Penetrating the "Black Box": Financial Incentives for Enhancing the Quality of Physician Services

Douglas A. Conrad
University of Washington
Jon B. Christianson
University of Minnesota

This article addresses the impact of financial incentives on physician behavior, focusing on quality of care. Changing market conditions, evolving social forces, and continuing organizational evolution in health services have raised societal awareness and expectations concerning quality. This article proceeds in four parts. First, the authors place financial incentives in the context of broader forces shaping the quality of physician services. Second, the article reviews the literature on financial incentive effects on physician behavior. Third, a simple net income maximization model of physician choices is presented, from which are derived formal hypotheses regarding the effect of financial incentives on physician choices of quality per unit of physician service and the quantity of services per patient. The model is extended qualitatively to offer further hypotheses and research directions. Finally, gaps and limitations of the model and of the extant empirical research are articulated, and additional researchable questions are posed.

Keywords: *financial incentives; quality; physician behavior*

The stage is set for experimentation with, and analysis of, the effects of financial (and nonfinancial) incentives on the quality of physician services. The dynamics of changing health plan models, increasing complexity of organizational forms extant in medical practice, and evolving quality improvement mechanisms provide the motivation to update the state of our knowledge and to develop new conceptual thinking related to quality incentives.

Medical Care Research and Review, Vol. 61 No. 3, (Supplement to September 2004) 37S-68S
DOI: 10.1177/1077558704266770

For this article, we focus on financial incentives at the level of individual physicians but also sketch ideas related to the broader context of market conditions and provider organizations.

We develop a new platform for theoretically modeling the effects of financial incentives on individual physician behavior; sketch the outlines of a conceptual framework that incorporates market conditions, organizational factors, and nonfinancial mechanisms; and outline a research agenda that is systematically related to prior theoretical and conceptual research on physician financial incentives.

The primary target audience for this article is researchers interested in the determinants of the quality of medical care, particularly those whose work is focused on the effects of economic incentives on access, cost, and quality. We aim also to inform persons and organizations in the management, policy, and practice domains of health services delivery and financing, for those stakeholders ultimately will play a major role in crafting and negotiating appropriate quality incentives.

The Institute of Medicine's (2001) recently published report, *Crossing the Quality Chasm*, recommends building organizational supports for change that can address the following challenges, among others:

- Redesign of care processes based on best practices
- Use of information technologies to improve access to clinical information and support clinical decision making
- Coordination of care across patient conditions, services, and time
- Incorporation of performance and outcome measurements for improvement and accountability

The IOM report (2001, 18-19) also argues that provider payment *incentives* should be aligned with quality improvement. The authors suggest the following "fundamental principles for the redesign of payment policy:"

- Provide fair payment for good clinical management of the types of patients seen
- Provide an opportunity for providers to share in the benefits of quality improvement
- Provide the opportunity for consumers and purchasers to recognize quality differences in health care and direct their decisions accordingly
- Align financial incentives with the implementation of care processes based on best practices and the achievement of better patient outcomes
- Reduce fragmentation of care

The IOM authors posit two critical dimensions of environmental change that must occur to facilitate the kinds of pervasive health care improvement

envisioned in their report. First, payment policies of purchasers and health plans should discourage fragmentation of care (as mentioned above) and encourage innovation in quality improvement, and purchasers, regulators, and consumers should share in accountability and measurement related to quality. Second, the authors highlight the need for environmental supports in several other areas: infrastructure for the dissemination and application of new clinical knowledge and technologies, information technology, and innovative models for preparing the workforce.

The IOM authors are not alone in identifying the importance of quality incentives. Several current initiatives illustrate that prominent societal stakeholders—the federal government, large employers, provider organizations, major health plans, and leading philanthropic organizations—are actively pursuing demonstration projects related to incentives for quality. For example, the Centers for Medicare and Medicaid Services (CMS) recently initiated its Doctor's Office Quality (DOQ) Project, which will examine the determinants of quality in physician office practices. Similarly, CMS has joined forces with Premier to establish clinical quality metrics (drawing on Joint Commission for Accreditation of Healthcare Organizations [JCAHO] core performance measures) and quality incentives related to hospital inpatient care for certain major health conditions. Hospitals attaining the 90th percentile of performance will receive 2 percent increases in payment; those at the 80th percentile will receive a 1 percent bonus.

Simultaneously, the Robert Wood Johnson Foundation, the California HealthCare Foundation, and the Agency for Healthcare Research and Quality have joined to support the Rewarding Results demonstration and evaluation program. Seven sites—ranging across the United States and representing private health plans, public program payers, medical groups, hospitals, and other organizations—are testing an array of financial and nonfinancial incentives for improved quality in hospitals and medical practices. The Pay for Performance (P4P) project in California—in which six large health plans have agreed to develop common quality metrics and to offer payments for quality to medical groups—constitutes another catalyst for quality improvement.

Four distinct patterns of financial incentives for quality are emerging: (1) bonus payments for superior quality to medical groups and individual physicians, (2) tiered co-payments (more generally, lower patient cost sharing for care received from providers with higher measured quality), (3) increased reimbursement rates for physicians with superior measured quality, and (4) quality "infrastructure" grants designed to defray a portion of the initial practice investment required to improve quality (Bailit Health Purchasing and Sixth Man Consulting 2001).

NEW CONTRIBUTION

This article seeks to advance both theoretical development and empirical research concerning the effect of financial incentives on the quality of physician services. We address the theoretical challenge by first specifying a simple, but we believe reasonably robust, formal model of individual physician optimizing behavior and then placing the individual physician model in context by referring to a more general model of the determinants of quality. The formal model of individual physician behavior is used to derive testable hypotheses, and the less formal sketch of the global determinants of quality is used to outline a set of complementary hypotheses for future research. Both sets of hypotheses are placed in the context of previous theory and empirical research on quality of physician services and emerging social awareness and concerns regarding the quality of medical care. Drawing on both theory and the identified gaps in prior research, the article articulates an agenda for future empirical and theoretical work.

LITERATURE SYNTHESIS AND STATE OF KNOWLEDGE

CARE SYSTEM STUDIES

Previous studies of *managed care*—a broad term applied to health care delivery and financing arrangements designed to influence the provision of care through a combination of financial incentives, organizational and clinical rules and constraints, and approaches to plan selection of provider panels (e.g., preferred and exclusive provider organizations)—have predominantly focused on differences between HMO and fee-for-service (FFS) systems. This emphasis is reflected in several major literature syntheses:

- Miller and Luft (1994) reviewed HMO/FFS comparative performance primarily on cost and utilization, updating prior syntheses based on research performed in the 1980s.
- Miller and Luft (1997) focused on relative performance of HMO and FFS systems, including results from the 1980s and early 1990s.
- Hellinger (1998) also published a review of empirical studies of the effect of managed care on quality. His general conclusion concisely illustrates the gaps in existing research:

  > The findings of the studies reviewed do not provide definitive results about the effect of managed care on quality. Indeed, relatively few studies

include data from the 1990s, and little is known about the newer types of health maintenance organizations that invest heavily in information systems and rely on financial incentives to alter practice patterns. Furthermore, managed care is not a uniform method that is applied identically by all health plans, and research studying the different dimensions of managed care also is needed. (P. 833)

- In a more recent literature review of studies published from 1997 to 2001, Miller and Luft (2002) concluded that overall quality of care is comparable among HMO and non-HMO plans, but they also found considerable heterogeneity in quality of care results. The authors comment that the evidence implies wide variation in quality by provider, by type of plan (HMO/non-HMO), and geographic area. The available studies do not shed light on the impact of financial incentives on this variation.

Dudley et al. (1998) also concluded that there has been little research on how incentives for individual providers influence quality and that little is known relative to two specific questions: (1) What types of payments increase quality? and (2) To whom should those payments be made? The authors then targeted several areas for future research:

1. Study of explicit financial incentives, rather than broad categories such as FFS, salary, capitation
2. Comparison of different types of HMOs and other forms of health plan and managed care organization
3. Identification of other management capabilities and policies, taking into account their direct effects on quality and their effects through interactions with one another and with financial incentives
4. Specification of appropriate comparison groups and settings (to minimize selection biases and contextual confounding in measurement of effects)
5. Development of better quality measures (e.g., through an appropriate weighting schema for individual indicators)
6. Creation of incentives for quality (both direct and indirect—the latter, for example, through risk-adjusted payments)

Among major studies of different care systems (i.e., HMO versus FFS), only the Medical Outcomes Study (MOS) examined long-term outcomes—finding that 4-year mortality was worse among the frail elders and low-income persons in HMO compared with FFS care systems. However, the MOS design did not allow (nor was it intended to allow) the investigators to disentangle the effects of organization-level or individual physician-level incentives.

