presence of complex tasks. TCE positively associates a transaction's level of complexity with contractual incompleteness and potential for *ex post* opportunism, which increases transaction costs and therefore the probability of complex tasks being kept in-house (Tadelis 2002). Using insights from agency theory and transaction cost economics, we hypothesize that, because task complexity increases the noise in performance measures, firms are more likely to keep complex tasks in-house, that is, firms are less likely to outsource complex tasks.

We empirically test whether performance measure noise mediates the effect of task complexity on outsourcing, using a sample of 305 inpatient and 1,255 ancillary and outpatient hospital departments of for-profit hospitals located in California. The hospital industry provides a good context to examine our research questions because it accommodates the construction of a measure of task complexity based on the types of patients treated. Different medical procedures require different treatment protocols and exhibit different levels of outcome variability. Moreover, because the hospital industry has a history of outsourcing services to external vendors, outsourcing options exist.

Our analysis uses department-level data from 1998 to 2003. We first examine the relation between department-level task complexity and outsourcing, and find a negative association consistent with our predictions. Examining the relation between task complexity and noise in departmental performance measures, we find that, even after controlling for size, patient-mix, and other department- and hospital-level factors, task complexity increases the noise in accounting performance measures. We then test the relation between performance measure noise and outsourcing and find that an increase in performance measure noise decreases the extent of outsourcing. Finally, we formally test the mediation model and find that performance measure noise partially mediates the relation between task complexity and outsourcing.

This study makes several contributions to the accounting literature. First, it is among the first to empirically examine the accounting factors that influence the relation between task complexity and outsourcing. Prior analytical research by Tadelis (2002) has shown that task complexity influences contract incompleteness and thereby increases friction due to *ex post* contractual changes, and consequently increases the likelihood that the complex task will be kept in-house. In addition, empirical research has shown task complexity to be associated with lower incentive contracting (Evans et al. 2006). However, prior studies have not empirically examined the relation among task complexity, performance measure properties, and outsourcing. Further, this paper is the first to show that performance measure noise mediates the relationship between task complexity and outsourcing. This is important because if task complexity influences the properties of performance measures, accounting systems need to provide information that facilitates the design of incentive contracts appropriate to various levels of task complexity. That is, the design of performance measurement systems should be tailored to reflect task characteristics.

Second, we empirically test whether task complexity is a driver of accounting performance measure noise. Performance measure noise is an important concept that has received considerable attention in contemporary managerial accounting research. But the *drivers* of performance measure noise have received less than adequate attention in the literature. Our findings provide further understanding of the causes of accounting performance measure noise and consequences for strategic decisions such as outsourcing.

Our third contribution is to demonstrate that firms making outsourcing decisions take into consideration the noise in performance measures. Relatively easy to measure tasks are outsourced, difficult to measure tasks are kept in-house. Finally, our sample from the hospital industry enables us to empirically measure task complexity based on characteristics of a task rather than make assumptions or inferences. Our empirical test of the influence of task complexity and performance measure noise on outsourcing contributes to the extant accounting literature. Although consistent with the analytical results of Holmström and Milgrom (1994), who show that difficulty in measuring performance reduces the likelihood that an activity will be contracted to external vendors, and Tadelis (2002), who shows that complex tasks are more likely to be procured internally, our results extend the research in this area by identifying task complexity as a source of the noise in performance measures.

The remainder of the paper is organized as follows. The next section presents our theory and hypotheses, and summarizes the relevant literature. The third section describes the research method we employed. The fourth section summarizes the hypotheses tests and results. The fifth section reports our conclusions and suggests possibilities for future research.

THEORY AND HYPOTHESES

Task Complexity and Outsourcing

Although prior research acknowledges that task characteristics such as complexity have important implications for performance measurement and incentive contracting (Brickley et al. 2006; Feltham and Xie 1994; Holmström and Milgrom 1991; Prendergast 2002), there is a paucity of empirical research in this area. The accounting literature defines task complexity using objective task characteristics such as number of cues that need to be processed, number of steps involved in processing, and extent of coordination required to perform the task effectively (Bonner 1994; Stuart and Prawitt 2005; Tan and Kao 1999). In much the same way, the economics literature characterizes a complex task as consisting of multiple, possibly unknown, or uncertain dimensions that must be coordinated to achieve a successful outcome (Holmström and Milgrom 1991; Prendergast 2002). Moreover, some of these task dimensions require the decision maker to process a large number of information cues, some of which might be inconsistent with others (Bonner 1994).[1]

[1] Prior research in budgeting has examined the relation between task complexity and uncertainty associated with task technology. Hirst (1983) defines task uncertainty in terms of repetitiveness and openness of the task (also described as routineness and variety of the task in Hartmann [2000]). Repetitiveness refers to the frequency with which the focal task is performed, and the extent to which a task is affected by uncontrollable events. Task repetitiveness/routineness captures a manager's ability to break down the task process into formalized steps to reduce uncertainty. Task openness/variability refers to the effect of interdependencies and unanticipated or novel events that increase the uncertainty of outcomes. Thus, task complexity can be understood as a combination of the diversity of likely outcomes, number of different inputs and resources, and difficulty understanding the relation between inputs and outputs.

Consider an example from the telecom industry. A traditional company that provides primarily local telephone services and high-speed DSL (e.g., Northeast Telephone Company) has lower task complexity than a company that provides a range of services such as high-speed Internet, cable, wireless services, and multimedia content generation (e.g., Comcast or Verizon). The latter has greater task complexity because the offered services are attended by different levels of market uncertainty and varying rates of change in production technology, which occasion variability in costs and revenues. In the pharmaceutical industry, for example, some firms maintain a portfolio of drugs that includes discovery of new and breakthrough drugs, whereas others are engaged primarily in contract manufacturing of generic drugs. The latter activity is less complex because the production technology and market demand and supply factors are well understood. Bajari and Tadelis (2001) define task complexity in the building construction industry as driven by the number of states of nature that can occur *ex post* (after construction begins) and that influence construction costs such as the foundation needed based on soil conditions, prices of building materials, and regulatory changes (such as pertain to historical sites or height limits).

Task complexity has implications for outsourcing because it increases the uncertainty of the effect of both managers' actions and uncontrollable factors on performance measures (Prendergast 2002). A transaction cost approach to examine the relation between complexity and outsourcing suggests that task complexity introduces transaction incompleteness, which increases the cost of contracting by increasing the extent of *ex post* contingencies that might occur, and, hence, reducing the extent of outsourcing. Tadelis' (2002) analytical modeling of this mechanism shows that a product's complexity reduces its design completeness and thereby increases the need for *ex post* adaptation, which reduces *ex post* surplus because of the costs of renegotiation. As a result, complex products are more likely to be kept in-house. Empirical studies have also found results consistent with the presence of an association between complexity and outsourcing. For example, Monteverde and Teece (1982), using data on 133 automobile components from an auto supplier, find that auto assemblers are more likely to vertically integrate when the production process requires design and engineering investment and is specific to the component and cannot be patented. Because a functioning market does not exist in such a case, both the auto firm and its supplier are exposed to the possibility of *ex post* contractual opportunism if the component is outsourced.

Along similar lines, component complexity is found by Masten (1984), using data on 1,887 aerospace components, to be positively associated with in-sourcing, and by Novak and Eppinger (2001), using data from 134 luxury-performance car components, to be positively associated with vertical integration. Anderson et al. (2000) also show complex tasks to be managed with fewer suppliers. Anderson and Dekker (2005) use a comprehensive database of 858 transactions of Dutch firms and find task complexity to be associated with *ex post* transaction problems and higher contracting costs. Based on the predictions of transaction cost economics, we predict that task complexity will reduce the extent of outsourcing (Figure 1, link a):

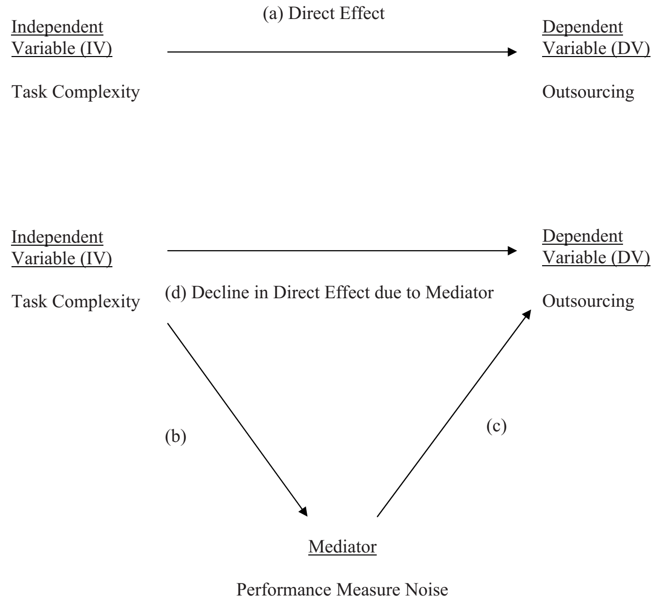
H1: Task complexity is negatively associated with the extent of outsourcing.

