

STRATEGIC INTERACTION AMONG HOSPITALS AND NURSING FACILITIES: THE EFFICIENCY EFFECTS OF PAYMENT SYSTEMS AND VERTICAL INTEGRATION

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SUMMARY

Rising post-acute care expenditures for Medicare transfer patients and increasing vertical integration between hospitals and nursing facilities raise questions about the links between payment system structure, the incentive for vertical integration and the impact on efficiency. In the United States, policy-makers are responding to these concerns by initiating prospective payments to nursing facilities, and are exploring the bundling of payments to hospitals. This paper develops a static profit-maximization model of the strategic interaction between the transferring hospital and a receiving nursing facility. This model suggests that the post-1984 system of prospective payment for hospital care, coupled with nursing facility payments that reimburse for services performed, induces inefficient under-provision of hospital services and encourages vertical integration. It further indicates that the extension of prospective payment to nursing facilities will not eliminate the incentive to vertically integrate, and will not result in efficient production unless such integration takes place. Bundling prospective payments for hospitals and nursing facilities will neither remove the incentive for vertical integration nor induce production efficiency without such vertical integration. However, bundled payment will induce efficient production, with or without vertical integration, if nursing facilities are reimbursed for services performed. Copyright © 2001 John Wiley & Sons, Ltd.

KEY WORDS — firm efficiency; Medicare payments; nursing facilities; Stackelberg model; strategic interaction; vertical integration

INTRODUCTION

When hospitals and nursing facilities provide episodes of care for Medicare transfer patients in the United States, are these two types of services combined efficiently to minimize total episode cost? Medicare transfer patients enter hospitals for acute care and then transfer to nursing facilities for follow-up care until they are ready to return home. While market forces are expected to

induce individual providers to produce medical care with efficient resource utilization, it is not clear that competition will push vertically related providers to combine their services efficiently.

This concern about production inefficiency stems from the fact that vertical relationships in the health care industry are uniquely affected by the third party payment system. In contrast with vertically related producers in other industries, the downstream producer does not purchase the

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upstream firm's output at a market-driven price. Absent from this market transaction, the downstream nursing facility takes the upstream hospital's treatment decision as given. If, for example, the hospital provides an inefficiently low level of physical therapy, the nursing facility cannot offer payments to induce the hospital to provide more physical therapy. It is not clear, therefore, that the two providers will produce the episode of care with an efficient combination of these substitutable services. Nash *et al.* [1] articulate this concern that patients are not generally treated with a least-cost mix of health care services, and urge greater collaboration between vertically-related providers to develop a more efficient 'continuum of care'.

Two industry trends heighten concern about the incentives faced by vertically-related providers. First, post-acute care is playing an increasing role in the health care industry. The proportion of United States health care expenditures devoted to hospital services has decreased from 44.7% of 1985 health care expenditures to 40.7% in 1994 [2], while expenditures on post-acute care increased at an annual rate of 27% during the first half of the 1990s [3, p. 70]. Second, vertical integration has increased dramatically during the last decade, with three-quarters of hospitals now owning post-acute care facilities [3, p. 80].

Policy-makers in the United States have responded to this concern with two policy initiatives: first, the Balanced Budget Act of 1997 mandated development of a national prospective rate system for nursing facility care; second, the Health Care Financing Administration has initiated demonstration programmes to study the impact of a bundled payment system, in which one institution would assume responsibility for the continuum of care required by a patient. That institution would receive payment for an entire episode of care, with the option of subcontracting with other providers. Welch [3] argues that both policies are needed for cost containment, and to induce efficient resource utilization.

In this paper, we abstract from the complexities of health care provision to develop a simple model of static profit-maximization for hospitals and nursing facilities, in order to examine the impact of these pricing policies on the efficiency of the health care service mix, the efficiency of the number of patients treated, and the incentive for

and efficiency impact of vertical integration. This model suggests that the prospective payment system for hospitals created an inefficient incentive for the hospital to profit at the nursing facility's expense, thus making vertical integration a profitable, if socially inefficient, strategy. The model predicts that the extension of prospective payments to nursing facility care will not eliminate the incentive to vertically integrate, and will only marginally improve efficiency unless the vertical integration takes place. Further, the model predicts that combining bundled payment with prospective nursing facility payments will not achieve the goal of inducing efficient production without vertical integration. Instead, the model suggests that a better strategy would combine the bundling of payments with externally-determined payments for nursing facilities determined by their service intensity.

Overview of the model

Our model encompasses four elements: (i) Medicare transfer patients who receive initial care at a hospital and follow-up care at a nursing facility before returning home; (ii) a production process that improves patient health status using two health care inputs, hospital services and nursing facility services; (iii) a market with one hospital and several nursing facilities in which entry barriers constrain nursing facility capacity; and (iv) assumptions delineating sets of possible payment systems and institutional structures. The model does not rely on technological economies of scale or scope to generate potential gains to vertical integration; neither are firms assumed to have market power over the prices paid by insurers for health care services.

Each transfer patient enters the health care system for an episode of hospital and nursing facility care, and returns home when his health status meets medical criteria for discharge. Patients are assumed to be identical, and thus enter the hospital with identical health conditions and respond to treatment with predictable, measurable and identical health status improvements. An episode of hospital and nursing facility care is complete when the patient meets discharge criteria established by external parties. In the United States, for example, Interqual (a business unit of McKesson HBOC Incorporated) is a well-established source of discharge criteria that defines

clinical indicators of the patient's medical stability and physical ability to return home after nursing facility care. This assumption that patients must meet medical criteria before discharge from the nursing facility shapes our model. As quality of care, as measured by the patient's discharge health status, is assumed to be an exogenous parameter, our model is able to focus on the efficiency with which vertically related providers produce a given level of quality. Production efficiency is an essential element of long-term cost control, and Medicare's ongoing payment system innovations are specifically aimed at inducing this type of vertically coordinated efficiency.

While each patient in our model requires both hospital and nursing facility care, some substitution is possible between these two inputs. If the hospital spends additional time on patient education, wound care, pain management or therapy, for example, the patient will require less intense treatment at the nursing facility. Anecdotal evidence that such substitution is possible was articulated by the nursing facility complaint in the mid-1980s that hospitals discharged patients 'quicker and sicker' when Medicare began phasing in the prospective payment system for reimbursing hospital care. Hadley and Zuckerman [4] and Holahan *et al.* [5] provide econometric evidence that substitution occurs between hospital and nursing facility services. Lee *et al.* [6] summarize the recent literature, citing consistent evidence that post-acute care is substituting for acute care, and that post-acute care costs grew rapidly from 7% of Medicare Part A spending in 1986 to 22% in 1993. Thus, while final quality (as measured by discharge health status) is assumed in our model to be exogenous, the level of service provided by the hospital is endogenous. In order to discharge the patient, the nursing facility is required to make up the difference with imperfectly substitutable services.