STUDIES OF INCENTIVE EFFECTS ON PHYSICIANS' QUALITY-RELATED PERCEPTIONS

A variety of empirical analyses and policy papers drawing on the Community Tracking Study (CTS) Physician Survey also should inform future research on physician quality incentives (Landon et al. 2001; Reschovsky et al. 2001; St. Peter et al. 1999; Sturm 2002). Landon et al. (2001) found that practice setting was the most consistent predictor of physicians' treatment choices for specific hypothetical clinical vignettes: compared with physicians in solo practice, those in all other settings reported less likelihood of ordering tests, referral, or treating the presenting symptoms. Practice-level penetration of managed care and financial incentives were minimally and inconsistently associated with reported physician behavior.

Reschovsky et al. (2001) focused on primary care (PCP) and specialty physician perceptions of ability to deliver high-quality care to all their patients. They found that physicians in group practice settings were generally less likely than those in solo or two-physician practices to express quality concerns. Conversely, higher market area (but not physician practice-level) managed care penetration and a greater number of managed care contracts was significantly associated with greater quality concern among both PCPs and specialists. Individual physician financial incentives were less consistently significant, but interesting findings did emerge. For example, both productivity- and quality-based incentives among specialists were positively related to their perception of having adequate time to spend with patients. Quality incentives were also positively associated with perceived clinical freedom and ability to maintain continuity in the patient-physician relationship.

St. Peter et al. (1999) drew on the Round 1 CTS Physician Survey and reported that PCPs expressed significant concern that their scope of care was greater than it should be. Their principal significant findings were that perceived appropriateness of scope of care was better among physicians in organized group practice settings but was worse the greater the percentage of patients for whom the PCP acted as "gatekeeper." Practice revenue from capitation also was negatively associated with perceived appropriateness, but the relationship was not significant for a capitation proportion above 75 percent. The investigators *did not* examine the potential effect of individual physician-level financial incentives on perceived appropriateness, nor did they investigate the factors affecting specialists' perceptions of changes in the general complexity of cases referred to them or their perception of the appropriateness of those referrals.

Sturm et al. (2002) also used the CTS Round 1 Physician Survey. Their analysis identified some significant effects of individual physician incentives on

selected perceived quality indicators. Compensation based on the individual physician's productivity and comparative profiling results were associated with reduced ability to meet patient needs without losing income. Profiling-based compensation also was associated with increased concern regarding (undue) time pressure on patient care. On the more positive side, compensation based on patient satisfaction results and quality, respectively, was associated with *less* income pressure on quality and greater ability to maintain continuity in physician-patient relationships.

Each of the above studies was cross-sectional in nature, and none published results taking explicitly into account the potential endogeneity of practice-level incentive and organizational structures. Moreover, none measured clinical quality of care for actual patients, but instead these analyses focused on physician *perceptions* of their ability to deliver high-quality care to their patients. However, these CTS-based studies have advanced significantly the scientific and policy foundation for future research on physician incentives.

ADDITIONAL STUDIES OF PHYSICIAN FINANCIAL INCENTIVES

A modest number of contemporary studies have assessed the effect of explicit financial incentives to physicians for preventive services (cf., Kouides et al. 1998; Hillman et al. 1998; Fairbrother et al. 2001), the findings of which are mixed and generally suggest small or statistically insignificant incentive effects on delivery of preventive services. However, except for those prevention incentive studies, there appear to be no peer-reviewed studies of explicit financial incentives for quality.

Except for the CTS-based studies reviewed above, existing empirical studies (cf. Hillman, Pauly, and Kerstein 1989) and literature syntheses (Hellinger 1998; Dudley et al. 1998; Gosden et al. 2001; Armour et al. 2001; Goodson et al. 2001) generally do not distinguish between the effects of financial incentives that target the physician *organization* and those that are applied directly to the individual *physician*. Physician organizations take multiple forms—for example, medical groups, the independent practice associations (IPAs), physician-hospital organizations, and "wrap-around IPAs" linked to medical groups. Because IPAs include small medical groups as well as solo and two-physician practices, there are potentially three levels of incentive effect: (1) health plan to IPA, (2) IPA to medical group, and (3) medical group to individual physician. Thus, the "cascade" of risk can be filtered through as many as three levels from the point of initial contract between health plan and the organizational intermediary (Rosenthal et al. 2002).

There have been no *longitudinal* studies that distinguish the impact of organization-level and physician-level incentives on either the utilization or quality of health services. Rice (1997) has called for such research, suggesting that researchers take advantage of natural experiments of variation in incentives across different markets. Variation in incentives over time *and* across markets would provide an even better set of test conditions for assessing the causal effects of incentives on quality.

The Institute of Medicine (2001) recently completed a major study of the quality of care in America, suggesting that a major cause of compromised patient care was "systemic" failure in care delivery and financial incentives in the present environment. Berwick (1996), among others, has applied the principles of systems thinking and quality improvement to frame a portrait of health care systems improvement. However, even with these important conceptual contributions, society still lacks credible and robust answers to the question of which provider financial incentives and clinical-managerial-organizational arrangements yield superior performance on quality and cost (cf. Hillman, Pauly, and Kerstein 1989; Flood et al. 1998; Medical Outcomes Study: Safran, Tarlow, and Rogers 1994; Ware et al. 1996; Safran et al. 2000; RAND Health Insurance Experiment: Ware et al. 1986; Conrad et al. 1998; Kralewski et al. 2000; Tufano et al. 2001; Zierler et al. 1998).

In a subsequent article building on the IOM *Quality Chasm* report, Fernandopulle et al. (2003) have articulated several elements of a research agenda for squaring payment approaches with quality improvement. They suggest that future studies estimate private stakeholder returns on investment (the "business case") in quality improvement. They also identify the need to evaluate new methods of paying for quality, such as quality infrastructure grants and differential payment levels based on provider clinical quality, and to analyze the potential unintended adverse consequences of financial incentives. These could include undue provider attention to measured aspects of quality to the detriment of unmeasured and possibly more clinically effective behaviors as well as deterioration in care quality among providers initially identified as superior clinical performers but whose service capacity proves inadequate to handle the increased demand from patients "channeled" to them on the basis of their high quality. They also call for analyses that incorporate *patient* financial incentives for quality.

Even though financial incentives and clinical-managerial-organizational arrangements typically are fashioned to fit distinct market environments, studies are lacking that examine the interaction of the effects of incentives and clinical-managerial-organizational arrangements with market and environmental conditions. Kralewski et al. (2000), drawing on data from the upper midwestern United States, found significant differences in cost and utilization

attributed to variations in methods of physician compensation and health plan payment to medical group practices. In contrast, Conrad et al. (1998), in their Washington State study, observed neither clinically meaningful nor statistically significant differences in cost and utilization due to physician compensation or plan payment variations. These contrasting findings might reflect differences in market and environmental conditions or in measurement and modeling. They raise the question of the extent to which financial incentive effects are contingent on market and environmental conditions and, if so, which particular features of local and regional markets and sociopolitical conditions might be significant.

Neither the Washington nor the Minnesota study found a significant share of physician compensation based on quality *or* individual physician utilization of resources per enrollee. In the Minnesota study, less than 1.2 percent of the physician's compensation was based on quality, and less than 0.4 percent was based on individual physician resource use. The 1994 data from Washington State revealed a similar paucity of quality-based financial incentives.

STUDIES OF DETERMINANTS OF PHYSICIAN FINANCIAL INCENTIVE METHODS

In a related study based on 100 group practices (of 129 originally surveyed), the Minnesota researchers examined the compensation methods used for individual primary care physicians (Pedersen et al. 2000). The survey data were collected between July 15, 1995, and October 15, 1996. Key findings were as follows:

- Seventeen groups (of the 100 responding) compensated physicians through fixed annual salary, 71 used productivity (when used, on average 62 percent of compensation was based on this factor), 30 used group financial performance, 4 used quality of care (and this represented less than 5 percent of the physician's compensation when used), and only 1 used individual physician utilization of resources.
- Two statistically significant determinants of individual PCP compensation method emerged: (1) a higher share of group revenues from FFS was associated with a higher proportion of PCP compensation based on individual productivity, and a lower portion of PCP compensation from base salary; (2) a higher share of group revenue from capitation contracts was positively correlated with the proportion of PCP compensation based on quality of care.

A seminal study of physician compensation and productivity (Gaynor and Pauly 1990) found several significant exogenous determinants of the method of physician compensation in medical groups (one important dimension of fi-

nancial incentives). The share of prepaid revenue in the group was negatively associated with the share of production-based compensation in physician pay. Physicians in larger groups were paid a higher share of production-based compensation, which the authors interpreted as a high-powered incentive to overcome "free rider" problems in the productivity of larger groups.