Although we formally test the association between task complexity and outsourcing, our main interest is in examining the *mechanism* by which task complexity influences outsourcing, and more importantly, the role of performance measure noise in driving this association. The next section takes a step in that direction.

Task Complexity and Performance Measure Noise

Performance measures play a critical role in firms' compensation plans in motivating managers to allocate their efforts optimally (Ittner et al. 1997). Economic models developed by researchers to explain characteristics that influence the use of performance measures in compensation

FIGURE 1
Mediator Relation between Task Complexity and Outsourcing



contracts commonly predict a negative relation between a performance measure's noise and its assigned incentive weight (e.g., Banker and Datar 1989; Datar et al. 2001; Feltham and Xie 1994; Holmström 1979). Noise in performance measures increases the effect of uncontrollable factors on managerial outcomes and, hence, the risk incurred by the risk-averse manager, which must be compensated by the firm. Incentive contracting thus becomes more expensive as noise in a performance measure increases, which, in turn, leads firms to reduce the weight on the performance measure.

Although the effect of performance measure characteristics on incentive contracting has received considerable attention in the literature (reviews are provided by [Baker 2000]; [Gibbons 1998]; and [Prendergast 1999]), the *drivers* of the noise in performance measures have received considerably less attention. Both agency theory and transaction cost economics predict that task complexity is likely to influence performance measure noise. Agency researchers maintain that noise in performance measures increases with task complexity (Prendergast 2002), and transaction cost economics posits that complex tasks entail more incomplete contracts and, hence, greater *ex post* contract renegotiation. Bajari and Tadelis (2001) demonstrate analytically, in the context of procurement contracts, that more complex products have less complete designs that increase the likelihood of inefficient *ex post* renegotiation. The implication is that, for complex tasks, performance outcomes are likely to exhibit greater variance and assessments of performance are less straightforward.

Complex tasks involve uncertainty about the environment as well as about the nature of the task and costs of production because such tasks are more likely to be affected by unforeseen changes in that environment (Vining and Globerman 1999). Firms with greater task complexity are likely to exhibit higher variance in overall performance measures such as margins and ROA because a broader range of potential outcomes is possible from the same inputs. Outcomes are also a function of the variances of individual activities. In a hospital, for example, the outcome of a complex procedure such as an organ transplant is more uncertain than the outcome of a less complex surgery such as an appendectomy because of factors beyond the control of the hospital or the physician. The implication is that variance in performance measures such as cost or profit will increase with task complexity, and thus greater noise is likely to be observed in performance measures for complex tasks (Figure 1, link b):

H2: Task complexity increases the noise in performance measures.

Performance Measure Noise and Outsourcing

In situations in which task complexity does increase the noise in performance measures, the use of incentive compensation for a risk-averse manager becomes expensive. In the extreme, firms might be unable to use incentive compensation when performance measure noise is too high. When wage contracts contain minimal or no incentive pay tied to output-based performance measures, alternative mechanisms such as monitoring of inputs must be employed. Holmström and Milgrom (1994) apply the linear principal agent model and show that activities for which performance is easy to measure and that are not critical to a firm's returns are more likely to be assigned to independent agents and compensated using stronger output-based incentives. A similar conclusion is reached by Bajari and Tadelis (2001), who show analytically that a simple component is more likely to be procured externally and compensated using stronger incentives (a fixed-price contract), whereas a complex component is more likely to be manufactured internally with the firm bearing the cost of risk. Finally, Williamson (1979) suggests that tasks that face higher environmental uncertainty incur greater coordination costs, a higher cost of measuring performance, and greater information costs, which increase the transaction costs of market exchange and make outsourcing less appealing for complex tasks. In addition to the noise in measuring financial outcomes, firms also face challenges in measuring other important non-financial outcomes of complex tasks such as quality (Vining and Globerman 1999).

We combine agency theory (Holmström and Milgrom 1991, 1994) and transaction cost economics (Bajari and Tadelis 2001; Williamson 1979) and predict that the increased performance measure noise of complex tasks influences firms' outsourcing decisions. It is advantageous to a firm to outsource less complex tasks and keep complex tasks in-house. The less complex tasks can be outsourced and monitored through more intensive incentive contracting with external vendors than could be employed in-house. This is consistent with Poppo and Zenger (1998), who argue that when performance can be more accurately measured, firms are better off using markets because they can employ more high-powered incentives than can be used within the firm (Figure 1, link c):

H3: Performance measure noise is negatively associated with the extent of outsourcing.

Performance Measure Noise as a Mediator in the Relation between Task Complexity and Outsourcing

The mediating role of performance measure noise in the relation between task complexity and outsourcing is illustrated in Figure 1. Both transaction cost economics and agency theory support this logic. For example, Bajari and Tadelis (2001) use a transaction cost economics framework to show that imposing strong incentives on a complex task reduces *ex ante* production costs, but increases *ex post* renegotiation costs. Tadelis (2002), extending this logic, shows the level of complexity in a transaction to be associated with contract incompleteness. Hence, task complexity is a parameter that influences both the extent of integration and type of incentives provided. Tadelis (2002) derives the following result: "More complex products are more likely to be procured internally [*make*] and have the upstream unit face lower incentives, while more simple products are more likely to be procured through the market [*buy*] and have the upstream supplier face high incentives."

We extend Tadelis' (2002) argument and identify performance measure noise as one of the elements of contract incompleteness because it increases the cost of contracting, and reduces the ability to monitor performance. Thus, when performance measure noise increases, less incentive weight can be assigned to the performance measure, which reduces its usefulness in incentive contracting. Tasks where performance can only be measured with considerable noise are thus more likely to be kept in-house and monitored using other mechanisms such as process or input controls.

In sum, we argue that because task complexity increases the noise in performance measure, firms are less likely to outsource more complex tasks (Figure 1, link d). We state this as:

H4: Performance measure noise mediates the relation between task complexity and outsourcing.

We expect mediation to be partial, that is, task complexity reduces outsourcing for other reasons as well as performance measure noise. Task complexity could, for example, increase the tendency for opportunistic behavior and potential for disruptive production externalities (Vining and Globerman 1999).

RESEARCH METHOD

Sample Selection

Data from inpatient, ancillary, and outpatient service departments for for-profit hospitals located in California were collected from the Office of Statewide Health Planning and Development (OSHPD). The use of hospitals from one state (California) reduces the effects of regulation because many health care regulations are at the state level (for example, the Medicaid program is state administered). Although the industry includes for-profit, nonprofit, and government hospitals, we consider only for-profit hospitals in our analyses because their objective functions more closely conform to the traditional notion of maximizing owner value. Moreover, for-profit hospitals are more likely to employ incentive contracts with managers (Brickley and Van Horn 2002). The hospitals in our sample are owned by partnerships (such as physician groups) or corporations (such as HCA or Tenet). We conduct two sets of analyses. First, we separately analyze hospital inpatient departments, and second, we perform combined analyses of inpatient, ancillary, and outpatient departments. Our final sample includes 305 inpatient and 1,255 outpatient departments in 95 hospitals, and covers the period 1998 to 2003. Unless otherwise mentioned, performance measure noise is computed using time-series data for the period 1998 to 2002, while the other independent and control variables are tested using 2003 data. This prevents spurious correlation between performance measure noise and the other independent and control variables.

Dependent and Independent Variables

Performance Measure Noise

Performance measure noise is used as a dependent variable in H2, as an independent variable in H3, and as a mediator variable in H4. Prior literature has used the standard deviation of a performance measure to operationalize performance measure noise (e.g., Holthausen et al. 1995; Lambert and Larcker 1987; Nagar 2002). For example, Nagar (2002) uses the standard deviation of a firm's net income scaled by assets for a four-year period as a measure of performance measure volatility. We measure performance measure noise for each hospital department by computing the standard deviation of departmental accounting performance using five years' time-series data for the period 1998 to 2002. Departmental accounting performance, defined as departmental revenue less departmental-direct costs, reflects how well a department performs on the revenue and cost items over which it has control, and is a commonly used proxy for accounting performance in hospitals (Dexter et al. 1998, 2002; Macario et al. 2001). While some patient reimbursements such as Medicare are flat-fee, the health care literature acknowledges that hospitals have the ability to influence their revenue streams (Galloro 2004; Rundle and Davies 2004). We construct two proxies to measure accounting performance measure noise. First, we scale departmental accounting performance by the number of beds to obtain accounting performance per bed for the five-year, time-series data, and calculate the standard deviation of accounting performance scaled by beds, which is our first proxy for accounting performance noise. Second, we scale by patient days and repeat the above process to obtain the standard deviation of accounting performance scaled by patient days to use as a second proxy for accounting performance noise. Scaling hospital performance measures by patient days is a common practice in the health care industry and provides comparable data for cross-sectional analysis (Finkler and Ward 1999).