The patients in this model live in a local market served by one hospital and several identical nursing facilities. The hospital admits patients and determines their treatment intensity. Nursing facilities subsequently provide sufficiently intense treatment to produce the level of patient health status required to complete the episode of care. The service intensity required for each patient influences the nursing facility's determination of the optimal number of patients. As we explain later, entry is assumed blocked, so the optimal

number of patients to be treated at existing nursing facilities is equal to the total number of patients that can be transferred from the hospital to nursing facilities in its market area. The hospital adjusts its capacity to avoid admitting patients that cannot be transferred to a nursing facility; as this is a one-period model, delayed transfer is not an option. The hospital recognizes the impact of its own treatment intensity decision on the number of patients that can be placed into nursing facilities, and considers this relationship when it determines its optimal strategy.

Health care providers are reimbursed with either fixed or variable payment systems. Under a fixed payment system, the hospital or nursing facility receives a fixed amount per patient, regardless of the treatment intensity they provide. Under a variable payment system, the revenue received for each patient is a function of the treatment intensity. Medicare switched from a variable to a fixed payment system for hospital reimbursement in 1984, but has continued to reimburse nursing facilities with a variable payment system.

In addition, three dimensions of institutional structure are considered: (i) hospital and nursing facility services may be produced by independent firms or by a single vertically integrated firm; (ii) each service provider may be reimbursed directly by Medicare, or the hospital may receive a bundled payment for the entire episode of care with the option to subcontract for nursing facility services; and (iii) the price paid for nursing facility services under a bundled payment system may be either set by Medicare or determined by market forces.

Organization of the paper

This paper includes six sections. The next section models the strategic interaction between upstream hospitals and downstream nursing facilities. The third section uses this model to examine the impact of payment system incentive structures on input mix efficiency, the impetus for vertical integration, and the number of patients treated at a given payment level. The fourth and fifth sections examine the policy options of bundled payment and prospective payment for nursing facility services. Conclusions are presented in the final section.

STRATEGIC INTERACTION BETWEEN HOSPITALS AND NURSING FACILITIES: THE GENERAL MODEL

The potential for substitution between hospital and nursing facility services, along with the requirement that each patient's health status meet discharge criteria, links upstream hospital and downstream nursing facility production decisions, and creates the framework for strategic interactions between the two providers. As the hospital provides its services before transferring the patient to the nursing facility, the hospital and nursing facility essentially interact as Stackelberg players, with the hospital choosing its treatment intensity and the nursing facility reacting by setting the number of patients to be treated. The resulting solution, as Varian [7, pp. 101–102] points out, is a stable Nash Equilibrium.

Revenue, cost and production functions in the general model

Each hospital and nursing facility generates revenue by providing X_i health care services to each patient, where $i = u$ for the upstream hospital and d for the downstream nursing facility. Each of the M nursing facilities treats N patients, and the hospital treats all NM patients. Each provider earns revenue equal to $P_i(X_i) = \alpha_i \cdot X_i + \beta_i$ per patient. This payment function may represent either a variable payment with $P_i(X_i) = \alpha_i \cdot X_i$, under which revenue is a function of the services provided, or a fixed payment system in which $P_i(X_i) = \beta_i$, and revenue is independent of its treatment intensity. As all patients are identical, variable revenue, $P_i(X_i) = \alpha_i \cdot X_i$, would equal total cost if the payer sets α_i equal to average cost.

As noted in the introduction, Medicare used a variable payment system to reimburse hospitals until 1983 ($P_u = \alpha_u \cdot X_u$), when it initiated the Diagnostic Related Group (DRG) fixed payment for hospitals ($P_u = \beta_u$). Under this reimbursement method, often called the prospective payment system, each hospital's per patient revenue is independent of the intensity of services actually delivered to patients. Medicare continued to provide, since 1983, variable payment for nursing facility days, with $P_d = \alpha_d \cdot X_d$. As all patients in the model presented here are identical, and all patients receive the same services, case-mix is not

an issue in determining the appropriate price levels. Medicare is currently developing a fixed payment system for nursing facility services, as mandated in the 1997 Balanced Budget Act. When fixed payment is implemented for nursing facility services, each facility will receive a flat rate for each patient day, regardless of the treatment intensity provided at that patient's specific facility; hence $P_d = \beta_d$. While Welch [3] raises the issue that nursing facilities may respond to the new payment system by increasing the number of patient days, we abstract from that issue by assuming that the number of patient days is fixed for this model's identical transfer patients.

We assume that each firm faces an upward-sloping marginal cost curve, and the firm's production cost is a convex function C_i of the total services provided ($X_i \cdot N_i$), with $C_i' > 0$ and $C_i'' \geq 0$. Thus, each provider is assumed to operate on its cost-minimizing production function, permitting us to focus on the efficiency with which the two services are combined. While health care is provided by both for-profit and non-profit organizations, we assume that all providers maximize profit, so $\pi_i = N_i \cdot P_i(X_i) - C_i(X_i \cdot N_i)$. This is clearly a simplifying assumption. Spector *et al.* [8] identify behavioral differences between for-profit and non-profit nursing facilities. They note, however, that their 1987 National Medical Expenditure Survey (NMES) data precedes implementation of federal regulations that constrain nursing facility behaviour, and probably reduce the scope for such behavioural differences.

Joint production of this health status by hospitals and nursing facilities is modelled with a standard neoclassical production function $f(X_u, X_d)$, which is assumed to be known to both firms and to be at least weakly concave, with first partial derivatives $f^i > 0$; $i = X_u, X_d$. Because the hospital and nursing facility must produce health status $f(X_u, X_d) = \Sigma$ before the patient can be discharged from the health care system, the hospital's choice of X_u constrains the nursing facility to provide sufficient X_d to produce Σ . Hence, X_d is an implicit function $X_d(X_u; \Sigma)$ rather than a choice variable, with $X_d' = -f^u/f^d < 0$. The elasticity of substitution is assumed to be positive and finite: while each institution provides some specialized inputs into the production of patient health, significant substitution is assumed to be possible between the services provided by the two types of institutions.

While the nursing facility does not control the treatment intensity it must provide for each patient, it can control its total output $X_d \cdot N$ by limiting the number of patients it is willing to accept. This optimal N is assumed to be feasible, in the sense that it is less than the number of licensed nursing facility beds. The hospital can only transfer $M \cdot N$ patients to nursing facilities, as the number of firms in the market is assumed to be fixed. New nursing facilities do not enter the market for two reasons. First, entry barriers, such as Certificate of Need (CON) requirements and construction moratoria, restrict nursing facility entry in many jurisdictions. A report by Lewin-VHI [9] hypothesizes that states may intentionally limit nursing facility capacity to reduce Medicaid expenditures. Limited nursing facility capacity restricts the number of Medicaid-eligible patients actually admitted to nursing facilities, and it also creates the potential for nursing facilities to earn economic profits treating private patients, thus permitting states to set Medicaid rates below average total cost without driving providers out of the market. While CON has been widely regarded as ineffective in constraining hospital investment [10, pp. 291–293], both Nyman [11] and Gertler [12] provide evidence that this regulation effectively limited nursing facility growth, and increased the price of services for privately paying patients. Second, the industry will not attract new entrants if the payment system succeeds in setting price equal to average total cost, so that facilities earn only normal profits.