IMPLICATIONS OF THE LITERATURE SYNTHESIS

Seven major findings emerge from this overview of the literature on physician financial incentives:

1. Previous work has not disentangled the quality of incentives at the level of the individual physician from organization-level health plan payment.
2. Virtually all previous empirical studies have focused on indirect, *implicit* quality incentives, for example, salary, capitation, or FFS physician payment.
3. Studies of *explicit* financial incentives for quality are almost exclusively related to preventive services, and their results are inconclusive. New direct incentives are emerging in the form of quality bonuses, tiered reimbursement schedules, and quality infrastructure grants, and these new forms require systematic evaluation (Bailit Health Purchasing and Sixth Man Consulting 2001; Bailit Health Purchasing 2002).
4. Knowledge regarding the role of market and organizational factors as mediators and determinants of financial incentive effects is limited. Future studies of financial incentive effects on quality should control for market conditions and organizational characteristics and should examine interactions, rather than solely independent effects, of incentives. Agency theory (Jensen and Meckling 1976; Prendergast 1999; Robinson 2001) provides a particularly robust paradigm for penetrating the black box of interactions between financial incentives, noncontract mechanisms, and other intraorganizational factors influencing quality.
5. No longitudinal studies of explicit financial incentives for quality have been performed, with the exception of a few pre-post, randomized controlled trials of preventive services (cf. Kouides et al. 1998; Hillman et al. 1998).
6. Financial incentives related to quality typically are not randomly assigned to providers but are generally negotiated between health care purchasers and provider organizations and within organizations between individual physicians and the compensation committee or leadership. Thus, unbiased estimation of incentive effects will be achieved only if the factors driving provider and organization self-selection of incentives are distinguished from the factors directly related to clinical quality.
7. Future empirical analyses of the effect of physician financial incentives on quality should incorporate patient financial incentives in their estimation models, including not only patient cost sharing and health plan benefit design but also

any direct quality financial incentives provided to patients for compliance with medically prescribed care regimens.

CONCEPTUAL FRAMEWORK AND TESTABLE HYPOTHESES

In this section, we first develop a conceptual model of the physician's choice of the quantity and quality of output as a means of organizing our thinking about the effects of financial incentives and other exogenous factors on physician practice. That model suggests a set of specific testable hypotheses. We conclude the section by discussing an expanded conceptual framework, which is then used to derive additional hypotheses and general directions for future research on quality incentives.

We begin by examining the physician practice's choice of quantity of services (output) and quality per unit of service. Then we place those practice choices within the context of a more general model of the interactions between local market and social environments; health plans; provider organizations; and the decisions of organizations, physicians, and patients.

PHYSICIAN CHOICE OF QUANTITY AND QUALITY OF OUTPUT

Physician practices offer differentiated services in local markets. The customization of physician services to individual patients with idiosyncratic preferences and physical and mental health needs, coupled with asymmetric information, confers a degree of pricing power on the individual medical practice (Pauly and Satterthwaite 1981; Dranove and Satterthwaite 1992; McGuire 2000), and we assume that the practice seeks to maximize net income by choosing the optimal quantity of services and quality per unit of service.[1]

First, we explicate the effect of quality incentives under an FFS regime of payment to physician practices. The market-determined price "markup" function per unit of quality captures the quality incentive, and specific hypotheses are derived concerning the effect of small changes in exogenous variables (factors beyond the medical practice's control) on the practice choice of quality and quantity. These hypotheses ultimately should be tested in *reduced form* equations, which address the total effect of small change in an exogenous variable—such as the price markup for higher quality—on the levels of quantity and quality.

Hypothesis 1 (Quality Effects of Quality-Based Financial Incentives): The *direct* effect of an increase in the market price markup for quality is to induce the provider to in-

crease the level of quality per unit of output, holding constant the marginal cost of quality and the level of exogenous variables that shift the demand for and cost of physician services (such as income and health insurance coverage).

The initial direct effect is shown in Figure 1, Panel A, as marginal revenue of quality shifts from $MR_Z(0)$ to $MR_Z(1)$ along the marginal-cost-of-quality curve, $MC_Z(0)$, and the "new" optimal level of quality, for which quality marginal revenue equals quality marginal cost, is at $Z(1) > Z(0)$. This effect reflects the intent behind private and public policy makers' use of financial incentives to encourage improved quality. However, there is more to the story.

Indirectly, the increased price markup also affects quality per unit of output by raising the marginal revenue per unit of quantity. This is shown in Figure 1, Panel B, as a shift in the marginal revenue of quantity from Mrq(0) to MRq(1), which leads to an increase in optimal quantity, that is, $q(1) > q(0)$. In turn, a new higher level of quantity implies a second round of changes in optimal quality because quality marginal revenue and quality marginal cost shift upward. Higher quality is now being applied to a larger number of units of output, thus proportionately increasing the marginal revenue of quality. If total costs rise less than proportionately as the practice's quantity of output increases (if there are economies of scale), quality marginal cost will shift upward less than in proportion to quantity, resulting in $Z(2) > Z(1)$. Even if diseconomies of scale are present, in which case $Z(2) < Z(1)$, as long as direct effects outweigh indirect effects in size, $Z(2) > Z(0)$ will apply, suggesting that the ultimate *net* effect of marginal quality incentives will be to increase quality.

Pope and Burge (1992) remarked that in light of the mixed results of econometric studies of physician practice production, "a hypothesis of *roughly* [emphasis added] constant returns to scale is not unreasonable" (p. 159). To the extent this generalization is valid, indirect effects on quality through induced quantity changes will be small. Thus, an increase in the marginal financial incentive for quality is predicted to result in increased quality per unit of service.

Hypothesis 2 (Quantity Effects of Quality-Based Financial Incentives): The *direct* effect of an exogenous increase in the market price markup for quality is to increase the quantity of practice output, holding other exogenous variables constant (e.g., demand price and cost shifters).

If the price markup for incremental quality is sufficiently large relative to the marginal cost of quality and if the diminution of the price markup as quality increases[2] is relatively small, the *indirect* effect on quantity of the increase in quality reward also will be positive. This indirect effect operates through the

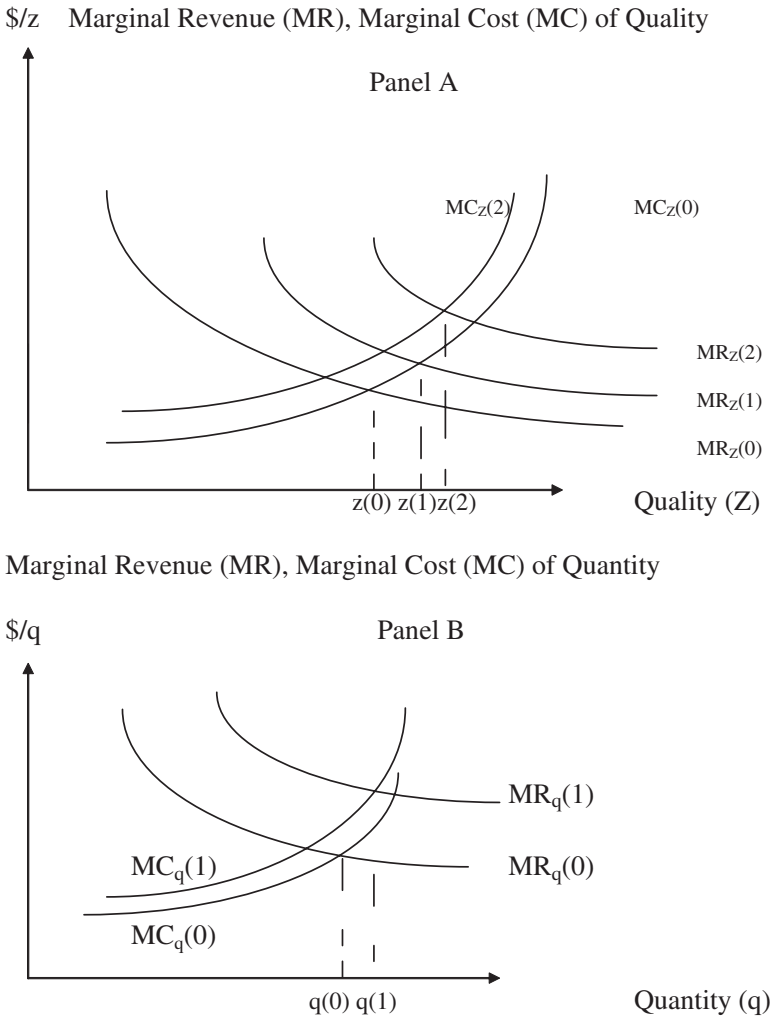

FIGURE 1 Marginal Revenue, Marginal Cost of Quality, and Marginal Cost of Quantity

increase in the marginal revenue and marginal cost per unit of quantity as providers enhance the quality per unit in response to the market reward for quality.