Outsourcing

Hypotheses 1, 3, and 4 use outsourcing as the dependent variable. We construct this variable as the cost of services procured from other organizations as a proportion of total cost. The OSHPD database provides the dollar value of services provided by outside vendors (i.e., "purchased services"): the higher this number, the greater the proportion of tasks outsourced by a department. This variable provides a continuous measure of the extent of outsourcing and facilitates estimation. The distribution of this variable is left skewed and therefore we use a log transformation for the analyses.[2]

Independent Variables

Task Complexity. Our primary independent variable in H1, H2, and H4 is task complexity. Organizational theory suggests that task complexity is composed of two constructs, task difficulty and task variability (Fry and Slocum 1984; Withey et al. 1983). Task difficulty refers to the degree of complexity of the decision-making process, and task variability to the numbers and types of exceptional cases that require different procedures, both of which increase the variability of costs and revenues (Sicotte and Beland 2001). The psychology literature suggests that task complexity is a function not only of objective characteristics of a task, but also of how individuals subjectively represent the task (e.g., cognitive processing requirements).[3] The empirical accounting literature on task complexity is sparse. Anderson et al. (2000) define task complexity for automobile parts as driven by uncertainty about resource requirements and whether parts meet specifications, and Hirst (1983) develops a measure of task complexity that encompasses task difficulty, task variability, and environmental uncertainty.

Prior literature in health care has used the case-mix index as an indicator of hospital complexity (Devaraj and Kohli 2003; Esposto 2004; Grassetti et al. 2005; Sicotte and Beland 2001). The case-mix index is a measure of the severity of illness of the average patient, estimated by the U.S. Department of Health and Human Services and is associated with a large set of patient attributes that includes severity of illness, risk of mortality, prognosis, treatment difficulty, need for intervention, and resource intensity. The index thus captures both task difficulty and task variability (Averill et al. 1998). A higher case-mix index implies greater resource consumption, and is associated with both higher average costs and higher variance of costs. A higher case-mix index also signals a more complex set of tasks that must be overseen by the hospital manager. Evans et al. (2006) use a similar logic to argue that physician specialists deal with more complex

[2] However, results are robust to using the raw percentage of outsourcing.
[3] See Campbell (1988) for a review.

ailments than primary care physicians and, hence, face greater cost of risk.

In light of the foregoing arguments, and consistent with prior literature, we classify hospital inpatient departments on the basis of relative case-mix complexity. Among all hospital inpatient services, intensive care departments such as medical/surgical intensive care, coronary intensive care, pediatric intensive care, neonatal intensive care, burn care, other intensive care, and definitive observation have the highest case-mix indices. Acute care departments such as medical/surgical acute care and pediatrics acute care also have high case-mix indices. We classify these services as high task complexity departments, and other hospital inpatient departments such as psychiatric care, physical rehabilitation care, chemical dependency services, hospice inpatient care, and skilled nursing care as low-complexity departments, the mean case-mix index of the latter being lower than a hospital's average case-mix index.

For the combined analyses of inpatient, ancillary, and outpatient departments, we classify the inpatient services as high-complexity and ancillary and outpatient departments as low-complexity, the latter two sets of departments requiring relatively lower coordination and resource intensity.[4]

Control Variables

Consistent with prior literature, we include several control variables, both at the department and at the hospital level.

Department-Level Control Variables

***Occupancy Rate*.** Occupancy rate is expected to influence outsourcing decisions. Hospitals with lower occupancy rates are more likely to have problems breaking even and, hence, might pursue cost-reducing strategies such as outsourcing, to a greater extent. Hospitals with higher occupancy rates also have incentives to outsource to reduce the likelihood of turning away patients due to lack of capacity. Occupancy rate is also likely to influence performance measure noise by influencing the cost structure negatively due to congestion costs. *Occupancy Rate* is defined as the number of actual patient days divided by available patient days, where available patient days equals staffed beds multiplied by 365.

***Contribution Margin Ratio*.** *Contribution Margin Ratio*, defined as revenue minus direct cost divided by revenue, controls for the effect of departmental current period accounting performance on outsourcing decisions. A department with a superior contribution margin ratio might have the resources needed to search out and find attractive outsourcing options. But a poor contribution margin ratio could spur firms to outsource in order to reduce costs.

***Medicare and MediCal patients*.** We control for the proportion of patients insured by Medicare and MediCal because these plans typically reimburse on a flat-fee basis, which influences revenue performance and other outcomes. We construct these variables using the proportion of gross revenue from each of these two categories, divided by total gross patient revenue.

Average length of stay (*ALOS*). ALOS is an important driver of hospital costs and revenues (Lynk 1995), and also controls for the extent of long-term care patients discharged by a department. Therefore, it is an important control variable. *ALOS* is defined as the number of days from admission to discharge.

***Department Size*.** Size is a significant driver of firm behavior and outcomes. Using a Cobb-Douglas production function, Yatchak (2000) finds that long-run average costs per bed are lower for larger hospitals than for smaller hospitals due to economies of scale. We define *Department Size* as the number of staffed beds in the department.

[4] We conducted an alternative analysis which included, in the low-complexity group, the inpatient departments that were classified as low-complexity along with the ancillary and outpatient services. In this analysis, the high-complexity group included only those inpatient departments that were classified as high-complexity in the inpatient analyses. The results (untabulated) are unchanged.

Product Mix. Variability in patient streams within departments may influence cost and revenue structures, and outsourcing decisions. We include a variable, *Product Mix*, defined as 1 divided by the square of proportion of revenue generated from the following plans: Medicare, Medicaid, County indigent program, and other third parties and payers. The higher this number, the higher the variability in patient streams.

Hospital-Level Control Variables

Net Margin. Net income divided by net patient revenue is used to control for the effect of hospital-level financial performance on hospital decisions and behavior.

Hospital Size. The analyses include a control for hospital size to control for factors that are influenced by size such as scale and scope economies.

Rural Hospital. Hospitals located in rural areas may have fewer attractive local outsourcing options. Therefore, we include a dummy to indicate whether the hospital is located in a rural area.

Teaching Hospital. Teaching hospitals have different cost structures because they have medical residency programs. The analyses include a dummy variable for teaching status.

Charity Care Ratio. Charity patients use resources of the hospital without generating commensurate revenue. Therefore, we include a control for the proportion of charity care costs to gross patient revenue.

Empirical Models

To test H1, which posits that outsourcing is negatively associated with task complexity, we use the following model:

$$\begin{aligned} Log\ (Outsourcing) = {} & \alpha + \beta_1 Task\ Complexity + \beta_2 Occupancy\ Rate \\ & + \beta_3 Contribution\ Margin\ Ratio + \beta_4 Medicare\ Patients \\ & + \beta_5 MediCal\ Patients + \beta_6 ALOS + \beta_7 Department\ Size \\ & + \beta_8 Product\ Mix + \beta_9 Net\ Margin + \beta_{10} Hospital\ Size + \beta_{11} Rural \\ & + \beta_{12} Teaching + \beta_{13} Charity\ Care\ Ratio + \varepsilon. \end{aligned} \tag{1}$$

To be consistent with H1, β_1 is predicted to be negative. The sign on *Occupancy Rate* cannot be predicted because a lower occupancy rate might motivate outsourcing by firms seeking new avenues to enhanced revenues or reduced costs, and a high occupancy rate could drive outsourcing to meet demand pressures. *Contribution Margin Ratio* and *Net Margin* might also have either a positive or negative effect on outsourcing, higher performance implying greater available resources for searching out and pursuing outsourcing opportunities, and lower performance potentially spurring outsourcing as a cost reduction option. Both *Medicare* and *MediCal* are likely to be positively associated with outsourcing because a hospital with a greater proportion of patients who pay on a flat-fee basis is more likely to pursue cost reduction strategies such as outsourcing. *ALOS* could be negatively associated with outsourcing because hospitals reimbursed on a per-diem basis could earn more revenue by extending the patient stays, thereby reducing the need for outsourcing. *Department Size* could have a positive or negative influence on outsourcing, a larger department having both a greater likelihood of achieving economies of scale in-house, which would reduce the need for outsourcing, and greater bargaining power that it might leverage to secure more favorable terms from vendors, which would increase the attractiveness of the outsourcing option. *Product Mix* is likely to be negatively associated with outsourcing because a hospital with a large diversity of patients is likely to have more complex operations. A larger *Hospital Size* might enjoy economies of scale that make outsourcing less likely overall, however, the bargaining power associated with larger hospital size can increase the benefits associated with, and, hence, the extent of outsourcing. A *Rural* hospital is likely to have fewer outsourcing options and hence the sign on β_{11} is predicted to be negative. *Teaching* hospitals are required to maintain staff for resident training purposes and, hence, less likely to outsource. *Charity Care* could be positively associated with outsourcing if a hospital with higher charity care is likely to pursue more cost reduction activities.