The restricted entry modelled here is also consistent with widespread discussion of chronic excess demand for nursing facility services. Nyman [13] provided statistical evidence that nursing facility beds represent a binding industry constraint. Nyman [14] and Ettner [15] analyse the potential for private-pay patients to crowd-out Medicaid patients, which would only occur in a supply shortage market. Empirical evidence published by Holahan *et al.* [5] and Weissert and Cready [16] indicated that hospitals that own nursing facilities experienced fewer discharge delays, which is consistent with the entry restriction hypothesis if hospital-owned nursing facilities preferentially admit patients treated at the parent hospital. Consistent with these empirical studies, nursing facility occupancy averaged 87% in 1995, which substantially exceeded the average hospital occupancy rate of 66% [17, pp. 122, 129].

Nursing facility optimization in the general model

When a patient arrives at a nursing facility, the treatment intensity required to produce health status Σ is already determined by the hospital's intensity decision; the nursing facility has only to determine the number of patients it will accept. Thus, the nursing facility maximizes

$$\pi_d(N) = N \cdot P_d(X_d(X_u)) - C_d(X_d(X_u)) \cdot N, \quad (1)$$

by satisfying

$$\begin{aligned} \pi'_d &= P_d - C'_d \cdot X_d = 0; \\ \pi''_d &= -C''_d \cdot X_d^2 < 0. \end{aligned} \quad (2)$$

The first-order condition indicates that the marginal revenue of an additional patient is equal to the marginal cost, given the service that must be provided to each patient. When nursing facilities receive variable payments, with $P_d = \alpha_d \cdot X_d$, Equation (2) implies that price is equal to marginal cost ($\alpha_d = C'_d$), thus ensuring allocative efficiency to the extent that price reflects social valuation of nursing facility care. When nursing facilities receive fixed payments, with $P_d = \beta_d$, Equation (2) equates marginal and average cost, thus ensuring production efficiency within the nursing facility. This portion of our model is consistent with results presented by Custer *et al.* [18], who focused on the impact of variable (fee-for-service) and fixed (prospective-fee payment) systems on the interaction between physicians and hospitals. It is important to note here that, while Medicare may set rates such that α_d is equal to average cost per unit of service per patient, or such that β_d is equal to average cost per patient, these rates are based on the costs of a group of providers, and thus are viewed by the individual nursing facility as exogenously determined.

The profit-maximizing number of patients $N(X_u; \alpha_d, \beta_d, \Sigma)$ depends on the service intensity provided by the hospital, the nursing facility reimbursement rate, and the health status required for discharge. Fully differentiating the first-order condition gives the slope of the downstream firm's reaction function:

$$\frac{\partial N}{\partial X_u} \equiv N' = \frac{[P'_d - C'_d - C''_d \cdot X_d \cdot N] \cdot X'_d}{C''_d \cdot X_d^2} > 0. \quad (3)$$

Thus, additional X_u provided by the hospital induces the nursing facility to provide additional N . Differentiation of $N(X_u; \alpha_d, \beta_d, \Sigma)$ also yields these comparative statics results for the price parameters

$$\frac{\partial N}{\partial \alpha_d} = \frac{1}{C'_d \cdot X_d} > 0; \quad \frac{\partial N}{\partial \beta_d} = \frac{1}{C''_d \cdot X_d^2} > 0. \quad (4)$$

These results indicate that a nursing facility will respond to a price increase, whether variable or fixed, by admitting more patients. It may be helpful to compare this prediction with Cohen and Spector's [19] findings that nursing facilities respond to a price increase by employing more licensed practical nurses. They model nursing facility care of long-term patients, assuming that the intensity of care is a choice variable and the number of patients is fixed; employing extra nurses in response to a higher price thus increases the quality of services provided. In contrast, our model focuses on transfer patients for whom discharge is a likely outcome, and we treat the ultimate quality of joint care as exogenously determined by the discharge criteria; nursing facilities thus respond to a price increase by admitting more patients. In both models, nursing facilities respond to higher prices by providing more services to each patient in their model and to more patients in ours. We will argue that the hospital may respond by reducing their services, thus forcing the nursing facility to also treat each patient more intensely.

Hospital optimization in the general model

The payer sets the fixed hospital payment, β_u , at a level intended to cover the average cost of the hospital portion of the episode of care. The hospital, therefore, only initiates treatment on patients who can be placed in one of the M nursing facilities. Hence, the hospital maximizes

$$\pi_u(X_u) = M \cdot N(X_u) \cdot P_u - C_u = M \cdot N(X_u) \cdot P_u(X_u) - C_u(M \cdot N(X_u) \cdot X_u), \quad (5)$$

with respect to the intensity of hospital services, X_u . Differentiation yields

$$\begin{aligned} \pi'_u &= [P'_u - C'_u] \cdot N \cdot M + [P_u - C'_u \cdot X_u] \cdot M \cdot N' = 0; \\ \pi''_u &= [P_u - C'_u \cdot X_u] \cdot M \cdot N'' + 2 \cdot [P'_u - C'_u] \cdot M \cdot N' \\ &\quad + P''_u \cdot M \cdot N - C''_u \cdot M^2 [N + X_u \cdot N']^2. \end{aligned} \quad (6)$$

The first-order condition reflects the upward-sloping supply of nursing facility services: the first term represents the cost impact of providing additional X_u per patient, while the second term represents the profit earned by treating the additional patients made possible by increasing X_u .

Production efficiency in the general model

Patient care is produced efficiently when two conditions are met. First, the mix of hospital and nursing facility services must minimize the cost of producing health status Σ for each patient, such that

$$\frac{C'_u}{C'_d} = \frac{f^u}{f^d} \equiv -X'_d. \quad (7)$$

Second, the number of patients treated must equate the total price per patient ($P_t = P_u + P_d$) with the marginal cost of treating the last patient ($C'_u \cdot X_u + C'_d \cdot X_d$). While the insurer's total price may not precisely capture society's willingness to pay for Medicare transfer patient care, this condition maximizes the surplus generated by society's decision to pay P_t per patient. Optimally, a more complete measure of production efficiency would also consider whether the marginal cost of producing health status Σ for each of the $M \cdot N$ patients reflected its marginal social value, but in the absence of freely functioning markets such a social value can only be imperfectly approximated by the insurer's price.

Vertical integration in the general model

Vertical integration is complete when the hospital buys all M nursing facilities, so that all of the hospital's $M \cdot N$ patients receive both upstream and downstream service within the vertically integrated firm. Since M is assumed to be fixed, this vertically integrated firm maximizes

$$\begin{aligned} \pi_{VT}(X_u, N) &= [M \cdot N \cdot P_u(X_u) - C_u(X_u \cdot M \cdot N)] \\ &\quad + M \cdot [N \cdot P_d(X_d(X_u))] \\ &\quad - C_d(X_d(X_u) \cdot N), \end{aligned} \quad (8)$$

by satisfying the first-order conditions

$$\begin{aligned} \partial \pi_{VT} / \partial X_u &= M \cdot N \cdot [[P'_u + P'_d \cdot X'_d] \\ &\quad - [C'_u + C'_d \cdot X'_d]] = 0; \\ \partial \pi_{VT} / \partial N &= M \cdot [[P_u + P_d] - [C'_u \cdot X_u + C'_d \cdot X_d]] = 0. \end{aligned} \quad (9)$$

The first equation equates the net marginal revenues of upstream hospital services and downstream nursing facility services; the second equates the marginal revenue and marginal cost of treating an additional patient.