Hypothesis 3 (Effects of Exogenous Price-Level Changes)
Hypothesis 3a: Quality effects: In this model, exogenous (i.e., market-determined) increases in price level do not directly influence quality.

The exogenous price level in our model does not directly influence either the marginal revenue of quality or marginal cost of quality.

However, it can be shown that the indirect effect of exogenous price increases on quality depends exclusively on the elasticity of total cost with respect to quantity. If costs rise more than in proportion to the quantity of output (i.e., diseconomies of scale), then exogenous price increases not explicitly tied to quality per unit of output would lead to *lower* quality as providers trade off the disproportionately higher costs of increased output levels against quality per unit of service. Alternatively, if costs increase in direct proportion to quantity (constant returns to scale), then quality will be *un*affected by price increases. On the same reasoning, if there are economies of scale in the production of physician services, price increases will lead to increased quality.

Hypothesis 3b: Quantity effects: Other things equal, by increasing the marginal profitability of output, an exogenous increase in price level will result in increased level of output.

Shifts in willingness to pay due to changes in health status, population income, and health insurance coverage are illustrative of exogenous demand factors that could give rise to such shifts.

EXTENSIONS OF THE PHYSICIAN QUALITY CHOICE MODEL

The issues involved in quality of physician services transcend the quality and quantity choices embedded in the model of the previous section. Figure 2 portrays diagrammatically a richer model of the interactions between market and social environments, the characteristics of health plans, provider organization attributes, and the production of quality. The lower half of Figure 2 (below the boxes for the environment and characteristics of area health plans and the provider organization) is adapted from the recent model of Michael Kuhn (2003). In what follows, we briefly motivate the conceptual framework depicted in Figure 2 as a means of formulating broad research directions that will complement the three specific testable hypotheses derived from the simplified physician net income maximization model.

Figure 2 implies that market and environmental conditions will drive investment in *structural quality*. In particular, the cost of capital and the costs of

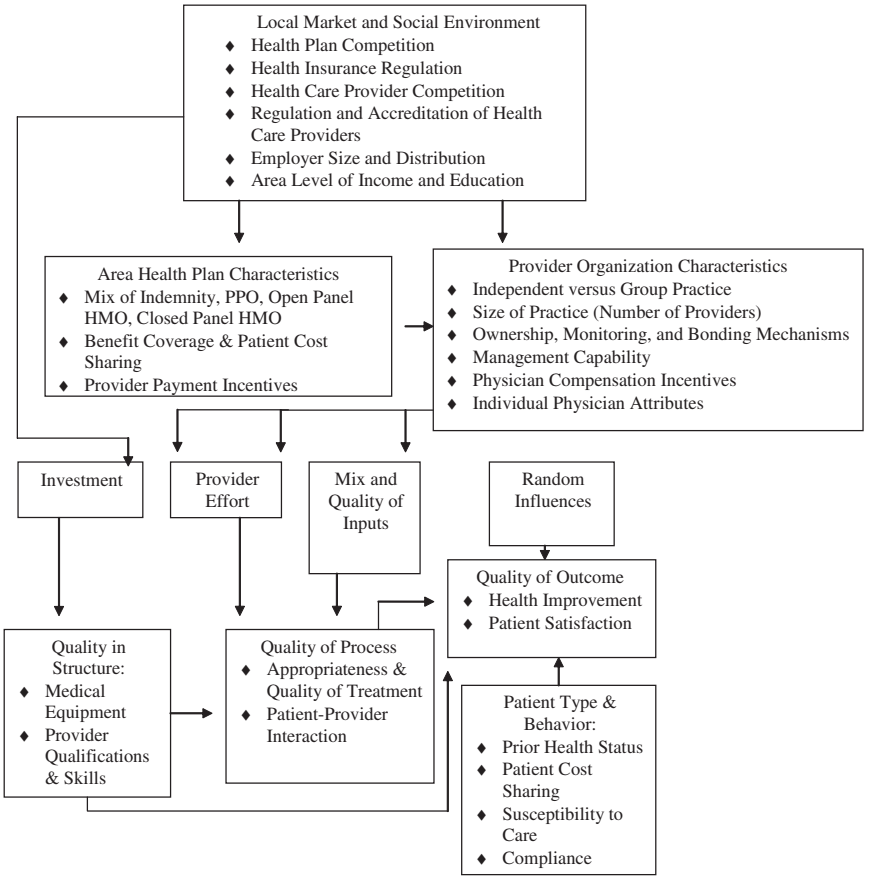

FIGURE 2 The Production of Quality in Health Services
Note: HMO = health maintenance organization; PPO = preferred provider organization.

graduate medical education will influence long-term investment in medical equipment and in human capital. Since the capital markets and graduate medical education financing are predominantly nationwide, the relevant variation across local markets for studies of physician quality infrastructure will come from local and state initiatives. The top text box in Figure 2 delineates several local market and environmental constructs suggested by prior empirical work to be exogenous determinants of health plan and provider organization characteristics.

Among area health plan characteristics, three are especially likely to shape provider organization characteristics. First, the degree of vertical integration between health plan and the provider organization, that is, the extent to which financing and delivery are unified in a common organization, will influence the options available to provider organizations. Greater integration—moving along the continuum from independent indemnity health plans to closed-panel prepaid group practices like Kaiser Permanente—encourages larger practice size, increased aggregation of physicians into groups, economies of scale in management, and a shift in physician compensation toward salaried and risk-sharing (e.g., capitation) arrangements. These changes in organizational form enhance risk spreading and risk management capacity and better align individual physician financial incentives with those of the health plan receiving fixed premiums. Second, more comprehensive health plan benefits and lower patient cost sharing will encourage greater specialization among physician practices by expanding the extent of local market demand for physician services, and increased demand will tilt organizations toward more production-based modes of physician compensation. Third, health plan provider payment incentives, as suggested in the work of Gaynor and Pauly (1990) and Pedersen et al. (2000), will affect the methods chosen by provider organizations to compensate their physicians; for example, medical groups paid by capitation will more likely choose salary or risk-sharing compensation.

In turn, provider organization traits—group versus independent practice; number of physicians; noncontract mechanisms such as ownership, bonding, and monitoring; management capability, physician compensation incentives; and individual physician attributes (age, gender, experience, specialty, board certification status)—are expected to affect the level of capital investment chosen by the firm, as well as the effort and the mix of inputs chosen by individual physician providers within the firm (cf. Conrad et al. 2002). Whereas long-run investment in human and physical capital will mold the practice's structural quality, short-term decisions on provider effort and the mix and quality of treatment and diagnostic inputs as well as the quality of the practice's infrastructure will drive process quality and health outcomes. Simultaneously, Figure 2 indicates that patient type and behavior will significantly affect health outcomes—reinforcing Fernandopulle and colleagues' thesis that quality incentive research must include *patient* financial incentives.

RESEARCH DIRECTIONS AND HYPOTHESES IMPLIED BY THE BROADER MODEL (FIGURE 2)

Physicians function as agents for their patients, for the provider organization to which they belong, and for the health plans with which they contract.

This theoretical perspective suggests a testable hypothesis for the relationship in Figure 2 between health plan payment incentives and the physician quality-based compensation incentives adopted by provider organizations such as a medical group. The CTS Physician Survey offers a potential database for testing this hypothesis with panel data on the practice's distribution of health plan payment methods (e.g., capitation, percentage of managed care revenues) and the individual physician's method of compensation.

> *Hypothesis 4 (aligning payment incentives):* Health plans contracting with individual, risk-averse physicians will fashion quality incentives focused primarily on individual provider *process quality* measures, rather than patient outcome measures, especially to the extent that outcomes in the particular physician's clinical domain (e.g., endocrinology for diabetes care, pulmonology for asthma care) are subject to random influences and patient compliance factors beyond the clinician's control.

Where outcomes measures are used, *relative* performance standards (e.g., identifying 90th percentile performers) will be preferred to absolute outcome standards, the former being a way of adjusting for common random variation.

As a corollary, when contracting with large medical groups (for which the assumption of risk neutrality is reasonable), *outcomes-based* quality incentives are more likely. Moreover, to the extent that outcomes are clearly measurable (even if not totally attributable to the process quality of physician care), the "informativeness principle" from agency theory (Kuhn 2003) suggests that higher quality will be induced by a combination of process *and* outcome-based incentives.