Hypothesis 2, which predicts *Task Complexity* to be associated with higher performance measure noise, is tested using the following model:

$$\begin{aligned} \textit{Performance Measure Noise} = \alpha &+ \beta_1 \textit{Task Complexity} + \beta_2 \textit{Occupancy Rate} \\ &+ \beta_3 \textit{Contribution Margin Ratio} + \beta_4 \textit{Medicare Patients} \\ &+ \beta_5 \textit{MediCal Patients} + \beta_6 \textit{ALOS} + \beta_7 \textit{Department Size} \\ &+ \beta_8 \textit{Mean Accounting Performance} + \beta_9 \textit{Product Mix} \\ &+ \beta_{10} \textit{Net Margin} + \beta_{11} \textit{Hospital Size} + \beta_{12} \textit{Rural} \\ &+ \beta_{13} \textit{Teaching} + \beta_{14} \textit{Charity Care Ratio} + \varepsilon. \end{aligned} \tag{2}$$

Task Complexity is measured using a dummy variable that takes the value of 1 if the department is an intensive care or an acute care department and 0 otherwise. Hypothesis 2 predicts a positive coefficient on β_1, implying that as a task becomes more complex, performance measure noise increases. *Occupancy Rate* is likely to increase the noise in performance measures due to congestion-related factors. *Contribution Margin Ratio* and *Net Margin* are expected to reduce the noise in performance measures because higher profitability generally reflects more stable revenues and costs. *Medicare* proportion is likely to be associated with higher performance measure noise because costs of treatment for older patients might vary to a greater degree as a consequence of complications that might arise in the course of medical treatments. Because it includes uninsured children and complications are more likely to occur in the treatment of young children, *MediCal* is also likely to be positively associated with performance measure noise. *ALOS* will also likely increase the noise in performance measures because it is likely to be associated with illness severity. To the extent that larger departments have more stable cash flows and revenues, *Department Size* is likely to decrease performance measure noise. The analyses include *Mean Accounting Performance* scaled by beds or patient days (for the period 1998 to 2002) because a hospital with a high mean is also likely to have a high standard deviation of accounting performance. *Product Mix* reflects variability in patient streams and is likely to increase performance measure noise. Larger *Hospital Size* is associated with the presence of a larger number of departments that draw from a variety of patient pools, and may increase performance noise. *Rural* hospitals are usually the only hospitals available in a catchment area and, hence, are likely to have diverse patient groups, which increases performance measure noise. *Teaching* hospitals usually provide a variety of expensive services, which increases performance measure noise. Charitable patients are more likely to be admitted from the emergency rooms and include a heterogeneous set of patients. As a result the *Charity Care Ratio* is likely to increase performance measure noise.

Hypothesis 3, which predicts outsourcing to be negatively associated with performance measure noise, is tested using the following model:

$$\begin{aligned} \textit{Log}\ (\textit{Outsourcing}) = \alpha &+ \beta_1 \textit{Task Complexity} + \beta_2 \textit{Performance Measure Noise} \\ &+ \beta_3 \textit{Occupancy Rate} + \beta_4 \textit{Contribution Margin Ratio} \\ &+ \beta_5 \textit{Medicare Patients} + \beta_6 \textit{MediCal Patients} + \beta_7 \textit{ALOS} \\ &+ \beta_8 \textit{Department Size} + \beta_9 \textit{Mean Accounting Performance} \end{aligned}$$

$$+ \beta_{10} Charity\ Care\ Ratio + \beta_{11} Product\ Mix + \beta_{12} Net\ Margin$$
$$+ \beta_{13} Hospital\ Size + \beta_{14} Rural + \beta_{15} Teaching + \varepsilon. \quad (3)$$

Hypothesis 3 predicts a negative sign on β_2. The other signs on the control variables are predicted to be similar to those predicted for H1. Models (1)–(3) are estimated using maximum likelihood estimation.

We use similar models for the combined inpatient, ancillary, and outpatient samples, except that we include service units to scale for the size of the outpatient departments, and exclude *Occupancy Rate* which is not available for ancillary and outpatient departments. *Performance Measure Noise* is scaled by service units for ancillary and outpatient departments. *ALOS* is set to 0 for ancillary and outpatient departments, and the results are robust if we remove this control variable. As an additional test, we also use the proportion of net patient revenue of each department divided by total revenue of the hospital as an alternative proxy of department size.

To test H4, which examines whether performance measure noise mediates the relation between task complexity and outsourcing, we conduct a formal mediation test as described by Baron and Kenny (1986). First, we test whether *Task Complexity* (the independent variable) is associated with *Outsourcing* (the dependent variable) (Figure 1, link a). Second, we test whether *Task Complexity* influences the mediator, that is, *Performance Measure Noise* (Figure 1, link b). Third, we include *Performance Measure Noise* as an additional explanatory variable in the equation that tests the association between *Task Complexity* and *Outsourcing*. To establish mediation by *Performance Measure Noise*, the following must occur. First, *Performance Measure Noise* (the mediator variable) must have an effect on *Outsourcing* (the dependent variable; Figure 1, link c) after controlling for the effect of *Task Complexity* (the independent variable). Second, including *Performance Measure Noise* should reduce the magnitude of the effect of *Task Complexity* on *Outsourcing* (Figure 1, link d). We use the Sobel (1982) test to formally establish this mediation.[5]

RESULTS

Table 1 provides descriptive statistics for the variables used in the analysis. The average inpatient department has 30 beds, 43 percent Medicare patient revenue, and 28 percent MediCal patient revenue. The mean extent of costs outsourced is 1.6 percent for inpatients, 31.58 percent for ancillary, and 6.37 percent for outpatient services. Table 2 reports the correlations between the variables included in the estimated models for the main analysis. Tables 3–6 contain the results of the hypotheses tests. In Tables 3–6, Panel A presents the results for the inpatient departments and Panel B contains the results for the combined analyses of inpatient, ancillary, and outpatient departments.

Hypotheses Testing

The results of estimating Equation (1), which tests H1, are presented in Table 3, Panels A and B. The coefficient on *Task Complexity* is negative and significant in all the models in both panels, implying that an increase in *Task Complexity* lowers the extent of outsourcing, as predicted by H1. Larger hospitals and teaching hospitals outsource less as predicted.

5 Sobel (1982) provides an approximate significance test for the indirect effect of the independent variable on the dependent variable via the mediator. As in Figure 1, if the coefficient on the independent variable to mediator is denoted as a and its standard error is S_a, and the coefficient on the mediator to dependent variable is denoted as b and its standard error is S_b, then the standard error of the indirect effect ab approximately equals $\sqrt{b^2 S_a^2 + a^2 S_b^2}$. The test of the indirect effect is given by dividing ab by $\sqrt{b^2 S_a^2 + a^2 S_b^2}$ and treating the ratio as a Z test. The Sobel test is a conservative method of testing indirect effect (MacKinnon et al. 1995).

TABLE 1
Descriptive Statistics

Variable	Mean	Median	Std. Dev.	Q1	Q3
Inpatient Department-Level Variables					
Complexity	0.84	1.00	0.36	1.00	1.00
Performance Measure (PM) Noise (Bed) ($000)	22.86	16.60	20.68	8.45	30.37
Performance Measure Noise (Patient Day) ($000)	81.38	59.30	77.23	35.95	99.89
Outsourcing	0.016	0.003	0.050	0.001	0.01
Occupancy Rate	65.15%	61.02%	26.59%	43.95%	90.98%
Contribution Margin Ratio	−9.94%	−5.13%	43.11%	−33.28%	19.85%
Medicare Patients	0.43	0.51	0.30	0.06	0.65
MediCal Patients	0.28	0.21	0.27	0.08	0.40
Average Length of Stay (ALOS)	21.30	6.50	75.69	3.62	13.20
Department Size	30.57	20.00	32.07	10.00	36.00
Product Mix	1.96	1.97	0.52	1.60	2.30
Ancillary and Outpatient Department-Level Variables					
Performance Measure Noise Scaled by Units	34.24	8.70	87.63	3.56	26.71
Outsourcing	0.30	0.09	0.38	0.02	0.49
Contribution Margin Ratio	27.90%	38.61%	49.71%	3.70%	64.86%
Medicare Patients	0.30	0.28	0.22	0.13	0.43
MediCal Patients	0.17	0.10	0.20	0.01	0.26
Product Mix	2.03	2.11	0.62	1.55	2.52
Hospital-Level Control Variables					
Net Margin	0.01	0.03	0.15	−0.08	0.11
Hospital Size	150.68	130.00	89.57	83.00	205.00
Rural	0.03	0.00	0.17	0.00	0.00
Teaching	0.02	0.00	0.15	0.00	0.00
Charity Care Ratio	0.04	0.04	0.02	0.02	0.05

Data are for the year 2003 unless otherwise specified. Sample size is 305 hospital inpatient departments and 1,255 outpatient departments.