FIXED PAYMENTS FOR HOSPITALS AND VARIABLE PAYMENTS FOR NURSING FACILITIES: EFFICIENCY AND VERTICAL INTEGRATION

The model developed in the last section is used here to analyse the impact of payment system incentives and institutional structures on production efficiency, incentives for vertical integration, and the potential gap between price and marginal cost. This analysis begins by modelling a system in which Medicare utilizes a fixed payment system for hospital services and a variable payment system for nursing facility services. The results, which are summarized in Table 1, indicate that

independent providers do not produce episodes of care efficiently under this payment system. This inefficiency creates a profit incentive for vertical integration, which did not exist under the pre-1984 system of cost-based reimbursement for all providers; such vertical integration is profitable because it reduces, but does not eliminate, the inefficiency of strategic interaction.

The results presented in Table 1 indicate that the intensity of care provided by individual hospital and nursing facilities is affected by payment system design. This is consistent with theoretical and empirical work on hospital responses to payment system changes. For example, Rogerson [20] models the impact of payment system incentives

Table 1. Payment system, institutional structure and efficiency

Hospital payment is fixed	Nursing facility payment	
	Variable	Fixed
Independent payments		
Independent providers	$-X'_d = \frac{C'_u}{C'_d} \cdot \frac{C'_d \cdot X_d}{[P_u - C'_u \cdot X_u]}$ $P_u > C'_u \cdot X_u$ $P_d = C'_d \cdot X_d$	$-X'_d = \frac{C'_u}{C'_d} \cdot \frac{C'_d \cdot X_d [1 - \delta]}{[P_u - C'_u \cdot X_u]}$ $P_u > C'_u \cdot X_u$ $P_d = C'_d \cdot X_d$
Vertical integration	$-X'_d = \frac{C'_u}{C'_d} \cdot \frac{C'_d \cdot X_d}{[P_u - C'_u \cdot X_u]}$ $P_u > C'_u \cdot X_u$ $P_d < C'_d \cdot X_d$	$-X'_d = \frac{C'_u}{C'_d}$ $P_u = C'_u \cdot X_u$ $P_d = C'_d \cdot X_d$
Bundled payment		
Independent providers (Medicare sets price for nursing facility services)	$-X'_d = \frac{C'_u}{C'_d}$ $P_t - P_d = C'_u \cdot X_u$ $P_d = C'_d \cdot X_d$	$-X'_d = \frac{C'_u}{C'_d} \cdot \frac{C'_d \cdot X_d^2 \cdot [1 - \delta]/N}{[P_t - P_d - C'_u \cdot X_u]}$ $P_t - P_d > C'_u \cdot X_u$ $P_d = C'_d \cdot X_d$
Independent providers (market-based price for nursing facility service)	$-X'_d = \frac{C'_u}{C'_d} \cdot \delta$ $P_t - P_d > C'_u \cdot X_u$ $P_d = C'_d \cdot X_d$	$-X'_d = \frac{C'_u}{C'_d} \cdot \delta$ $P_t - P_d > C'_u \cdot X_u$ $P_d = C'_d \cdot X_d$
Vertical integration	$-X'_d = \frac{C'_u}{C'_d}$ $P_t = C'_d \cdot X_d + C'_u \cdot X_u$	$-X'_d = \frac{C'_u}{C'_d}$ $P_t = C'_d \cdot X_d + C'_u \cdot X_u$

on the hospital's optimal patient care intensity, and Dranove and White [21] provide an overview of empirical literature indicating that hospitals do respond to incentives built into third party payment systems.

Fixed hospital and variable nursing facility payments to independent firms: efficiency

Substituting $P_d = \alpha_d \cdot X_d$ into Equation (2) yields the following first-order condition for the nursing facilities:

$$\pi'_d = [\alpha_d - C'_d] \cdot X_d = 0, \quad (10)$$

which implies that the marginal revenue earned by caring for an additional patient is equal to the marginal cost of providing that care. Equation (10) also implies that $\alpha_d = C'_d$; hence, the marginal revenue of an additional unit of patient-service is equal to its marginal cost. If the payer computes α_d such that $\alpha_d \cdot X_d$ is equal to the average cost of treating a patient, then Equation (10) implies that average cost would be equal to marginal cost, and nursing facility care is delivered efficiently.

To assess whether nursing facility care is combined with hospital care efficiently, we examine the hospital's optimization decision. The hospital receives a fixed price per patient $P_u(X_u) = \beta_u$. Substituting this price into Equation (6) yields the first-order condition

$$\beta_u = C'_u \cdot X_u + \frac{C'_u \cdot N}{N'}, \quad (11)$$

which equates the marginal revenue earned by treating each patient with the sum of two components of the hospital's marginal cost: the marginal cost to treat the last patient and the marginal cost incurred to induce the nursing facilities to accept this patient.

This condition highlights the hospital's role, in this model, as a monopsonistic purchaser of nursing facility services, thereby raising the question of whether each hospital in a multi-hospital market would face an upward-sloping supply of nursing facility services. Hospitals in oligopolistically or monopolistically competitive markets would face upward-sloping supply curves for nursing facility services if repeated contacts between hospitals and nursing facilities in the same geographic area enable nursing facilities to identify hospitals that provide high-intensity care and preferentially admit patients from those hospitals, perhaps be-

cause intense hospital care facilitates accurate assessment and comprehensive billing for new nursing facility patients.

The vertical relationship between the hospital and the nursing facility is unusual, as the upstream and downstream providers do not conclude a market transaction when the patient is transferred. The nursing facility cannot influence the hospital's treatment intensity by offering to pay more for healthier patients. If the hospital reduces nursing facility costs by providing additional hospital services, it cannot ask the nursing facility for reimbursement.

Absent a market transaction between the hospital and nursing facilities, will this payment system induce an efficient combination of hospital and nursing facility services? Substitution from Equation (3) into (11) yields

$$\frac{f^u}{f^d} \equiv -X'_d = \frac{C'_u}{C'_d} \cdot \frac{C'_d \cdot X_d}{[\beta_u - C'_u \cdot X_u]}, \quad (12)$$

which implies that input mix efficiency depends on the relationship between β_u and the marginal cost of producing an episode of care, $C'_d \cdot X_d + C'_u \cdot X_u$. If the hospital's net marginal revenue, $\beta_u - C'_u \cdot X_u$, is less than the marginal patient cost of nursing facility care, $C'_d \cdot X_d$, the intensity of care provided by the hospital will be inefficiently low.

