Order Number 9108156

Theoretical aspects of hospital reimbursement: A price discrimination model

Oh, Chee Ju, Ph.D.

City University of New York, 1990

U·M·I
300 N. Zeeb Rd.
Ann Arbor, MI 48106

A

THEORETICAL ASPECTS OF HOSPITAL REIMBURSEMENT: A PRICE DISCRIMINATION MODEL

by

CHEE JU OH

A dissertation submitted to the Graduate Faculty in Economics in partial fulfillment of the requirements for the degree of Doctor of Philosophy, The City University of New York

1990

This manuscript has been read and accepted for the Graduate Faculty in Economics in satisfaction of the dissertation requirements for the degree of Doctor of Philosophy.

6/14/90	Michael Grossman
date	chairman of Examining Committee
6/14/90	Michael Grossman
date	Executive Officer

Professor Michael Grossman

Professor Ronald Anderson

Professor Salih Neftci

Supervisory Committee

The City University of New York

Abstract

THEORETICAL ASPECTS OF HOSPITAL REIMBURSEMENT:
A PRICE DISCRIMINATION MODEL

by

Chee Ju Oh

Adviser: Professor Michael Grossman

This dissertation provides theoretical expectations on hospital decision making with respect to the change in reimbursement rate. Applying the framework from price discrimination monopoly theory, this study demonstrates the conditions for the existence of equilibria under alternative hospital reimbursement methods and utilizes these conditions to provide theoretical expectations.

With CBR and in case of cost-plus(r>1) or full-payment (r=1), increases in reimbursement rate lead to:

1) decreases in the number of private patients, thereby raising private patient charges,

2) increases in the number of Medicare/Medicaid patients,

3) increases in the expenditures on quality.

Therefore,

4) increases in private patient charges(cross-subsidy) since $dx/dr < 0$ and $dq/dr > 0$.

With CBR and in case of underpayment($r<1$), the changes are ambiguous. By introducing fixed quality into the model, quality effects are controlled, and increases in reimbursement rate lead to:

1) either increases in number of private patients(decreases in private patient charges:cost-shift) or decreases in number of private patients(increases in private patient charges:cross-subsidy),

2) increases in number of Medicare/Medicaid patients.

From above results and static analysis:

The introduction of underpayment may be or may not be the cause of private price increase. It depends on the viewpoints of hospitals when the government policy is introduced. The size of private market which determines patient-mix(δ) at equilibrium and the operating situation which determines the curvature(ϕ) of average costs are key factors in clarifying the effects of government policy.

As soon as PPS($R=rc$ or $R=r+c$) is introduced into the unconstrained model, quality-access trade-off is expected in Medicare/Medicaid patients. Increases in "R" leads to decreases in the number of private patients, increases in the number of Medicare/Medicaid patients, and decreases in the expenditure on quality.

Acknowledgements

To simply thank Professor Michael Grossman would not adequately reflect my gratitude for the intellectual debt I owe him. He suggested the general model of this study and supervised the work at all stages. For his help and for his rigorous training in economic theory, I am deeply grateful. I must also thank Professor Ronald Anderson for the suggestion concerning the bounding restriction of the model. I wish to also thank Professor Salih Neftci who encouraged me and taught me that econometrics and mathematical reasoning can be an enjoyable tool to work with.

Finally, I would like to thank my wife Younghee for everything.

TABLE OF CONTENTS

INTRODUCTION

The aim of this paper is to construct conditions for the existence of different stationary equilibria under alternative hospital reimbursement methods, and to provide theoretical expectation on hospital decision-making with respect to the change in reimbursement rate.

Since the introduction of reimbursement policy in the United States, several authors have analyzed the impacts of the policy on the price of private patients, the quality of care, and hospital costs. In this paper an unconstrained price discrimination monopoly model is utilized as a standard with which to compare various restricted models.

$$\text{Max } \pi = p(x,q)*x + r*c(x+m,q)*m - c(x+m,q)*(x+m)$$

where
p = price of private patients,
x = number of private patients,
q = quality of care,
r = rate of reimbursement,
c = average cost--i.e., total cost/(x+m),
m = number of Medicare/Medicaid patients.

By introducing a restriction of "m=m(q)" into above standard model, Sloan(1980) suggests the possibility of "cost-shifting(dp/dr < 0)" in the case of cost-plus reimbursement(r>1). Later, Sloan & Becker(1983) observed "cost-shifting" in their empirical study. They argued that the price differentials between private patients(x) and government patients(m) were not justified.

But Hay(1983) and Foster(1985), by introducing a restriction of "fixed quality($\bar{q}$)" into the standard model, illustrate "cross-subsidy(dp/dr > 0)" in case of underpayment reimbursement(r<1). Foster demonstrates that "cross-subsidy" still exists even in the case of adding "adjustment cost($a(m-\bar{m})^2$)" and "fixed price of government paid patients(e.g., PPS : R=rc)".