Provider organizations, such as medical group practices, seeking to align compensation to individual physicians with their quality-based health plan contracts will predominantly choose salaried arrangements or production-based compensation augmented by direct quality incentives, tracking the same metrics built into their health plan contracts.

NONCONTRACT MECHANISMS

The text box of provider organization attributes in Figure 2 also refers to noncontract mechanisms for enforcing the delivery of high-quality physician services. Three noncontract devices are prominent in the agency theory literature: ownership, monitoring, and bonding. Jensen and Meckling (1976) argued that these three mechanisms can serve as (imperfect) substitutes for contractual incentives in motivating agents to act in the interests of the principal.

Ownership by the physician of health care enterprises influences quality indirectly by giving the clinician a share of the net income of the practice. If practice net income is affected by quality (as well as quantity, price, and cost), then the physician with a "residual claim" to practice profits is likely to have stronger quality incentives than an independent contractor or employee. Monitoring (e.g., peer review of clinical quality, physician profiling) is expected to directly shape physician behavior by virtue of the exchange of information and peer comparison. Bonding—as used in the finance literature to refer to the agent posting a dollar amount to be relinquished in the event of failure to conform at the targeted level—is illustrated in hybrid form by health plans' use of *withholds* in physician payment: if health care costs per patient exceed the target, only a fraction of the initially withheld payment is returned to the physician. Other features in medical practice function like implicit bonding devices: (1) the "due care" standard of medical malpractice law; (2) the physician's and medical group's reputation for quality of care, which reputation is equivalent to an intangible capital asset subject to depreciation if clinical quality is less than originally "promised."

We offer the following testable hypothesis related to these noncontractual, quality-enforcing instruments within the provider organization:

> *Hypothesis 5 (noncontract quality-assuring mechanisms):* Medical group practices have a reputational stake in maintaining quality—especially on those metrics observable to health plans, employers, and consumers. Other things equal, the age of the group; its size; the extent of the local market; the degree of consumer mobility (search and switching costs); the level of market competition among physicians (physicians per capita by specialty type); the structure of the health plan market; and the sophistication of consumers will affect the use of monitoring, bonding, and physician equity ownership as means of assuring high clinical quality.

Except for monitoring, which is required to measure performance and establish quality incentive payments, these noncontract mechanisms (bonding and physician ownership) will substitute for quality-based incentive compensation. That is, the greater the level of these activities, the less the share of the typical physician's compensation in the form of direct quality incentives.

Specifically, we posit that, ceteris paribus, medical group practices that are older; larger; in markets with larger population; greater competitiveness among physicians; higher market concentration of health plans; and a more educated, mobile, and higher consumer population will be more likely to use internal monitoring, physician equity ownership, and various forms of quality bonding. Negotiating a higher fee for service or capitation rate in exchange for superior quality is one means of bonding since this price premium and the

corresponding investment in quality reputation will be forgone in future periods if the implicit quality promise is not honored. In smaller medical groups, low-powered compensation arrangements will be relatively more common, as informal monitoring and ownership act as substitutes for high-powered direct financial incentives.

Increasing the physician share of equity ownership in the practice would be expected to increase technical efficiency (cost per unit of output) by giving the providers a higher powered stake in the practice's bottom line and also could increase clinical quality by enhancing the individual physician's and the practice's stake in its reputation for clinical quality.

QUALITY TOURNAMENTS

The increased interest that employers are now expressing in linking physician payments to quality is manifesting itself, in a small number of instances, in what could be termed *quality tournaments*. There is a direct analogy here to the literature on executive compensation in firms. This literature, as summarized by Prendergast (1999),

> considers a group of agents competing for a fixed set of prizes. The prizes are specified in advance and agents exert effort to increase the likelihood of winning the better prize. Rather like a sports game, all that matters for winning is not the absolute level of performance, but how well one does relative to others.

The theoretical literature in this area generates a number of testable hypotheses about the impact of this sort of incentive structure on agent behavior.

In the health care arena, the 'principal" role could be played by a purchaser or a health plan, while the agent is a physician or a physician group. The purchaser would award fixed prizes to physicians or groups of physicians performing better than their rivals. A visible example of such a "tournament" compensation scheme has been implemented by the Buyers Health Care Action Group (BHCAG) in the Twin Cities (Christianson and Feldman 2002). Under BHCAG's quality award program, which was established in 1999, care systems compete for financial awards each year of $50,000 or $100,000. These awards are paid for out of BHCAG member dues. Various criteria are used to select the winners of the awards, but an important component is the demonstrated effectiveness of a specific quality improvement program or new initiative. In addition to the financial payment, there is a potential indirect benefit to winning the quality tournament in any given year. The winners are allowed to advertise their victory for 3 years, and a "blue ribbon" is attached next to their name in BHCAG's care system Performance Results Book. Thus, care systems

winning the awards may attract additional enrollees at the expense of other care systems and potentially increase their profits. Interview data suggest that the care systems contracting with BHCAG compete vigorously for the awards. However, there has been no long-run analysis of the impact of the quality tournaments on care system (including losing care system) behavior and on how this affects the behavior of physicians in care systems.

Hypothesis 6 (research directions regarding quality tournaments): If quality tournaments such as the above become more widespread, they offer a potentially fruitful area for research.

Important questions would include the following: How does the theoretical tournament literature on executive compensation translate to the health care environment, and which hypotheses generated by this literature seem most relevant to health care quality tournaments? Empirically, how does variation in the structure of tournaments affect results? Do behavioral changes occur that improve quality? Are they sustainable in the long run? How cost-effective are quality tournaments for purchasers?

PRICE POSTING AND QUALITY

The way in which pricing information is made available to consumers, and the incentives they have to act on that information, could also affect physician behavior with respect to the quality of services they offer. New health benefit designs in "defined contribution" health insurance plans try to motivate consumers to care about physician prices when making their purchase decisions (Christianson, Parente, and Taylor 2002). Under these plans, consumers have access to Internet sites where physician prices are posted, along with evidence regarding physician training and markers of quality of care. Physicians set their own prices but, in theory, consumers have enough information available to make a cost/quality trade-off in their purchase decision. If quality "sells," this model creates an opportunity for physicians who provide higher quality services (even at a higher price) to attract more patients and generate greater revenues. Under these circumstances, physicians may have an incentive to produce higher quality services. These models are in their infancy but, if they grow in popularity, they will generate a variety of interesting research opportunities.

Hypothesis 7 (research directions for posting of prices and quality): Will physicians place greater emphasis on quality in a market where there is easily accessible and standardized comparative information on physician prices and quality? How will

this vary across services of different types and across markets with different types of consumers?

A fundamental question in health care pricing concerns the choice of the "price" unit of measure. In the context of FFS payment, the price per unit of service (five-digit Resource-Based Relative Value Scale code) is the relevant measure of transaction price between payer and provider. In capitation arrangements, the payment per member per month (PMPM) constitutes the salient price. However, for the decision making of individual doctor and patient, the appropriate full price is the dollar cost and time cost to patient and payer of the treatment episode. The full price for the chronically ill person might be the money and time cost of caring for them for each year (per member per year, or PMPY), while for the acutely ill person the true price would be the cost of caring for each acute episode. How price is defined and metered will inevitably influence quality of care per unit of service and per episode—witness, for example, the debates regarding alleged quality erosion under capitation payment. In the context of Figure 2, the posting of prices and quality measures will shape the provider-patient interactions (in the lower right text boxes).

Hypothesis 8 (indirect incentive effects on quality of different physician compensation methods): Other things equal, to the extent quality per unit of service and quantity per unit of service are *complements* in production, compensating individual physicians by FFS methods is expected to lead to the highest level of *process quality* since the direct quantity incentives are strongest under FFS.

In the absence of adjunct incentives not directly incorporated in the fixed salary, salaried arrangements will lead to levels of process quality between those of FFS and capitation. Under capitation, the direct financial incentive of which is to reduce quantity per patient, complementarity of quantity and quality implies the lowest level of process quality among the three forms of compensation.

The rationale for this hypothesis flows from the direct financial incentives implicit in the three pure forms:

- FFS pays for doing more of what is measured and encourages providers to expand the range of services measured and therefore reimbursed. If quality per unit and quantity of service output are complements, the FFS inducement of higher quantity will lead to higher quality as well. Higher levels of marginal quality reward (r) relative to quality marginal cost will accentuate the positive effect of FFS on quality, and higher price levels (p) will also indirectly stimulate higher quality by inducing higher quantity.