The hospital and nursing facility isoprofit contours shown in Figure 1 clarify the strategic interaction between the two firms. The slope of the upstream hospital's isoprofit contours

$$\frac{\partial X_u}{\partial N} = \frac{\beta_u - C'_u \cdot X_u}{C'_u \cdot N}, \quad (13)$$

is positive for small values of N , negative for large values, and equal to zero when the marginal revenue of hospital services equals the marginal cost; thus, the upstream hospital isoprofit contours are hill-shaped. As $\partial \pi_u / \partial X_u$ is negative (holding N constant), the hospital maximizes profit by operating as close to the horizontal axis as possible, and its isoprofits can be ranked in preference ($U_1 > U_2 > U_3 > U_4$). If X_u were determined exogenously instead of endogenously, the hospital would maximize profits by operating on an isoprofit peak; in such a case, the locus of these maxima would be the upstream hospital's reaction function.

Each nursing facility's reaction function, as given in Equation (3), implies that the optimal N

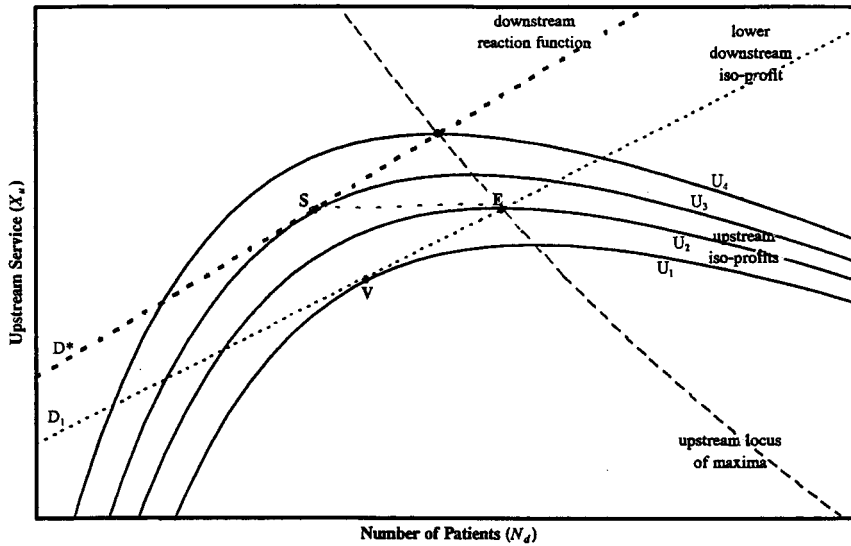


Figure 1. Equilibrium with fixed payments for hospitals and variable payments for nursing facilities

is a positive function of X_u , resulting in the upward-sloping downstream reaction function D^* shown in Figure 1. Since the nursing facility's profit is constant along this reaction function, it is also the nursing facility's isoprofit contour for the maximum possible nursing facility profit; other downstream isoprofits would be similarly upward-sloping, though less profitable (i.e. $D^* > D_1$).

The patient-admission constraint imposed by the nursing facility implies that the equilibrium will lie on the downstream reaction function. As the first mover, the hospital chooses the point along the downstream reaction function at which hospital profits are maximized. As shown in Figure 1, this occurs at point S , at which the downstream reaction function is tangent to an upstream isoprofit contour. Equating these slopes yields the condition given in Equation (12). Point S , at which this condition holds, maximizes hospital profits, but does not generally minimize the cost of providing an episode of care.

The payer determines the location of this tangency along the nursing facility reaction function since a decision to change β_u will shift the hospital isoprofit contours. Total differentiation of the first-order condition in Equation (6) yields $\partial X_u / \partial \beta_u > 0$; hence, lower prices for hospital services imply substitution of nursing facility services for hospital services and a reduction in the number of patients treated. In the unlikely case that $\beta_u = C'_d \cdot X_d + C'_u \cdot X_u$, implying that the total payment

for an episode of care is equal to the marginal cost of the hospital care plus twice the marginal cost of the nursing facility care (since $P_t = P_u + P_d$), hospital and nursing facility services will be combined efficiently. In the more realistic case in which the payer reduces β_u below that level, the episode of care will not be produced at minimum cost. Instead, the hospital will under-provide its services. Similarly, the level of α_d set by the payer determines the position of the downstream nursing facility reaction function. A lower level of α_d would shift the reaction function to the left, inducing a new equilibrium with more X_u and fewer patients.

At the equilibrium point, the hospital will perceive a nursing facility bed shortage, which is the horizontal distance from the Stackelberg equilibrium at point S to point E . The hospital would prefer to treat more patients, given the level of X_u it provides them, if it could place these patients in nursing facilities. It does not initiate treatment on additional patients, however, because it would not be able to transfer them. The distance from S to E is the gap between the number of patients the hospital implicitly chooses to treat and the number it would prefer to treat if it were not constrained by the nursing facility's reaction function. Owing to the missing market between hospitals and nursing facilities, the perceived shortage does not lead to above-normal nursing facility profits, and, therefore, does not initiate market adjustment processes.

Robinson [22], in a paper focused on the nursing facility bed shortage, suggests permitting some market transactions between hospitals and nursing facilities to reduce the incentive for vertical integration. Specifically, he recommends permitting hospitals to pay nursing facilities to both maintain excess capacity and provide patient care. The analysis presented here suggests that nursing facilities might also pay hospitals to increase care intensity. Whether this is a viable approach for achieving production efficiency depends on the providers' ability to overcome transactions cost problems. While efforts by independent firms to induce production efficiency through careful contracting face enforcement problems in any industry [23], these problems are likely to be particularly difficult in the health care industry. The patient, whose health status is the industry's output, is also an input into the production process. The production function posed in this model could be written in more detail as $f(X_u, X_d; Z)$, where Z is a vector of patient characteristics, and the impact of these characteristics on the marginal products of health services is not understood with precision. Suppose a patient transferred from a hospital to a nursing facility is unable to perform tasks at the level expected after provision of the contracted level of hospital services. Did the patient's unexpectedly low health status result from failure of the hospital to actually provide services of intensity X_u , or did patient characteristics complicate the healing process?

Fixed hospital and variable nursing facility payments to independent firms: vertical integration

Is vertical integration profitable under these payment systems, and would a vertically integrated firm produce the episode of care efficiently? Under fixed reimbursement for hospitals and variable reimbursement for nursing facilities, the first-order conditions outlined in Equation (9) for a vertically integrated firm become

$$\begin{aligned} \partial \pi_{VI} / \partial X_u &= M \cdot N \cdot [(\alpha_d - C'_d) \cdot X'_d - C'_u] = 0, \\ \partial \pi_{VI} / \partial N &= M \cdot [(\beta_u - C'_u \cdot X_u) + (\alpha_d - C'_d) \cdot X_d] = 0. \end{aligned} \quad (14)$$

Since $X'_d < 0$ and $C'_u > 0$, these conditions require $\alpha_d < C'_d$ and $\beta_u > C'_u X_u$. Rearranging terms yields the following conditions for integrated firm profit maximization:

$$\begin{aligned} -X'_d &= \frac{C'_u}{C'_d} \cdot \frac{C'_d \cdot X_d}{\beta_u - C'_u \cdot X_u}; \\ \alpha_d - C'_d &= \frac{C'_u}{X'_d} < 0. \end{aligned} \quad (15)$$

From Equations (10) and (15), the integrated firm produces more nursing facility services than the independent firms, driving the marginal cost of nursing facility patients above marginal revenue, and cross-subsidizing these services with profits earned by providing hospital services to these patients. The vertical integration optimum (point V) in Figure 1 will lie southeast of the Stackelberg equilibrium (point S).