Variable Definitions:

Complexity = indicator variable (0/1) based on service type;
Performance Measure Noise = computed using five years' department-level, time-series data for the period 1998 to 2002;
Performance Measure Noise Scaled by Bed (Patient Day) = standard deviation of accounting performance (i.e., revenue-direct cost) scaled by the number of staffed beds (patient days) for inpatient departments;
Outsourcing = proportion of direct cost outsourced;
Occupancy Rate = number of patient days scaled by staffed beds times 365;
Contribution Margin Ratio = revenue less direct costs as a percentage of revenue;
Medicare (MediCal) Patients = proportion of Medicare (MediCal) revenue to total revenue;
ALOS = length of stay from admittance to discharge;
Department (Hospital) Size = number of staffed beds in the department (hospital);

(continued on next page)

TABLE 1 (continued)

Product Mix =	1 divided by the square of proportion of revenues generated from the following plans: Medicare, Medicaid, County indigent program, and other third party payers;
Performance Measure Noise Scaled by Service Unit =	standard deviation of accounting performance scaled by the number of service units for outpatient departments;
Net Margin =	hospital net income as a proportion of hospital net patient revenue;
Rural =	1 if the hospital is located in a rural area, and 0 if otherwise;
Teaching =	1 if the hospital is a teaching hospital, and 0 if otherwise; and
Charity Care Ratio =	proportion of charity care to gross patient revenue.

Table 4, Panels A and B provide the results of estimating Equation (2). In Panel A, Column 1 reports the results when performance measure noise is measured as the standard deviation of accounting performance scaled by beds, Column 2 when measured as accounting performance scaled by patient days. In Panel B, Columns 1 and 3 present the results when *Department Size* is measured by staffed beds for inpatient departments and service units for ancillary and outpatient departments. Columns 2 and 4 provide the results obtained when the proportion of departmental revenue to hospital total revenue is used as the measure of *Department Size*. In all models, and in both panels, *Task Complexity* is significantly and positively related to performance measure noise, as predicted by H2. All the control variables that are significant are in the predicted directions.

The results of our examination of the effect of *Performance Measure Noise* on outsourcing are presented in Table 5, Panels A and B. In Panel A, Column 1 (2) reports the results when contribution scaled by beds (patient days) is used to measure *Performance Measure Noise*. In Panel B, Column 1 and 3 (2 and 4) show the results when *Department Size* is measured by staffed beds and service units (department revenue as proportion of hospital revenue). The results show that, even after controlling for task complexity and department-level and hospital-level factors, an increase in performance measure noise is associated with a decrease in the extent of outsourcing, as predicted by H3. The results for the control variables are similar to the results presented in Table 3. Taken together with the earlier result of the positive relation between task complexity and performance measure noise, these results suggest that noise in accounting performance measures increases with task complexity and reduces the utility of that performance measure in incentive contracting. That is, task complexity increases the cost of contracting with external vendors. To deal with the moral hazard problem that arises in such instances, hospitals are more likely to keep these complex tasks in-house.

In Table 6, Panels A and B, we formally test the mediation role of performance measure noise in outsourcing. The results of the Sobel (1982) test for the mediating effect of accounting performance noise indicate that performance measure noise partially mediates the relation between task complexity and outsourcing. Thus, when performance measure noise is used as an additional explanatory variable, the effect of task complexity on outsourcing is reduced in both magnitude and significance, but not eliminated. This indicates the presence of partial mediation. That is, performance measure noise mediates some of the effect of task complexity on outsourcing.

Robustness Analyses

Level of Analysis

We conducted our analyses at the level of the department rather than the hospital because, as noted earlier, we observe considerable variation in the extent of complexity across departments. But we explore the robustness of our results to a hospital-level measure of complexity. Using the

TABLE 2
Pearson Correlations among Variables

	2	3	4	5	6	7	8
Department-Level Variables							
1. *Task Complexity*	0.21	0.22	−0.19	−0.12	0.15	−0.12	−0.06
2. *PM Noise* (*Bed*)		0.78	−0.18	0.21	0.00	−0.02	−0.01
3. *PM Noise* (*Patient Day*)			−0.16	−0.04	−0.05	−0.05	0.01
4. *Log* (*Outsourcing*)				0.03	−0.09	−0.10	0.14
5. *Occupancy Rate*					0.07	0.05	−0.05
6. *Contribution Margin Ratio*						−0.03	−0.19
7. *Medicare Patients*							−0.65
8. *MediCal Patients*							
9. *ALOS*							
10. *Department Size*							
11. *Product Mix*							
Hospital-Level Variables							
12. *Net Margin*							
13. *Hospital Size*							
14. *Rural*							
15. *Teaching*							
16. *Charity Care Ratio*							

	9	10	11	12	13	14	15	16
Department-Level Variables								
1. *Task Complexity*	−0.43	0.08	0.35	−0.00	−0.01	0.02	−0.05	0.09
2. *PM Noise* (*Bed*)	−0.06	−0.30	0.08	0.05	0.08	−0.00	0.07	0.01
3. *PM Noise* (*Patient Day*)	−0.08	−0.28	0.04	0.04	0.04	0.02	−0.01	0.08
4. *Log* (*Outsourcing*)	0.18	−0.02	−0.12	−0.02	−0.19	−0.03	−0.10	−0.06
5. *Occupancy Rate*	0.20	−0.19	−0.07	0.12	−0.25	−0.06	0.19	−0.14
6. *Contribution Margin Ratio*	−0.12	0.24	0.24	0.23	−0.11	0.03	−0.04	0.02
7. *Medicare Patients*	−0.19	0.03	0.10	−0.02	−0.03	0.07	−0.01	−0.15
8. *MediCal Patients*	0.38	−0.10	−0.16	−0.14	0.08	−0.07	−0.02	0.32
9. *ALOS*		−0.03	−0.24	0.00	−0.06	−0.04	−0.03	−0.12
10. *Department Size*			0.20	0.06	0.24	−0.07	−0.06	0.00
11. *Product Mix*				0.01	−0.00	0.09	0.06	0.35
Hospital-Level Variables								
12. *Net Margin*					−0.07	0.19	−0.16	−0.12
13. *Hospital Size*						−0.19	−0.05	0.11
14. *Rural*							−0.03	−0.01
15. *Teaching*								0.05
16. *Charity Care Ratio*								

Correlations above 0.10 are significant at $p < 10$ percent or better.
Please see Table 1 for definitions.

aggregate hospital level, case-mix index as a measure of task complexity, we re-estimated Equations (1)–(3). Our results (untabulated) are similar to the results reported in Tables 3–6, and all our hypotheses are supported at $p < 0.05$ or better.

TABLE 3

Relation between Task Complexity and Outsourcing (H1)

Panel A: Inpatient Departments Only

$$\begin{aligned} Log(Outsourcing) = {} & \alpha + \beta_1 Task\ Complexity + \beta_2 Occupancy\ Rate + \beta_3 Contribution\ Margin\ Ratio \\ & + \beta_4 Medicare\ Patients + \beta_5 MediCal\ Patients + \beta_6 ALOS + \beta_7 Department\ Size \\ & + \beta_8 Product\ Mix + \beta_9 Net\ Margin + \beta_{10} Hospital\ Size + \beta_{11} Rural \\ & + \beta_{12} Teaching + \beta_{13} Charity\ Care\ Ratio + \varepsilon \end{aligned}$$

Predictors	Predicted Sign	Coefficient (t-statistic)
Department-Level Variables		
Task Complexity	−(H1)	−0.9365
		(−2.61)***
Occupancy Rate	+/−	−0.0051
		(−0.01)
Contribution Margin Ratio	+/−	−0.3498
		(−1.19)
Medicare Patients	+	−0.4876
		(−0.90)
MediCal Patients	+	0.6678
		(1.01)
ALOS	−	−0.0005
		(−0.30)
Department Size	+/−	0.0044
		(1.72)*
Product Mix	−	0.0342
		(0.14)
Hospital-Level Variables		
Net Margin	+/−	−0.3009
		(−0.45)
Hospital Size	+/−	−0.0047
		(−4.12)***
Rural	−	−0.5115
		(−0.77)
Teaching	−	−1.4206
		(−3.62)***
Charity Care Ratio	+	−4.3812
		(−0.75)
Intercept		−4.2975
		(−6.00)***
n		305
Adjusted R^2		0.13

(continued on next page)

Panel B: Inpatient, Ancillary, and Outpatient Departments Combined

$$
\begin{aligned}
Log(Outsourcing) = \alpha &+ \beta_1 Task\ Complexity + \beta_2 Contribution\ Margin\ Ratio \\
&+ \beta_3 Medicare\ Patients + \beta_4 MediCal\ Patients \\
&+ \beta_5 ALOS + \beta_6 Product\ Mix + \beta_7 Department\ Size \\
&+ \beta_8 Net\ Margin + \beta_9 Hospital\ Size + \beta_{10} Rural \\
&+ \beta_{11} Teaching + \beta_{12} Charity\ Care\ Ratio + \varepsilon
\end{aligned}
$$