- Fixed salary (in the absence of salary adjustments linked to quality) offers no direct reward for increased quality (or quantity). On the other hand, fixed salary also insulates the individual physician from the direct practice costs of increasing quality—with the important exception of the physician's own time and psychic costs of the increased effort required to improve quality. Logically, it is possible that by insulating the physician from a portion of the direct marginal costs of quality improvement, the salaried compensation form might elicit higher quality than FFS even in the absence of a direct financial reward.
- Based purely on direct financial incentive, individual physician compensation by capitation is likely to produce the lowest level of quality among the three compensation methods. Unless the capitation amount is adjusted for quality performance, capitation discourages quality in two ways: first, by not paying at the margin for increased quantity (or quality), and second, by imposing the direct practice input costs of improved quality on the individual physician. The physicians' psychic and economic stake in maintaining reputation mitigates these financial incentive effects but will only change the predicted ordering among payment regimes if those psychic or economic factors differ systematically by payment method.

GAPS IN THE CONCEPTUAL FRAMEWORK AND EMERGING ISSUES

One of the significant gaps in our framework is that physicians undoubtedly have motivations other than net income. Clearly, both as social beings and as agents for their patients, physicians are driven by important social and professional norms and by altruism, in addition to net income. There is an important literature in economics, sociology, and psychology (cf. Adams 1963; Condry and Chambers 1978; Congleton 1991; Frey 1997) that addresses aspects of equity and intrinsic motivation and their relationship to the application and effects of economic incentives. Certain health economists (cf. McGuire 2000) have addressed net patient health benefit as a motive for physician decision making on quantity of output and quality (physician effort), but the *mediating* impact of extrinsic financial incentives on intrinsic motivation has not been modeled theoretically in health care, nor have the cross effects of extrinsic rewards on intrinsic motivation been examined empirically in the health services literature.

As Frey (1997) elucidated, a priori, the use of external financial incentives might actually enhance (or "crowd in," as he puts it) intrinsic motivation if the economic incentive is viewed as legitimating or reinforcing internal or professional norms. Alternatively, if the implicit signal is that external rewards are a substitute for internal motivators, the use of financial incentives might "crowd out" or diminish the strength of intrinsic quality motivators. The

ultimate direction of the mediating effect is an empirical question, which to our knowledge has not been investigated in the health services research literature.

Another important gap in our framework relates to the breadth of choices considered for the physician firm (e.g., the medical group practice) and the effects of different exogenous parameters (e.g., factors shifting demand and cost levels) on physician choices. Our formal model and hypotheses considered choices of quality and quantity of physician services but did not distinguish between quality of process and quality of *structure* in the physician practice, nor did the model differentiate quantity of services *per patient* from number of patients ("panel size") served by the practice.

The use of salary or capitation to compensate physicians offers no direct financial incentive to the individual physician for provision of quality or quantity of physician services. Therefore, physician organizations adopting these forms of compensation, which need to ensure physician productivity (quantity of quality-adjusted output per provider) and quality, must devise other quality-assuring mechanisms. The study of such organizational decisions—practice size, monitoring and profiling of clinical and economic performance, distribution of ownership equity, and various forms of performance "bonding"—should accompany any analysis of the effect of quality incentives.

Some of the hypotheses regarding the effect of capitation payment on quality per unit of service might be changed if the dimensions of panel size and quantity of services per patient were separated in the analysis. Competition among physicians for patients does create incentives for provision of quality that might indirectly catalyze quality improvement under capitation even more strongly than under regimes such as salary or FFS where payment is not per patient.

The synthesis of our present state of knowledge and the conceptual framework highlight a number of additional gaps in the state of our knowledge regarding the effects of financial incentives, organizational factors, and market conditions. In addition to testing the hypotheses formally implied by the framework enunciated in this article, future research should address an array of emerging issues. For example,

- How can "informed consumer" and organized purchaser incentives be aligned with provider incentives to encourage sustainable quality improvement? For example, is there a particular blend of provider payment, ownership, other incentive mechanisms (e.g., price and quality posting), and organized purchaser "rewards for results" that produces superior quality of care?

- What is the nature of the *interaction* between different organizational conditions (e.g., the size, structure, ownership form) and the effects of provider financial incentives?
- What market conditions (e.g., in terms of managed care penetration, provider supply, population attributes) are most favorable for quality improvement?

The recently published work of the National Health Care Purchasing Institute (cf. Bailit Health Purchasing and Sixth Man Consulting 2001; Bailit Health Purchasing 2002) offers interesting examples of provider incentive models that have been implemented in a variety of provider organizations and market settings. Their work raises a number of additional questions for research (Bailit Health Purchasing and Sixth Man Consulting 2001, 8):

1. To what extent is the effectiveness of incentives in influencing physician performance related to certain key factors?
   - Level of trust between physicians and those implementing the incentive
   - Size of the incentive
   - Peer and/or consumer knowledge of individual provider performance
   - Perceived and actual accuracy of the underlying database for the incentive
   - Recognition among physicians of stimulus and need for change
   - Medical leadership support for incentive program
   - practicing physicians' knowledge and understanding of the incentive(s)
   - Simplicity and directness of the incentive program
2. How and to what degree do nonfinancial incentives (e.g., public recognition of superior performance, price posting) and other organizational and market mechanisms (e.g., clinical guidelines, variable patient cost sharing tied to provider performance) interact with physician financial incentives to influence clinical quality and efficiency?

These emerging issues, along with the specific testable hypotheses elucidated in this article, offer a fruitful series of questions for conceptual and empirical research. Let the inquiry continue.

APPENDIX
Physician Practice Equilibrium

To simplify the comparative statics, while retaining the essence of the firm's problem, consider the following practice demand and cost functions:

$$\text{Physician Practice Demand: Price} = p(q, h) + r(z)z \quad \text{(inverse demand function in terms of price)} \tag{1}$$

$$\text{Total Cost: Cost} = z^c q^s \times i \tag{2}$$

$$\text{Net Income: } \pi = [p(q, h) + r(z)z]q - z^c q^s \times i(m'), \tag{3}$$

where terms are defined as follows: q = quantity of output, z = quality per unit of quantity, r = the market-determined price markup ("marginal reward") for quality per unit of service above that implied by the reservation demand price (p), c is the quality elasticity of total cost, z is the measure of quality per unit of service, and h and i are vectors of exogenous demand (price) and cost shifters, respectively. This functional form of cost implies a flexible total cost elasticity of quantity, with $s > 1$ ($s = 1$) indicating rising (constant) marginal costs with increasing quantity of output. Assuming downward sloping demand for quantity and quality, $p'(q)$ and $r'(z)$ are both negative. The quality reward function, $r(z)$, is a positive function of quality.

In this model, the monopolistically competitive physician firm (practice) has some indirect influence over price through choice of quality (z) and the quantity of output (q). The firm is assumed to maximize net income by choice of z and q, subject to the demand constraint.

The maximization problem is presented in equations A1 through A3:

$$\text{Physician Practice Demand: } P = p(q, h) + r(z)z \tag{A1}$$

$$\text{Total Cost: } C = z^c q^s \times i(m') \tag{A2}$$

$$\text{Net Income: } \pi = [p(q, h) + r(z)z]q - z^c q^s \times i(m'). \tag{A3}$$

Necessary first-order conditions (NFOCs): first partial derivatives written as primes (′), second and cross partials written as double primes (″), and the arguments following in parentheses ( ).

$$\text{Quantity: } \pi'(q) = 0 = p(q, h) + r(z)z + p'(q)q(h) - z^{c} \times i \times s \times q^{s-}1 \tag{A4}$$

$$\text{Quality: } \pi'(z) = 0 = q(h) \times [r(z) + r'(z)z - c \times iq^{s-}1z^{c-}1] \tag{A5}$$

Sufficient second-order conditions for a maximum (SSOCs):

$$\begin{gathered}\pi''(q) = p'(q) + p'(q) + p''(q) \times q - s(s-1)q^{s-}2z^{c}i = 2p'(q) + \\ p''(q) \times q(h) - s(s-1)q^{s-}2z^{c}i < 0,\end{gathered} \tag{A6}$$

assuming downward sloping demand ($p'(q) < 0$), and $p''(q) > 0$ but sufficiently small and/or s is sufficiently greater than 1 (diseconomies of scale in quantity of output), that $\pi''(q)$ is < 0.

$$\begin{gathered}\pi''(z) = r'(z)q + r''(z)zq + r'(z)q - c(c-1)q^{s} \times \\ z^{c-}2 \times i = q[2r'(z) + r''(z)z - c(c-1)q^{s-}1 \times z^{c-}2 \times i] < 0,\end{gathered} \tag{A7}$$

assuming $c > 1$, which implies that the marginal cost of quality is increasing with quality (holding constant the quantity of output) and that the absolute value of $r''(z)z$, which has a positive sign by concavity of the price markup function ($r(z)$), is sufficiently small compared to $r'(z)$ that the SSOC inequality, $\pi''(z) < 0$, holds.