This result is consistent with evidence presented by Ahern *et al.* [24] that hospital-owned Health Maintenance Organizations (HMOs) use more hospital resources than HMOs owned by non-hospital entities, suggesting that actual or 'virtual' vertical integration may affect the input mix. It is also consistent with anecdotal observations that hospitals which own nursing facilities substitute nursing facility services for hospital services as much as possible [25].

This result is also consistent with empirical evidence that suggests that Medicare's shift to fixed payment for hospital services created incentives for vertical integration. Robinson [22, p. 371] provides empirical evidence that Medicare's shift away from variable reimbursement for hospital care induced hospitals to integrate vertically into the nursing facility business, and concludes: 'Hospitals with larger fractions of their patients covered by Medicare were significantly more likely to integrate vertically into nursing home services than were hospitals with proportionately fewer Medicare patients, and the effect grew over time as the administered pricing system was fully phased in'. Indeed, vertical integration in the health care industry increased after 1984, with the number of nursing facilities affiliated with acute care hospitals doubling [26], while the total number of nursing facilities increased by only 20% [27].

Thus, while this model abstracts from the complexity and uncertainty endemic to health care, it nonetheless produces comparative static results consistent with published empirical work and it clarifies policy dilemmas posed by the vertical relationship between hospitals and nursing facilities. While increased vertical integration among health care providers raises issues of concern to some analysts and policy-makers, this model

suggests that complete vertical integration would also give Medicare the flexibility to resolve the conflict between the two fiscal goals of cost-based prices and efficient production. In this model, the third-party payer can attain input mix efficiency, with price equal to marginal cost, by setting $\alpha_d = 0$ and $\beta_u = C'_d \cdot X_d + C'_u \cdot X_u$, which represents a single fixed payment to a vertically integrated provider.

Variable payments to both hospitals and nursing facilities: efficiency and vertical integration

To assess whether the profit incentive for vertical integration is an artifact of Medicare's 1984 shift to fixed payment for hospitals, consider the first order conditions for a payment system in which both hospitals and nursing facilities receive variable reimbursement. Substituting $P_i = \alpha_i \cdot X_i$ into Equations (2), (3) and (6) yields the following first-order conditions for independent hospitals and nursing facilities:

$$\begin{aligned}\pi'_d &= [\alpha_d - C'_d] \cdot X_d = 0; \\ \pi'_u &= M \cdot [\alpha_u - C'_u] \cdot [N + X_u \cdot N'] = 0.\end{aligned}\quad (16)$$

These conditions imply that $\alpha_i = C'_i$ for $i = u$ and d (as N , X_u and N' are all positive); hence, the marginal revenue of an additional unit of patient-service at each level is equal to its marginal cost. The total price $\alpha_u \cdot X_u + \alpha_d \cdot X_d$ is equal to the marginal cost of providing an episode of care, so the number of patients treated is efficient, given the payment level. As the providers will set the marginal cost ratio equal to the price ratio α_u/α_d , patient health is produced at minimum cost if the price ratio is also equal to the marginal product ratio $f^u/f^d = -X'_d$.

This conclusion, that fixed payments for both hospitals and nursing facilities would induce efficient combination of hospital and nursing facility services, does not account for the concern that led to implementation of the DRG-based fixed payment system for hospitals. That concern focused on the possibility that hospitals might maximize profits by producing 'too much quality', in the sense that the marginal cost of hospital care exceeded the marginal value of that care. This issue is not addressed here, because we assume that the discharge health status is a binding constraint. Variable reimbursement for both hospitals and

nursing facilities, a case we don't consider in this paper, might easily render the constraint non-binding, and Medicare might find itself with a much greater outlay per patient.

Is vertical integration profitable in this case? With $P_i = \alpha_i \cdot X_i$, the vertically integrated firm's first-order condition given in Equation (9) implies

$$\begin{aligned}\partial \pi_{VI} / \partial X_u &= M \cdot N \cdot [[\alpha_u - C'_u] + [\alpha_d - C'_d] \cdot X'_d] = 0; \\ \partial \pi_{VI} / \partial N &= M \cdot [[\alpha_u - C'_u] \cdot X_u + [\alpha_d - C'_d] \cdot X_d] = 0.\end{aligned}\quad (17)$$

This firm will equate the price per unit of service with the relevant marginal cost for each service; otherwise the two equations would imply that $0 < X_d/X_u = X'_d < 0$, which would be a contradiction. Since Equations (16) and (17) yield equivalent conditions, hospitals and nursing facilities reimbursed with variable fees have no profit incentive to integrate, and vertical integration does not affect production efficiency. Thus, introduction of fixed payment for hospital services created an incentive for vertical integration, and it created a gap between per-patient marginal revenue and marginal cost.

BUNDLED PAYMENT

One policy option for addressing the problem of production inefficiency inherent in the current system is a bundled payment system, in which the hospital receives fixed reimbursement for the patient's entire episode of care, and is free to subcontract with nursing facilities to provide a portion of that care. Buzcko [25] and Lee *et al.* [6] argue that the potential for substitution between hospital and nursing facility services suggests a need for a bundled payment system to induce efficient resource utilization. The model developed here is used to examine whether a bundled payment will accomplish this goal.

Two alternate mechanisms for determining the variable nursing facility price α_d are modelled here: this price may be set by the third party payer or it may be set by a market transaction between the monopsonistic hospital and the competitive nursing facilities. As the nursing facility is a price taker in either scenario, its first order condition is still given in Equation (10).

Bundled payment with externally-determined reimbursement rates

When the nursing facility price, α_d , is set by the third-party payer, the hospital's profit function and first-order condition are given by

$$\begin{aligned} \pi_u &= M \cdot N \cdot [\beta_t - \alpha_d \cdot X_d] - C_u(X_u \cdot M \cdot N); \\ \frac{\partial \pi_u}{\partial X_u} &= M \cdot [[\beta_t - \alpha_d \cdot X_d - C'_u \cdot X_u] \cdot N' \\ &\quad - N \cdot [\alpha_d \cdot X'_d + C'_u]] = 0. \end{aligned} \quad (18)$$

The first-order condition delineates the three impacts of increased X_u per patient on the hospital: the hospital saves $N \cdot \alpha_d \cdot X_d$ because fewer services must be purchased from nursing facilities, the additional X_u must be produced at cost $C'_u \cdot N$, and profit can be earned by treating the additional patients that can be placed in nursing facilities. Substituting for N' from Equation (3) yields

$$-X'_d = \frac{C'_u}{C'_d} \cdot \frac{C'_d \cdot X_d}{\beta_t - C'_u \cdot X_u}. \quad (19)$$

Thus, care is produced efficiently when the second term, $(C'_d \cdot X_d) / (\beta_t - C'_u \cdot X_u)$ is equal to one, which requires that the bundled payment, β_t , is equal to the marginal cost of producing an episode of care. Hence, the goals of input mix efficiency and price equal to marginal cost can be achieved via bundled payment to non-integrated providers, with the downstream price set by the third party payer. The level of $\alpha_d > 0$ set by the payer does not affect production efficiency, because it does not affect the hospital's choice of X_u . Rather, α_d determines the number of patients that will be treated because it affects the nursing facility's subsequent decision to admit patients.