Predictors	Predicted Sign	(1) Beds or Units as Department Size Coefficient (t-statistic)	(2) Revenue Proportion as Department Size Coefficient (t-statistic)
Department-Level Variables			
Task Complexity	−(H1)	−3.3575	−3.2476
		(−20.83)***	(−20.00)***
Contribution Margin Ratio	+/−	−0.0576	−0.0553
		(−0.50)	(−0.48)
Medicare Patients	+	−0.0708	−0.0518
		(−0.26)	(−0.19)
MediCal Patients	+	−0.3094	−0.2985
		(−1.01)	(−0.97)
ALOS	−	0.0025	0.0024
		(1.34)	(1.29)
Product Mix	−	−0.4132	−0.4315
		(−3.91)***	(−4.03)***
Department Size	+/−	−0.0000	−2.5700
		(−2.58)***	(−2.39)**
Hospital-Level Variables			
Net Margin	+/−	−0.3132	−0.3564
		(−1.05)	(−1.19)
Hospital Size	+/−	−0.0018	−0.0022
		(−1.93)*	(−2.28)**
Rural	−	−0.1488	−0.1678
		(−0.51)	(−0.59)
Teaching	−	−1.4057	−1.4625
		(−16.92)***	(−16.91)***
Charity Care Ratio	+	4.9983	5.1901
		(1.94)*	(1.99)**
Intercept		−1.4944	−1.4822
		(−5.83)***	(−5.55)***
n		1,560	1,560
Adjusted R^2		0.32	0.32

*, **, *** Significant at $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.

Please see Table 1 for variable definitions.

The data set includes 305 inpatient departments and 1,255 ancillary and outpatient departments. The analyses exclude occupancy rate because it can be used for inpatient departments only.

TABLE 4

Relation between Task Complexity and Performance Measure Noise (H2)

Panel A: Inpatient Departments Only

$$\begin{aligned} \textit{Performance Measure Noise} = {} & \alpha + \beta_1 \textit{Task Complexity} + \beta_2 \textit{Occupancy Rate} \\ & + \beta_3 \textit{Contribution Margin Ratio} + \beta_4 \textit{Medicare Patients} \\ & + \beta_5 \textit{MediCal Patients} + \beta_6 \textit{ALOS} + \beta_7 \textit{Department Size} \\ & + \beta_8 \textit{Mean Accounting Performance} + \beta_9 \textit{Product Mix} + \beta_{10} \textit{Net Margin} \\ & + \beta_{11} \textit{Hospital Size} + \beta_{12} \textit{Rural} + \beta_{13} \textit{Teaching} + \beta_{14} \textit{Charity Care Ratio} + \varepsilon \end{aligned}$$

Predictors	Predicted Sign	(1) Standard Deviation of Acc. Performance Per Bed	(2) Standard Deviation of Acc. Performance Per Patient Day
Department-Level Variables			
Task Complexity	+(H2)	16.4810***	54.8360***
		(6.48)	(5.14)
Occupancy Rate	+	25.9558***	−39.9198
		(5.26)	(−1.59)
Contribution Margin Ratio	−	−14.2933**	−113.725**
		(−2.51)	(−2.29)
Medicare Patients	+	3.3646	17.5790
		(0.71)	(0.93)
MediCal Patients	+	1.4196	14.4615
		(0.21)	(0.58)
ALOS	+	−0.0004	0.0062
		(−0.03)	(0.12)
Department Size	−	−0.2007***	−0.8609***
		(−6.27)	(−6.17)
Mean Accounting Performance	+	0.1337**	0.2655**
		(2.21)	(2.14)
Product Mix	+	1.3944	9.1101
		(0.76)	(1.10)
Hospital-Level Variables			
Net Margin	−	−19.0644*	−7.1115
		(−1.87)	(−0.16)
Hospital Size	+	0.0493***	0.1118**
		(3.52)	(2.36)
Rural	+	4.0971	9.0827
		(1.37)	(0.70)
Teaching	+	3.0194	6.4737
		(1.15)	(0.63)
Charity Care Ratio	+	−14.3855	−48.4227
		(−0.41)	(−0.38)
Intercept		−16.0271***	37.5811
		(−2.61)	(1.57)
Adjusted R^2		0.30	0.30

(continued on next page)

Panel B: Inpatient, Ancillary, and Outpatient Departments Combined

$$\begin{aligned} \textit{Performance Measure Noise} = \alpha &+ \beta_1 \textit{Task Complexity} + \beta_2 \textit{Contribution Margin Ratio} \\ &+ \beta_3 \textit{Medicare Patients} + \beta_4 \textit{MediCal Patients} + \beta_5 \textit{ALOS} \\ &+ \beta_6 \textit{Mean Accounting Performance} + \beta_7 \textit{ Product Mix} \\ &+ \beta_8 \textit{ Department Size} + \beta_9 \textit{Net Margin} + \beta_{10} \textit{Hospital Size} + \beta_{11} \textit{Rural} \\ &+ \beta_{12} \textit{Teaching} + \beta_{13} \textit{Charity Care Ratio} + \varepsilon \end{aligned}$$

		Standard Deviation of Acc. Performance Per Bed		Standard Deviation of Acc. Performance Per Patient Day	
		(1)	(2)	(3)	(4)
Predictors	**Predicted Sign**	**Beds or Units as Department Size**	**Revenue Proportion as Department Size**	**Beds or Units as Department Size**	**Revenue Proportion as Department Size**
Department-Level Variables					
Task Complexity	+(H2)	22.4963***	22.8252***	41.2969***	45.5043***
		(14.95)	(14.88)	(7.34)	(7.88)
Contribution Margin Ratio	−	−0.1912	−0.1549	−29.1471***	−29.1827***
		(−1.41)	(−1.37)	(−14.93)	(−15.22)
Medicare Patients	+	−1.0802	−1.0449	1.1312	2.8051
		(−0.72)	(−0.72)	(0.11)	(0.30)
MediCal Patients	+	1.4160	1.2618	56.9910***	57.6928***
		(0.51)	(0.47)	(3.83)	(3.85)
ALOS	+	−0.0212***	−0.0208***	−0.1774***	−0.1798***
		(−3.07)	(−3.02)	(−6.18)	(−6.17)
Mean Accounting Performance	−	0.0601	0.0674	0.2735***	0.2798***
		(1.46)	(1.58)	(8.05)	(8.33)
Product Mix	+	0.1497	0.1728	−15.6569***	−16.3098***
		(0.26)	(0.31)	(−4.14)	(−4.38)
Department Size	+/−	−0.0007	−17.8611**	−0.0000***	−142.0040***
		(−1.29)	(−2.12)	(−3.02)	(−2.72)
Hospital-Level Variables					
Net Margin	−	−0.7045	−1.1750	−12.2270	−16.6299
		(−0.43)	(−0.70)	(−0.94)	(−1.25)
Hospital Size	+	0.0055	0.0036	0.0438	0.0231
		(1.57)	(1.06)	(1.59)	(0.85)
Rural	+	0.6657	0.5092	5.2926	4.0241
		(1.12)	(0.86)	(0.70)	(0.54)
Teaching	+	3.1444***	2.9454***	−1.3445	−3.7872
		(5.73)	(5.37)	(−0.50)	(−1.31)
Charity Care Ratio	+	−8.6252	−9.0292	59.7515	63.6296
		(−1.19)	(−1.24)	(0.94)	(1.02)
Intercept		−0.5568	−0.1496	42.7470***	46.0593***
		(−0.72)	(−0.19)	(5.36)	(5.66)
Adjusted R^2		0.51	0.51	0.44	0.44

(continued on next page)

*, **, *** Significant at $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.
Please see Table 1 for variable definitions.
The data include 1,560 observations, of 305 in-patient and 1,255 ancillary and outpatient departments.

Depreciation Expense

To control for the effect of depreciation expenses, we tested the robustness of the results to the inclusion of depreciation expense. We constructed an alternative measure of accounting performance as revenue less departmental-direct costs plus depreciation expense. Similarly, we measured contribution margin ratio as revenue less direct cost plus depreciation expense as a percentage of revenue. Estimating Models (1)–(3) using these constructs yielded results (untabulated) similar to those reported in Tables 3–6.

Performance Measure Type

We use accounting contribution margin as the performance measure because it is a commonly used proxy to measure accounting performance in hospitals. To examine the robustness of our results to the type of performance measure used, we used standard error of departmental-direct cost scaled by beds or patient days to proxy for performance measure noise. The results (untabulated) are consistent with the results reported in Tables 4–6.