The Hessian determinant (order $k = 2$, for the two endogenous variables) is

$$H = \pi''(q) \times \pi''(z) - \pi''(q, z) \times \pi''(z, q) > 0. \tag{A8}$$

The key cross-partial derivatives are

$$\pi''(q, z) = \pi''(z, q) = r(z) + r'(z)z - c \times i \times sq^{s-}1z^{c-}1. \tag{A9}$$

Since the right-hand side of (A5) must equal zero and $\pi''(q, z) = \pi''(z, q) = r(z) + r'(z)z - c \times i \times sq^{s-}1z^{c-}1$ differs from that first-order condition only by the multiplier s after the minus sign, we can determine the sign for $\pi''(q, z)$, conditional on assumptions regarding the magnitude of s (returns to scale in physician production. If $s > 1$, then $\pi''(q, z) < 0$. If $s = 1$, then $\pi''(q, z) = 0$. If $s < 1$, $\pi''(q, z) > 0$.

$$\pi''(q, r) = z \tag{A9'}$$

$$\pi''(z, r) = q \tag{A9''}$$

COMPARATIVE STATICS

Applying Cramer's rule (Silberberg 1990), we solve for the total derivatives of the change at equilibrium in each of the two endogenous variables for small changes in the primary exogenous parameter of interest, $r(z)$, which denotes the market-determined markup of price for a unit change in quality above the reservation level:

$$\text{Quantity Effects: } q'(r) = \{-\pi''(q, r) \times \pi''(z) - (-1)\pi''(z, r)\, \pi''(q, z)\}/\text{H}. \tag{A10}$$

Substituting the values of $\pi''(q, r)$, $\pi''(z)$, $\pi''(z, r)$, and $\pi''(q, z)$ into equation (A10),

$$\begin{aligned} q'(r) = -zq\{2r'(z) + r''(z)z - c(c-1)z^{c-}2 \times sq^{s-}1 \times i\} - \\ (-1)q[r(z) + r'(z)z - csq^{s-}1z^{c-}1 \times i]/\text{H}. \end{aligned} \tag{A10'}$$

The first term in {} on the right-hand side of (A10′) is negative by SSOC condition (A7). When multiplied by $-zq$, the first half of the equation $\{-\pi''(q, r) \times \pi''(z)\}$ is therefore positive. The first half of the equation can be interpreted as the *direct* effect of an increase in the $r(z)$ reward function on the marginal net income attributable to increased quantity—$\pi''(q, r)$—weighted by the rate of diminution in the marginal net income of quality as quality increases—$\pi''(z)$.

The second half of the equation captures the *indirect* effect of an increase in the level of the reward function $r(z)$ on the marginal net income of quality—$\pi''(z, r)$—weighted by the cross-effect of quality on the marginal net income of quantity—$\pi''(q, z)$. As discussed above, the sign of this indirect effect depends totally on the cost elasticity of quantity (i.e., returns to scale, or s). If returns to scale are decreasing ($s > 1$), the effect will be to dampen the rise in quantity induced by an increase in the price markup. Under constant returns the indirect effect is zero, and for increasing returns the indirect effect will be to *reinforce* the direct effect of quality rewards.

Similar reasoning and application of Cramer's rule (Silberberg 1990) yields:

$$\text{Quality Effects: } z'(r) = \{\pi''(q) \times (-1)\pi''(z, r) - \pi''(z, q) \times (-1)\, \pi''(q, r)\ /\ \text{H}. \tag{A11}$$

Substituting and collecting terms yields the following expression:

$$\begin{aligned} z'(r) = \{[2p'(q) + p''(q) \times q(h) - s(s-1)q^{s-}2z^{c}i] \times \\ [\,q]/\text{H}\} + \ldots \{[r(z) + r'(z)z - c \times i \times sq^{s-}1z^{c-}1]z\ /\text{H}\}. \end{aligned} \tag{A11'}$$

The first term of this expression in {} before the + . . . is unambiguously positive for positive output (q) given the SSOC for $\pi''(q) < 0$. This first term is larger the *less* price-elastic is demand, that is, the greater is $p'(q)$ in absolute value, and the less rapidly price-elasticity rises with increased quantity, that is, the smaller is $p''(q)$. This first term will decline with increases in the cost elasticity of quality and quantity—c and s, respectively—and with higher levels of input cost shifters (i). This first term captures the *direct* marginal effect of increased reward on the marginal net income from increased quality—$\pi''(z, r)$—weighted by the rate of diminution in the marginal net income from increased quantity as quantity increases—$\pi''(q)$.

The second term, after {} + . . . , balances the marginal revenue from increased quality per unit of quantity, which equals $[r(z) + r'(z)z]$, against the marginal cost of quality multiplied by the cost elasticity of quantity, s. Both marginal revenue and marginal cost of quality are then multiplied by the level of quality (z). The second term reflects the *indirect* effect of increasing the level of the reward function, $r(z)$, which then increases the marginal net income from quantity increases—as reflected in $\pi''(q, r) = z$.

In turn, the induced increase in quantity exerts a cross-effect on quality through the cross-partial, $\pi''(z, q)$. Thus, as shown earlier, the direction of the indirect effect will depend solely on the cost elasticity of the quantity (s) factor.

Higher cost elasticity of quality (larger c), higher cost elasticity of quantity (larger s), and higher levels of exogenous input cost shifters (i) are negatively related to $z'(r)$. The negative relation between $z'(r)$ and cost shifters, i, reflects the cost shifters' effect of reducing quantity, which thereby results in higher marginal costs of quality *per unit* of quantity.

By similar reasoning, we can derive the total effect on equilibrium quality of an exogenous increase in the price level (p). Since price level does not enter the first-order condition for quality (equation A5), the total derivative of quality with respect to price level simplifies to

$$z'(p) = r(z) + r'(z)z - cisq^{s-1}z^{c-1}/\mathrm{H}. \tag{A12}$$

The numerator of the right-hand side of this equation, $\pi''(q, z)$, reflects the *indirect* effect of increased price level on quality—through its effect on quantity. Except for the factor s after the minus sign, the numerator is identical to the right-hand side of the first-order condition (A5). Thus, in this model, the (indirect) effect of increased price level on quality will be positive, zero, or negative depending on whether the cost elasticity of quantity (s) is less than 1 (increasing returns to scale), equal to 1 (constant returns to scale), or greater than 1 (decreasing returns to scale).

NOTES

1. A formal version of this model is specified and solved in the appendix for the interested reader.
2. The market price markup for quality, represented in the appendix by $r(z)$, remains positive at higher levels of quality (Z in the formal model), but $r'(z)$—the change in the marginal "reward" for quality for a given change in quality—is posited to be negative. This reflects an assumption of diminishing marginal "willingness to pay" as quality increases (a variant on the "satiation" axiom in microeconomic theory).

REFERENCES

Adams, J. S. 1963. Towards an understanding of inequity. *Journal of Abnormal and Social Psychology* 67:422-36.

Armour, B. S., M. M. Pitts, R. Maclean, C. Cangialose, M. Kishel, H. Imai, and J. Etchason. 2001. The effect of explicit financial incentives on physician behavior. *Archives of Internal Medicine* 161 (May 28): 1261-66.

Bailit Health Purchasing, LLC. 2002. Provider incentive models for improving quality of care. Prepared for the National Health Care Purchasing Institute: An Initiative of the Robert Wood Johnson Foundation.

Bailit Health Purchasing, LLC, and Sixth Man Consulting, Inc. 2001. The growing case for using physician incentives to improve health care quality. Prepared for the National Health Care Purchasing Institute: An Initiative of the Robert Wood Johnson Foundation.

Berwick, D. M. 1996. A primer on leading the improvement of systems. *British Medical Journal* 312:619-22.

Christianson, J. B., and R. Feldman. 2002. Evolution in the Buyers Health Care Action Group Purchasing Initiative. *Health Affairs* 21 (1): 76-88.

Christianson, J. B., S. Parente, and R. Taylor. 2002. Defined-contribution health insurance products: Development and prospects. *Health Affairs* 21 (1): 49-64.

Condry, J., and J. Chambers. 1978. Intrinsic motivation and the process of learning. In *The hidden cost of rewards: New perspectives on the psychology of human motivation*, edited by M. R. Lepper and D. Greene, 61-83. Hillsdale, NJ: Lawrence Erlbaum.

Congleton, R. D. 1991. The economic role of a work ethic. *Journal of Economic Behavior and Organization* 15:365-85.