Bundled payment with market-determined reimbursement rates

As the hospital exerts market power in this case, it maximizes

$$\begin{aligned} \pi_u(X_u, \alpha_d) &= M \cdot N(X_u, \alpha_d) \cdot [\beta_t - \alpha_d \cdot X_d(X_u)] \\ &\quad - C_u(M \cdot N(X_u, \alpha_d) \cdot X_u), \end{aligned} \quad (20)$$

with respect to both X_u and α_d , where β_t is the total fixed amount paid to the hospital. The hospital's first-order conditions are

$$\begin{aligned} \frac{\partial \pi_u}{\partial X_u} &= M \cdot [\beta_t - \alpha_d \cdot X_d - C'_u \cdot X_u] \cdot N' \\ &\quad - M \cdot [\alpha_d \cdot X'_d + C'_u] \cdot N = 0; \end{aligned}$$

$$\frac{\partial \pi_u}{\partial \alpha_d} = M \cdot [\beta_t - \alpha_d \cdot X_d - C'_u \cdot X_u] \cdot \frac{\partial N}{\partial \alpha_d} - M \cdot X_d \cdot N = 0, \quad (21)$$

where the first equation is the same as when the payer sets the price. Combining Equations (3), (4) and (21) yields

$$-X'_d = \frac{C'_u}{C'_d} \cdot \frac{C'_d}{[C'_d + C''_d \cdot N \cdot X_d]} = \frac{C'_u}{C'_d} \cdot \delta, \quad (22)$$

where $0 < \delta = C'_d / (C'_d + C''_d \cdot X_d) < 1$. The denominator of δ is equal to the marginal cost incurred by any monopolistic purchaser facing an upward-sloping supply curve; hence the gap between δ and 1 stems from the upward-slope of the nursing facility reaction function.

Thus, if the hospital faces an upward-sloping nursing facility supply function, hospital services will be overused. This strategy induces the nursing facility to accept more patients and also reduces hospital payments to the nursing facility. As a result, bundled payment with a market-based price for the downstream service generates a new type of inefficiency: in contrast with the earlier concern that the hospital will provide too few services, the hospital in this version of the model has an incentive to provide too many.

Bundled payment to a vertically integrated firm

The solution for the vertically integrated firm in this case is identical to Equation (14), with $\alpha_d = 0$ and $\beta_u = C'_d \cdot X_d + C'_u \cdot X_u$, so the vertically integrated firm will treat the efficient number of patients with an efficient mix of hospital and nursing facility services. The providers have no profit incentive to vertically integrate when the nursing facility rate is set by the third-party payer, but vertical integration is profitable if the nursing facility reimbursement rate is market-driven.

The conclusion reached here ignores two concerns about bundled payments. Lee *et al.* [6] note that bundled payment gives the hospital an incentive to readmit patients with long nursing facility stays, thus starting a new episode of care. Such readmissions might offset the gains from more efficient production of each individual care episode. Second, Welch [3] argues that bundled payments may lead to increased integration because, in conditions of excess nursing facility capacity, freestanding nursing facilities might have difficulty competing for patients.

FIXED PAYMENT FOR HOSPITALS AND NURSING FACILITIES

A second policy option for inducing providers to produce episodes of care efficiently is a fixed payment system that is extended to nursing facility care. The impacts of this policy on independent firms, a vertically integrated firm, and a hospital receiving bundled payment are summarized in Table 1.

Fixed payments to independent firms

Substituting $P_d(X_d) = \beta_d$ into Equations (2) and (3) yields a new first-order condition and reaction function for the nursing facility

$$\beta_d - C'_d \cdot X_d = 0, \tag{23}$$

with

$$N' = - \frac{[C'_d + C''_d \cdot X_d \cdot N] \cdot X'_d}{C'_d \cdot X_d^2} = - X'_d \cdot \left[\frac{N}{X_d} \right] \cdot \left[\frac{1}{1 - \delta} \right] > 0. \tag{24}$$

Whereas the nursing facility was indifferent under variable reimbursement between providing additional X_d and additional N , the nursing facility now faces zero marginal revenue for increased X_d and positive marginal revenue for increased N .

The slope of the downstream nursing facility isoprofit contours under fixed payments, illustrated in Figure 2, simplifies to $\partial X_u / \partial N = (\beta_d - C'_d \cdot X_d) / (C'_d \cdot N \cdot X'_d)$. Since the second derivative is positive, each isoprofit contour is U-shaped, with higher downstream profits occurring at higher levels of upstream service, X_u (so $D_1 > D_2 > D_3$). The reaction function, which is the locus of points that yield the highest nursing facility profit for a given level of hospital service, connects the points at which the isoprofit curves have zero slope; hence $\beta_d = C'_d \cdot X_d$ at every point on the nursing facility reaction function.

Combining the hospital first-order condition from Equation (11) with the reaction function given in Equation (24) yields

$$- X'_d \equiv \frac{f^u}{f^d} = \frac{C'_u}{C'_d} \cdot \left[\frac{C'_d \cdot X_d}{\beta_u - C'_u \cdot X_u} \right] \cdot [1 - \delta];$$

$$0 \leq 1 - \delta = \left[\frac{C''_d \cdot N \cdot X_d}{C'_d + C''_d \cdot N \cdot X_d} \right] < 1. \tag{25}$$

Thus, when all providers are reimbursed with fixed fees, care will only be produced efficiently if β_u exceeds the marginal cost of producing the hospital care. However, the gap between marginal revenue and marginal cost required for efficient production ($\beta_u - C'_u \cdot X_u = C'_d \cdot X_d(1 - \delta)$) is smaller than in the case of variable reimbursement for nursing facility care, indicating that the shift to fixed reimbursement for nursing facility ser-

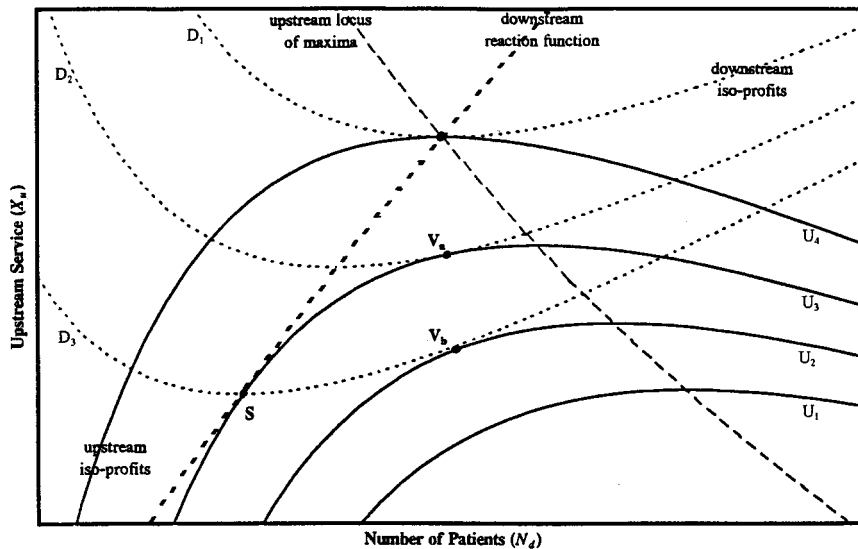


Figure 2. Equilibrium under fixed payments for both hospitals and nursing facilities

vices reduces the non-integrated industry's inefficiency.