Outsourcing of Core Competencies

An alternate explanation for lower outsourcing of complex tasks is that such tasks are also more likely to be a source of competitive advantage. In the case of a hospital, for example, a surgical procedure is more complex than an ancillary task such as a blood test or X-ray and therefore has greater cost or profit variability. However, the complex procedure is also more likely to be a source of competitive advantage because patients choose a hospital based on the quality of medical, not ancillary, services (Town and Currim 2002). Research in strategy argues that firms are less likely to outsource core competencies (such as surgery in the case of a hospital) because these are the proficiencies that enable them to deliver unique value to customers (Gilley and Rasheed 2000; Hamel and Prahalad 1994; Quinn 2000), and outsourcing creates risky dependency on contractees' knowledge (Fine and Whitney 1996). Thus, our results could be driven by strategic decisions to keep core competencies, which happen to also be complex, in-house.

To explore this issue in greater detail, we examined the inpatient departments and sorted them into core versus non-core competencies. To conduct this sorting, we followed the following procedure. The *U.S. News & World Report* periodical publishes a yearly ranking of hospitals by specialty, and it is likely that patients' hospital choices are influenced by these rankings. We assumed that the specialties that are used to provide published rankings about the quality of hospitals are likely to be core specialties whereas specialties that are not ranked are not likely to be core competencies because patients are less influenced by these rankings when making a choice. The specialties that are ranked separately include Cancer, Ear Nose and Throat, Endocrinology, Gastrointestinal disorders, Geriatric care, Gynecology, Heart and Heart surgery, Kidney disease, Neurology, Ophthalmology, Orthopedics, Psychiatry, Rehabilitation, Respiratory disorders, Rheumatology, and Urology. We mapped this list to our list of inpatient departments and identified the following specialties as core competencies: coronary care, pediatric intensive care, neonatal intensive care, psychiatric intensive care, pediatric acute, psychiatric acute—adult, psychiatric acute—adolescent and child, obstetrics acute, physical rehabilitation care, psychiatric—long-term care, and residential care. Notice that the core competencies also include services that

TABLE 5

Relation between Outsourcing and Performance Measure Noise (H3)

Panel A: Inpatient Departments Only

$$Log(Outsourcing) = \alpha + \beta_1 Task\ Complexity + \beta_2 Performance\ Measure\ Noise + \beta_3 Occupancy\ Rate + \beta_4 Contribution\ Margin\ Ratio + \beta_5 Medicare\ Patients + \beta_6 MediCal\ Patients + \beta_7 ALOS + \beta_8 Size + \beta_9 Mean\ Accounting\ Performance + \beta_{10} Charity\ Care\ Ratio + \beta_{11} Product\ Mix + \beta_{12} NetMargin + \beta_{13} Hospital\ Size + \beta_{14} Rural + \beta_{15} Teaching + \varepsilon$$

Predictors	Predicted Sign	(1) Standard Deviation of Acc. Performance Per Bed	(2) Standard Deviation of Acc. Performance Per Patient Day
Department-Level Variables			
Task Complexity	−	−0.7892**	−0.7807**
		(−2.29)	(−2.26)
Performance Measure Noise	−(H3)	−0.0112**	−0.0030**
		(−2.09)	(−2.02)
Occupancy Rate	+/−	0.1926	−0.0261
		(0.45)	(−0.06)
Contribution Margin Ratio	+/−	−0.5517	−0.5952
		(−1.39)	(−1.46)
Medicare Patients	+	−0.4723	−0.4445
		(−0.91)	(−0.86)
MediCal Patients	+	0.6781	0.6888
		(1.05)	(1.05)
ALOS	−	−0.0006	−0.0005
		(−0.30)	(−0.26)
Department Size	+/−	0.0021	0.0021
		(0.82)	(0.79)
Mean Accounting Performance	−	0.0029	0.0009
		(1.07)	(1.10)
Charity Care Ratio	+	−4.6580	−4.0386
		(−0.82)	(−0.70)
Product Mix	−	0.0698	0.0446
		(0.29)	(0.18)
Hospital-Level Variables			
Net Margin	+/−	−0.0450	−0.1512
		(−0.07)	(−0.22)
Hospital Size	+/−	−0.0044***	−0.0047***
		(−3.37)	(−3.77)
Rural	−	−0.5222	−0.5404
		(−0.77)	(−0.80)
Teaching	−	−1.3265***	−1.4033***
		(−5.67)	(−6.22)
Intercept		−4.3925***	−4.2126***
		(−6.39)	(−5.96)
Adjusted R^2		0.10	0.10

(continued on next page)

Panel B: Inpatient, Ancillary, and Outpatient Departments Combined

$$\begin{aligned} Log(Outsourcing) = \alpha &+ \beta_1 Task\ Complexity + \beta_2 Performance\ Measure\ Noise \\ &+ \beta_3 Contribution\ Margin\ Ratio + \beta_4 Medicare + \beta_5 MediCal + \beta_6 ALOS \\ &+ \beta_7 Mean\ Accounting\ Performance + \beta_8 Product\ Mix + \beta_9 Department\ Size \\ &+ \beta_{10} Net\ Margin + \beta_{11} Hospital\ Size + \beta_{12} Rural + \beta_{13} Teaching \\ &+ \beta_{14} Charity\ Care\ Ratio + \varepsilon \end{aligned}$$

		Standard Deviation of Acc. Performance Per Bed		**Standard Deviation of Acc. Performance Per Patient Day**	
		(1)	**(2)**	**(3)**	**(4)**
Predictors	**Predicted Sign**	**Beds or Units as Department Size**	**Revenue Proportion as Department Size**	**Beds or Units as Dept. Size**	**Revenue Proportion as Dept. Size**
Department-Level Variables					
Task Complexity	−	−3.0610***	−2.9447***	−3.2438***	−3.1288***
		(−16.06)	(−15.43)	(−20.59)	(−19.69)
Performance Measure Noise	−(H3)	−0.0128**	−0.0136**	−0.0028***	−0.0029***
		(−2.34)	(−2.50)	(−2.76)	(−2.74)
Contribution Margin Ratio	+/−	−0.0584	−0.0673	−0.1481	−0.1650
		(−0.50)	(−0.57)	(−1.23)	(−1.39)
Medicare Patients	+	−0.0838	−0.0627	−0.0898	−0.0767
		(−0.31)	(−0.23)	(−0.34)	(−0.29)
MediCal Patients	+	−0.3029	−0.2879	−0.2218	−0.2063
		(−0.98)	(−0.93)	(−0.74)	(−0.69)
ALOS	+	0.0023	0.0022	0.0022	0.0021
		(1.22)	(1.19)	(1.19)	(1.14)
Mean Accounting Performance	−	−0.0001	0.0012	0.0008*	0.0010**
		(−0.06)	(0.59)	(1.74)	(2.14)
Product Mix	−	−0.4071***	−0.4246***	−0.4510***	−0.4697***
		(−3.86)	(−3.98)	(−4.31)	(−4.41)
Department Size	−	−0.0009***	−2.8342***	−0.0000***	−3.0378***
		(−2.59)	(−2.63)	(−2.60)	(−2.68)
Hospital-Level Variables					
Net Margin	+/−	−0.2902	−0.3336	−0.2957	−0.3414
		(−0.96)	(−1.11)	(−1.22)	(−1.18)
Hospital Size	+/−	−0.0017*	−0.0022**	−0.0018*	−0.0023**
		(−1.86)	(−2.24)	(−1.92)	(−2.36)
Rural	−	−0.1490	−0.1702	−0.1507	−0.1763
		(−0.51)	(−0.59)	(−0.53)	(−0.63)
Teaching	−	−1.3696***	−1.4197***	−1.4160***	−1.4849***
		(−16.33)	(−16.49)	(−17.20)	(−17.37)
Charity Care Ratio	+	4.9241*	5.0812**	5.2721**	5.4618**
		(1.92)	(1.97)	(2.06)	(2.10)
Intercept		−1.5085***	−1.4532***	−1.3510***	−1.2913***
		(−5.87)	(−5.55)	(−5.30)	(−4.94)
Adjusted R^2		0.32	0.32	0.32	0.32

(continued on next page)

*, **, *** Significant at $p < 0.1$, $p < 0.05$, and $p < 0.01$, respectively.
Please see Table 1 for variable definitions.
The data include 1,560 ovservations, of 305 in-patient and 1,255 ancillary and out-patient departments.

are less complex than others. These include psychiatric intensive care, psychiatric acute—adult, psychiatric acute—adolescent and child, psychiatric acute—adolescent and child, obstetrics acute, physical rehabilitation care, psychiatric—long-term care, and residential care. Services that are non-core include sub-acute care, skilled nursing care, intermediate care, alternate birthing, and chemical dependency care. We next estimated Equations (1)–(3) using the core competency dummy constructed using the list described earlier. The core competency dummy has an insignificant coefficient ($p = 0.57$). Thus, we do not find an association between core competency and outsourcing. If we use core competency in lieu of task complexity in Figure 1, we also do not find a significant mediating effect (all ps > 0.40). These results provide some confidence that the effect of task complexity on outsourcing is not being driven by outsourcing of core competencies.