Conrad, D. A., C. Maynard, A. Cheadle, S. Ramsey, M. Marcus-Smith, H. Kirz, C. A. Madden, et al. 1998. Primary care compensation methods in medical groups: Does it influence the use and cost of health services for enrollees in managed care organizations? *Journal of the American Medical Association* 279 (11): 853-58.

Conrad, D. A., A. Sales, S. Y. Liang, A. Chaudhuri, C. Maynard, L. Pieper, L. Weinstein, D. Gans, and N. Piland. 2002. Impact of financial incentives on physician productivity in medical groups. *Health Services Research* 37 (4): 885-906.

Dranove, D., and M. A. Satterthwaite. 1992. Monopolistic competition when price and quality are imperfectly observable. *Rand Journal of Economics* 23 (4): 518-34.

Dudley, R. A., R. H. Miller, T. Y. Korenbrot, and H. S. Luft. 1998. The impact of financial incentives on quality of health care. *Milbank Quarterly* 76 (4): 649-86.

Fairbrother, G., M. J. Siegel, S. Friedman, P. D. Kory, and G. C. Butts. 2001. The impact of financial incentives on documented immunization rates in the inner city: Results of a randomized controlled trial. *Ambulatory Pediatrics* 1 (4): 206-12.

Fernandopulle, R., T. Ferris, A. Epstein, B. McNeil, J. Newhouse, G. Pisano, and D. Blumenthal. 2003. A research agenda for bridging the "quality chasm." *Health Affairs* 22 (2): 178-90.

Flood, A. B., A. M. Fremont, K. Jin, D. M. Bott, J. Ding, and R. C. Parker Jr. 1998. How do HMOs achieve savings? The effectiveness of one organization's strategies. *Health Services Research* 33 (1): 79-99.

Frey, B. S. 1997. On the relationship between intrinsic and extrinsic work motivation. *International Journal of Industrial Organization* 15:427-39.

Gaynor, M., and M. V. Pauly. 1990. Compensation and productive efficiency in partnerships: Evidence from medical group practice. *Journal of Political Economy* 98 (3): 544-73.

Goodson, J. D., A. S. Bierman, O. Fein, K. Rask, E. C. Rich, and H. P. Selker. 2001. The future of capitation: The physician role in managing change in practice. *Journal of General Internal Medicine* 16 (April): 250-56.

Gosden, T., F. Forland, I. S. Kristiansen, M. Sutton, B. Leese, A. Giuffrida, M. Sergison, and L. Pedersen. 2001. Impact of payment method on behavior of primary care physicians: A systematic review. *Journal of Health Services Research and Policy* 6 (1): 44-55.

Hellinger, F. J. 1998. The effect of managed care on quality: A review of recent evidence. *Archives of Internal Medicine* 158 (April 27): 833-41.

Hillman, A. L., M. V. Pauly, and J. Kerstein. 1989. How do financial incentives affect physicians' clinical decisions and financial performance of HMOs? *New England Journal of Medicine* 321 (July 13): 86-92.

Hillman, A. L., K. Ripley, N. Goldfarb, I. Nuamah, J. Weiner, and E. Lusk. 1998. Physician financial incentives and feedback: Failure to increase cancer screening in Medicaid managed care. *American Journal of Public Health* 88 (11): 1699-701.

Institute of Medicine. 2001. *Crossing the quality chasm: A new health system for the 21st century.* Washington, DC: National Academy Press.

Jensen, M., and W. Meckling. 1976. Theory of the firm: Management behavior, agency costs, and capital structure. *Journal of Financial Economics* 3:305-60.

Kouides, R. W., N. M. Bennett, B. Lewis, J. D. Cappuccio, W. H. Barker, and F. M. LaForce. 1998. Performance-based physician reimbursement and influenza immunization rates in the elderly: The primary-care physicians of Monroe County. *American Journal of Preventive Medicine* 14 (2): 89-95.

Kralewski, J. E., E. C. Rich, R. Feldman, B. E. Dowd, T. Bernhardt, C. Johnson, and W. Gold. 2000. The effects of medical group practice and physician payment methods on costs of care. *Health Services Research* 35 (3): 591-613.

Kuhn, Michael. 2003. *Quality in primary care: Economic approaches to analysing quality-related physician behavior.* London: Office of Health Economics.

Landon, B. E., J. Reschovsky, M. Reed, and D. Blumenthal. 2001. Personal, organizational, and market level influences on physicians' practice patterns. *Medical Care* 39 (8): 889-905.

McGuire, T. G. 2000. Chapter 9: Physician agency. In *Handbook of health economics*, vol. 1A, edited by A. J. Culyer and J. P. Newhouse, 461-536. New York: Elsevier.

Miller, R. H. and H. S. Luft. 1994. Managed care plan performance since 1980. *Journal of the American Medical Association* 271 (May 18): 1512-19.

———. 1997. Does managed care lead to better or worse quality of care? *Health Affairs* 16 (5): 7-25.

———. 2002. HMO plan performance update: An analysis of the literature, 1997-2001. *Health Affairs* 21 (4): 63-86.

Pauly, M. V., and M. Satterthwaite. 1981. The pricing of primary care physicians services: A test of the role of consumer information. *Bell Journal of Economics* 12 (2): 488-506.

Pedersen, C. A., E. C. Rich, J. Kralewski, R. Feldman, B. Dowd, and T. Bernhardt. 2000. Primary care physician incentives in medical group practices. *Archives of Family Medicine* 9 (5): 458-62.

Pope, G. C., and R. T. Burge. 1992. Inefficiencies in physician practices. *Advances in Health Economics and Health Services Research* 13:129-64.

Prendergast, C. R. 1999. The provision of incentives in firms. *Journal of Economic Literature* 37:7-63.

Reschovsky, J., M. Reed, D. Blumenthal, and B. Landon. 2001. Physicians' assessments of their ability to provide high-quality care in changing health care system. *Medical Care* 39 (3): 254-69.

Rice, T. 1997. Physician payment policies: Impact and implications. *Annual Review of Public Health* 18:549-65.

Robinson, J. C. 2001. Theory and practice in the design of physician payment incentives. *Milbank Quarterly* 79 (2): 149-77.

Rosenthal, M. B., R. G. Frank, J. L. Buchanan, and A. M. Epstein. 2002. Transmission of financial incentives to physicians by intermediary organizations in California. *Health Affairs* 21 (4): 197-205.

Safran, D. G., W. H. Rogers, A. R. Tarlov, T. Inui, D. A. Taira, J. E. Montgomery, J. E. Ware, and C. P. Slavin. 2000. Organizational and financial characteristics of health plans: Are they related to primary care performance? *Archives of Internal Medicine* 160 (January 10): 69-76.

Safran, D. G., A. R. Tarlov, and W. H. Rogers. 1994. Primary care performance in fee-for-service and prepaid health care systems: Results from the Medical Outcomes Study. *Journal of the American Medical Association* 271 (20): 1579-86.

St Peter, R. F., M. C. Reed, P. Kemper, and D. Blumenthal. 1999. Changes in the scope of care provided by primary care physicians. *New England Journal of Medicine* 341 (26): 1980-85.

Silberberg, E. 1990. *The structure of economics: A mathematical analysis*. 2nd ed. San Francisco: McGraw-Hill.

Sturm, R. 2002. Effect of managed care and financing on practice constraints and career satisfaction in primary care. *Journal of the American Board of Family Practice* 5 (5): 367-77.

Tufano, J., D. A. Conrad, A. Sales, C. Maynard, J. Noren, E. Kezirian, K. G. Schellhase, and S. Y. Liang. 2001. Effects of compensation method on physician behaviors. *American Journal of Managed Care* 7 (4): 363-73.

Ware, J. E., Jr., M. S. Bayliss, W. H. Roger, M. Kosinski, and A. R. Tarlov. 1996. Differences in 4-year health outcomes for elderly and poor chronically ill patients treated in HMO and fee-for-service: Results from the Medical Outcomes Study. *Journal of the American Medical Association* 276:1039-47.

Ware, J. E, Jr., R. H. Brook, W. H. Rogers, E. B. Keeler, A. R. Davies, C. D. Sherbourne, G. A. Goldberg, P. Camp, and J. P. Newhouse. 1986. Comparison of health outcomes at a health maintenance organization with those of fee-for-service care. *Lancet* 1:1017-22.

Zierler, B. K., M. S. Marcus-Smith, A. Cheadle, D. A. Conrad, H. L. Kirz, C. Madden, J. Noren, E. B. Perrin, S. D. Ramsey, and A. Ross. 1998. Effect of compensation method on the behavior of primary care physicians in managed care organizations: Evidence from interviews with physicians and medical leaders in Washington State. *American Journal of Managed Care* 4 (2): 209-20.