Recently Dusansky(1988) and Gertler(1989) introduced "fixed number of total patients($\bar{z}$=x+m)" into the standard model. While Dusansky observes "cost-shift(dp/dr < 0) " with OLS estimation, Gertler argues the possibility of "cross-subsidy(dp/dr > 0)" by adding "fixed price(R=r+c)". Both assume cost-plus reimbursement policy.

From the past studies, the following four fundamental issues related to the reimbursement methods can be organized.

1. Existence of equilibrium

Can equilibrium be achieved in the case of cost-plus? While many authors assume the existence of equilibrium, Danzon(1982) observes infinite optimal level.

Can equilibrium be achieved in the case of underpayment? --Is it desirable for hospitals to sustain losses on government programs in order to generate greater revenue on private sector services(e.g., Hay(1983)?

2. Cost-shift vs. Cross-subsidy

Cost-shift(dp/dr < 0): Reduction in government payment leads to increases in the price charged to private patients--cf., Sloan(1980), Sloan-Becker(1983) and Dusansky(1988). For example, private insurance carriers argue that government underpayment causes hospital costs to increase. Underpayment induces hospitals to impose higher charges on private-pay patients, thereby resulting in higher insurance premiums, and out-of-pocket payments.

Cross-Subsidy(dp/dr > 0): Reduction in government payment leads to decreases in the prices charged to private patients--cf., Hay(1983), Foster(1985) & Gertler(1989).

3. Production cost

Production inefficiency: There is no incentive for minimizing costs since hospitals are reimbursed more than average costs.--i.e., Cost-plus reimbursement contributes to hospital cost increase(e.g., Enthoven(1980) and others).

Stabilizer: The more the prospective system constrains hospital's revenue, the slower increases in hospital costs are observed(e.g., Feder, Hadley & Zuckerman(1987)).

4. Quality of care(in case of increasing "r")

Quality decrease($dq/dr < 0$): Increases in reimbursement rates induce hospitals to lower quality(e.g., Dusansky(1988). Quality-Access tradeoff, e.g., $dq/dr < 0$ and $dm/dr > 0$, is observed by Gertler(1989).

Quality increase($dq/dr > 0$): increases in reimbursement rates induce hospital to increase the quality of care--e.g., Nursing home administrators argue that increases in reimbursement rate can induce them to admit more Medicaid patients and provide higher quality--i.e., $dq/dr > 0$ and $dm/dr > 0$. Under cost-plus reimbursement Sloan(1980) assumed the possibility of $dq/dr > 0$.

Strange as it may seem, there are always arguments and counter arguments related to each of the four issues. What make them lead to such different conclusions? Can the different restrictions really induce them to different results? Are there other interpretations or assumptions employed to induce these results ?

In this paper, we will start with the unconstrained price discrimination monopoly model.

We construct the conditions for the existence of equilibria and utilize these conditions to deal with the above four issues. Then, the restrictions mentioned are introduced. At this stage, testable questions are answered and possible changes of the theoretical predictions are explored.

We hope that these conditions are utilized as criteria to clarify the importance of the aforementioned arguments and counter arguments for the development of further studies.

CHAPTER I--Unconstrained Model

The following chapter reviews the theoretical conditions on the unconstrained price discrimination model and assesses possible effects of cost-based reimbursement on hospital decision making. A variety of restricted models are compared to explain the differences in hospital pricing and output policy.

A. Model

Assume that the hospital maximizes profits π and that it has some degree of local monopoly power[1]. Assume that the hospital has two types of patients. Let "x" be private paid patients and "m" be Medicare/Medicaid patients who are paid by cost-based reimbursement. Respectively "p" and "r*c"[2] are price of private patients and the amount reimbursed by hospital. Assume p=p(x,q), c=c(x+m,q) and that m and q are independent. The hospital will therefore choose x, m & q to maximize profits:

$$\max_{x,m,q} \pi^U = p(x,q)*x + r*c(x+m,q)*m - c(x+m,q)*(x+m) \quad (1)$$

subject to $x \geq 0$ and $m \geq 0$

---

[1] Feldman & Dowd(1986) indicate that the hospital had monopoly power in their market for Blue Cross and self pay patients.

[2] Where "r" is the rate of cost-based reimbursement. Let r>1, r=1, r<1 represent, respectively, cost-plus reimbursement, full reimbursement, underpayment reimbursement. "c" represents average costs

where

p = price of private patients,
x = number of private patients,
q = quality of care,
r = rate of reimbursement,
c = average cost--i.e., total cost/(x+m),
m = number of Medicare/Medicaid patients,
z = x+m(total number of patients).

It is helpful to begin with the argument that government expenditure and hospital profit are non decreasing functions of marginal cost.