The hospital maximizes profit by locating at the Stackelberg point S in Figure 2, where a hospital isoprofit contour is tangent to the nursing facility's reaction function. As the downstream isoprofit curve slope is zero at every point on the nursing facility's reaction function, this Stackelberg equilibrium is not located at a tangency between the upstream and downstream firms' isoprofit contours. Joint profit is thus not maximized, and a hypothetical movement to a tangency, such as point V_a or V_b , would be a Pareto-improvement under appropriate compensation.

Fixed payments to a vertically integrated firm

Vertical integration is a profitable strategy when fixed payments apply to both the hospital and the nursing facility, because it eliminates the constraint of locating on the nursing facility reaction function. Under fixed payments, the vertically integrated firm would satisfy the following first-order conditions, as given in Equation (9):

$$\begin{aligned} \partial \pi_{VI} / \partial X_u &= -M \cdot N \cdot [C'_u + C'_d \cdot X'_d] = 0, \\ \partial \pi_{VI} / \partial N &= M \cdot [\beta_u - C'_u \cdot X_u] + [\beta_d - C'_d \cdot X_d] = 0. \end{aligned} \tag{9}$$

As the first condition implies $C'_u / C'_d = -X'_d = f^u / f^d$, the vertically integrated firm will combine X_u and X_d efficiently to minimize the cost of producing health status Σ . The second condition implies that the number of patients treated by this firm will equate marginal cost with price.

These two conditions can be combined to yield

$$\frac{\beta_u - C'_u \cdot X_u}{C'_u \cdot N} = \frac{\beta_d - C'_d \cdot X_d}{C'_d \cdot N \cdot X'_d} \tag{27}$$

As the left-hand side is the slope of the hospital's isoprofit contour, and the right-hand side is the slope of the nursing facility's isoprofit contour, the integrated firm maximizes joint profit at a point such as V_a or V_b in Figure 2 (note that the vertical integration equilibrium does not necessarily imply that each provider is on its locus of maxima). Thus, fixed payment for nursing facilities does not eliminate the incentive for vertical integration, but it does induce the integrated firm to produce care efficiently.

Bundled fixed payments

In this final version of the model, hospitals are reimbursed with a bundled fixed payment, and may choose to subcontract for downstream services at a fixed rate.

Externally-determined fixed rates. The hospital maximizes profit

$$\begin{aligned} \pi_u(X_u, \beta_d) &= M \cdot N(X_u, \beta_d) \cdot [\beta_t - \beta_d] \\ &\quad - C_u(M \cdot N(X_u, \beta_d) \cdot X_u), \end{aligned} \tag{28}$$

by satisfying the first-order condition

$$M \cdot [\beta_t - \beta_d] \cdot N' = M \cdot C'_u \cdot [N + X_u \cdot N'] \tag{29}$$

Combining this equation with the expression for N' in Equation (24) yields

$$-X'_d = \frac{C'_u}{C'_d} \cdot \frac{C'_d \cdot N}{[\beta_t - \beta_d - C'_u \cdot X_u]} \cdot \frac{X_d}{N} \cdot [1 - \delta] \tag{30}$$

Thus, combining the strategies of bundled payment and an externally determined fixed payment for nursing facility services does not induce efficient production with the total price equal to marginal cost.

Market-determined fixed rates. If the nursing facility fixed payment is market-based (i.e. essentially determined by the monopsonistic power of the hospital), the nursing facility's first-order condition is given in Equation (23), while the hospital maximizes

$$\begin{aligned} \pi_u(X_u, \beta_d) &= M \cdot N(X_u, \beta_d) \cdot [\beta_t - \beta_d] \\ &\quad - C_u(M \cdot N(X_u, \beta_d) \cdot X_u), \end{aligned} \tag{31}$$

by satisfying the first-order conditions

$$\begin{aligned} \frac{\partial \pi_u}{\partial X_u} &= M \cdot [\beta_t - \beta_d - C'_u \cdot X_u] \cdot N' \cdot M \cdot C'_u \cdot N = 0; \\ \frac{\partial \pi_u}{\partial \beta_d} &= M \cdot [\beta_t - \beta_d - C'_u \cdot X_u] \cdot \frac{\partial N}{\partial \beta_d} - M \cdot N = 0. \end{aligned} \tag{32}$$

The first expression in both equations in (32) is positive, which implies that the hospital's net marginal revenue earned by treating an additional patient, $\beta_t - \beta_d$, will exceed the marginal cost of providing hospital services to that marginal patient; hence the number of patients treated will be inefficiently low.

Combining the two equations in (32) with the expression for $\partial N / \partial \beta_d$ from Equation (4) and the expression for N' from Equation (24) yields

$$-X'_d = \frac{C'_u}{C'_d} \cdot \delta, \quad (33)$$

which implies that provision of hospital services will exceed the efficient treatment intensity.

Vertical integration with bundled fixed payment

The vertically integrated firm is not affected by the decision to bundle payments. Hence, this case is described by Equations (26) and (27). Episodes of care are produced efficiently with the total price equal to marginal cost.

CONCLUSION

The model of strategic interaction between vertically related firms developed here provides a framework for analysing the interactions between payment system structure, incentive for vertical integration, and the efficiency of producing substitutable health care services. This model suggests that the 1984 shift from a variable hospital reimbursement system to a fixed payment system created incentives for inefficient production and vertical integration. While vertical integration increases provider profit, it does not induce efficient production in this combination of payment systems, because the combination of fixed hospital and variable nursing facility payments encourages inefficient substitution away from hospital services toward nursing facility services.

The United States federal government is pursuing two policies to induce efficient production of care for transfer patients by independent hospitals and nursing facilities: bundled payments and fixed payment for nursing facility services. This model suggests that hospital and nursing facilities will jointly produce an episode of care efficiently in only a limited number of cases. The current strategy of implementing fixed payment for nursing facilities may somewhat improve production efficiency with independent firms and it will induce efficient production by a vertically integrated firm, but it will not eliminate production inefficiency by independent firms, and it will not eliminate the incentive for vertical integration. Bundling payments will induce efficient production by vertically integrated firms under fixed or variable payments. Achieving efficiency without vertical integration, according to the simple model

developed in this paper, would require a bundled payment system that combines fixed payments for hospital services with variable payments for nursing facility services.

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