Inter-Departmental Linkages

It is unlikely that hospitals would outsource departments that are linked with others that are not outsourced. For example, hospitals with a medical/surgical intensive care department are unlikely to outsource the medical/surgical acute care department. To explore this issue further, we conducted the following analysis. First, we identified departments where such interdependencies may occur. These include the following pairs of departments: (1) medical/surgical intensive care and medical/surgical acute care; (2) pediatric intensive care and pediatric acute care; and (3) psychiatric intensive care and psychiatric acute—adult. The correlation coefficients between each of the three pairs of departments for the outsourcing variable are as follows: (1) medical/surgical intensive and acute care = 0.27; (2) pediatric intensive and acute care = 0.38; and (3) psychiatric intensive and acute care = −0.14. These correlations suggest that a majority of the outsourcing decisions in departments that are likely to be interdependent are driven by department-specific factors and not due to interdependencies. In addition, the standard errors are clustered at the hospital level, which should control for any interdependencies between departments.

Supplier Industry

We next explored the hospital supplier industry. Because we lack data on the types of contracts hospitals use with vendors, we cannot assess the extent of the incentives provided or the companies to whom services are outsourced. We interviewed a local hospital administrator and two medical vendors, and based on the insights obtained from these conversations and a review of the literature, we identified several companies that hospitals use for outsourcing inpatient, ancillary, and outpatient services, shown in Table 7. Some of these companies are large, publicly traded companies, which offer a comprehensive set of services and have billions of dollars of revenue, while others are smaller specialized firms. Thus there is no discernable pattern of behavior in the hospital supplier industry in terms of size or specialization.

CONCLUSIONS

We examine whether firms outsource to a lesser extent when tasks are complex, and the role of performance measure noise in mediating the relation between task complexity and outsourcing. Task complexity increases the noise in performance measures, rendering them less useful for contracting and giving rise to a moral hazard problem. We empirically explore whether firms' outsourcing decisions take into consideration the incentive problems posed by task complexity.

TABLE 6

Hypotheses Tests to Establish a Mediating Relation between Task Complexity and Outsourcing Using Logarithm of Proportion of Direct Cost Outsourced as Dependent Variable (H4)

Panel A: Inpatient Departments Only (n = 305)

		Noise Scaled by Bed	Noise Scaled by Days
(a) The independent variable (*Task Complexity*) influences the dependent variable (*Log* (*Outsourcing*)).	Yes	−0.9365 (p < 0.01)	
(b) The independent variable (*Task Complexity*) is associated with the mediator (*Performance Measure Noise*).	Yes	16.4810 (p < 0.0001)	54.8360 (p < 0.0001)
(c) The mediator (*Performance Measure Noise*) is associated with the dependent variable (*Log* (*Outsourcing*)).	Yes	−0.0112 (p < 0.04)	−0.0030 (p < 0.05)
(d) The mediator (*Performance Measure Noise*) causes the direct effect of (a) to decline.	Yes	p < 0.047	p < 0.061

Panel B: Inpatient, Ancillary, and Outpatients Departments Combined (n = 1,560)

		Beds or Units as Dept. Size		Revenue Proportion as Dept. Size	
		Noise Scaled by Bed	**Noise Scaled by Patient Days**	**Noise Scaled by Bed**	**Noise Scaled by Patient Days**
(a) The independent variable (*Task Complexity*) influences the dependent variable (*Log* (*Outsourcing*)).	Yes	−3.3575 (p < 0.0001)		−3.2476 (p < 0.0001)	
(b) The independent variable (*Task Complexity*) is associated with the mediator (*Performance Measure Noise*).	Yes	22.4963 (p < 0.0001)	41.2969 (p < 0.0001)	22.8252 (p < 0.0001)	45.5043 (p < 0.0001)
(c) The mediator (*Performance Measure Noise*) is associated with the dependent variable (*Log* (*Outsourcing*)).	Yes	−0.0128 (p < 0.02)	−0.0028 (p < 0.01)	−0.0136 (p < 0.02)	−0.0029 (p < 0.01)
(d) The mediator (*Performance Measure Noise*) causes the direct effect of (a) to decline.	Yes	p < 0.021	p < 0.01	p < 0.014	p < 0.01

Our analysis of data from 305 inpatient and 1,255 outpatient departments of for-profit California hospitals supports our hypotheses. Additionally, we document that task complexity is an important

TABLE 7
Examples of Hospital Vendors

1. InSight Health Corp. (http://www.insighthealth.com/): A publicly traded corporation that provides diagnostic imaging services, through a network of fixed-site centers and mobile facilities. Services include magnetic resonance imaging (MRI), Open MRI, computerized tomography (CT), positron emission tomography (PET), and combined PET/CT.
2. EmCare (http://www.emcare.com/): A private company that provides outsourced physician services to hospital emergency departments, inpatient physician services, inpatient radiology management programs and anesthesiology services.
3. Cardinal Health (http://www.cardinal.com/): A publicly traded company that provides pharmacy outsourcing and instrument management for surgery.
4. Mobile Anesthesiologists (http://www.zzzmd.com/): A private company that provides full-service office-based and outpatient anesthesia practice.
5. ProCure (http://procure.com/): A private company that provides full-service proton therapy center developer and operator. It collaborates with radiation oncology practices and hospitals.
6. TeamHealth (http://www.teamhealth.com/): A private company that provides a variety of services including emergency medicine, medical call centers, hospital medicine, teleradiology, radiology, pediatrics, and reimbursement coding and collections.
7. Webmedx (http://corpweb.webmedx.com/): A private company that provides medical transcription outsourcing for hospitals.
8. US Oncology (http://www.usoncology.com/): A publicly traded company that provides cancer care including research, specialty pharmacy and drug distribution, billing and reimbursement, electronic medical records (EMR), continuing education, and the use of evidence-based medicine pathways.
9. Aptium Oncology (http://www.aptiumoncology.com/): A private company that staffs, funds, and manages hospital-based cancer centers.

driver of noise in accounting performance measures. Our research makes a contribution to the accounting literature by demonstrating that task complexity is a driver of performance measure noise and, through its effect thereon, influences strategic decisions such as outsourcing.

In the presence of uncertainty and task complexity, an additional benefit of outsourcing easily measurable tasks is that it increases the ratio of variable to fixed costs. When uncertainty is high, decision makers prefer to incur fewer fixed and more variable costs because of the greater flexibility afforded in managing variable costs. Kallapur and Eldenburg (2005) estimate a Cobb-Douglas production function on a sample of 59 Washington hospitals and show that when environmental uncertainty increases, hospitals respond by increasing the ratio of variable to fixed costs. Using the real-options framework, they demonstrate empirically that, because uncertainty increases the value of flexibility, increasing the proportion of variable to fixed costs becomes more attractive as uncertainty increases. By outsourcing less complex tasks, hospitals can reduce the total proportion of fixed costs and increase the controllability of total costs.

We acknowledge that outsourcing decisions are complex and involve assessing a multiplicity of additional factors not examined in this study, including transaction costs, risk sharing, and extent of relation-specific investments. Our intent here is to demonstrate that the relation between outsourcing and task complexity is partially mediated by performance measure noise, which hampers incentive contracting with external vendors. By keeping a complex task in-house, a firm can reduce the incentive weight on noisy performance measures and use alternative mechanisms such as input monitoring and subjective performance measures.[6]

In our theory and hypotheses development, we use predictions from linear principal-agent models (LEN) such as that proposed by Holmström and Milgrom (1991). Hemmer (2002, 2004) argues that the assumption of LEN models that performance measure variance is not informative of agents' actions might not hold in some institutional settings. His main argument is that managerial effort that results in an increase in mean performance (shifting the distribution of outcome to the right) is also likely to increase the variance of the distribution. In such a scenario, higher incentives are needed to drive greater effort, which would give rise to a positive relation between risk and incentives. Hemmer (2004) also advises caution in the use of LEN models in situations in which the noise in different performance measures is correlated, and shows that the intuitive results of LEN analysis (which assumes linear contracts) can differ fundamentally from the results obtained from unrestricted contracts (i.e., that allow for nonlinear contracts). Because the source of the noise we are interested in examining is largely exogenous, we expect the general agency prediction of a negative relation between performance measure noise and incentive compensation to hold in our case.

Task complexity is likely to vary within departments based on the nature of the task. However, we do not have data at this finer level of within-departmental tasks to conduct this analysis. Our method of classifying departments based on complexity provides a *relative* measure of high-complexity versus low-complexity departments. Future field research can explore within-department variations in task complexity. Future research might also explore the relation between task complexity, outsourcing, and incentive compensation in settings in which task complexity does not influence the noise in performance measures.

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[6] Note that input monitoring can also be complicated for firms, and subjective performance appraisal gives rise to a number of issues such as leniency and centrality biases (Prendergast 1999).

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