1. Government Expenditure

To start with, consider two alternative reimbursement rates for the hospital: $r_2 > r_1 > 0$

Let p_1, r_1c_1, x_1 and m_1 denote hospital's price for private patients, reimbursed price for Medicare/Medicaid patients, number of private patients and government paid patients when the reimbursement rate is "r_1": p2, r_2c_2, x_2 and m_2 are defined similarly. When the reimbursement rate is "rl", the hospital's choice at equilibrium will be x_1(thereby p_1) and m_1. Thereby c_1 is its choice. But the hospital can choose any level of x & m and if it chooses x_2(thereby p_2) and m_2 instead of x_1(thereby p_1) and m_1 when r_1 is given,

$$p_1x_1 + r_1c_1m_1 - c_1(x_1 + m_1) \geq p_2x_2 + r_1c_2m_2 - c_2(x_2 + m_2) \qquad (1)\text{-a}$$

Similarly, if it chooses x_1(thereby p_1) and m_1 instead of x_2(thereby p_2) and m_2 when r_2 is given,

$$p_2x_2 + r_2c_2m_2 - c_2(x_2 + m_2) \geq p_1x_1 + r_2c_1m_1 - c_1(x_1 + m_1) \qquad (1)\text{-b}$$

Adding equations (1)-a and (1)-b yields

$$r_1c_1m_1 + r_2c_2m_2 \geq r_1c_2m_2 + r_2c_1m_1$$

or $$(r_2 - r_1)\ c_2m_2 \geq (r_2 - r_1)\ c_1m_1$$

Since $(r_2 - r_1) > 0$, $$c_2m_2 \geq c_1m_1 \qquad (1)\text{-c}$$

and $$r_2c_2m_2 > r_1c_1m_1 \qquad (1)\text{-d}$$

Therefore, government expenditure is an increasing function of reimbursement rate. This holds true even in the case of decreasing average costs--i.e., if $c_2 < c_1$, then m_2 should be fairly bigger than m_1 in order to get $c_2m_2 \geq c_1m_1$. .... (1)-e

2. Hospital Profit

From the above case, if the hospital chooses x_1(thereby p_1) and m_1 instead of x_2(thereby p_2) and m_2 when r_2 is given,

$$p_2x_2 + r_2c_2m_2 - c_2(x_2 + m_2) \geq p_1x_1 + r_2c_1m_1 - c_1(x_1 + m_1) \qquad (1)\text{-b}$$

For another illustration, if the hospital treats the same number of patients even in case of increasing reimbursement from--i.e., r_1 to r_2,

$$p_1x_1 + r_2c_1m_1 - c_1(x_1 + m_1) > p_1x_1 + r_1c_1m_1 - c_1(x_1 + m_1) \qquad (1)\text{-f}$$

Adding equations (1)-b and (1)-f yields

$$p_2x_2 + r_2c_2m_2 - c_2(x_2 + m_2) > p_1x_1 + r_1c_1m_1 - c_1(x_1 + m_1) \qquad (1)\text{-g}$$

Therefore, hospital profits are increasing function of reimbursement rate.

B. Equilibrium Conditions

With non-negativity restrictions, the first order conditions
(Kuhn-Tucker) of (1) are:

$$\pi_x^0 = p_x\ x + p + r\ c_x{}^{[3]}m - MC \le 0 \qquad (2)\text{-a}$$

$$\text{or}\quad p(\ 1 - 1/|\epsilon|\ ) + r\ c_x\ m - MC \le 0 \qquad (2)\text{-b}$$

$$\text{or}\quad MR(x) - c + (rm-x-m\ )\ c_x \le 0 \qquad (2)\text{-c}$$

where, $|\epsilon|$ = absolute value of elasticity

---

[3] Since x and m enters into cost function symmetrically, $c_x = c_m = c_x$.

$$\pi_m^U = r\ c + r\ c_z\ m - MC \le 0 \qquad (3)\text{-a}$$

$$\text{or}\quad (r - 1)\ c + (rm - x - m)\ c_z \le 0 \qquad (3)\text{-b}$$

$$\pi_q^U = p_q\ x + r\ c_q\ m - (x+m)\ c_q$$
$$= p_q\ x + (rm - x - m)\ c_q \le 0 \qquad (4)$$

Non-negativity restriction and complementary-slackness conditions should be added to each of the conditions to get boundary solutions--i.e., x=0 or m=0 or q=0. To deal with effective reimbursement policy which leads x, m & q to be positive at equilibrium, we mainly assume that each of the conditions are equal to zero. But we will refer to the situations in which non-negative constraints may be binding.

From (4), we see that the marginal revenue of quality must equal the marginal cost of quality. Hence we will call this condition "marginal quality neutrality condition".

From (2) and (3), optimal x^{*U}(thereby p^{*U}) and m^{*U} are determined.

From (3)-b, <u>$(r - 1)\ c + (rm - x - m)\ c_z = 0$</u>:

If $r < 1$, then $(r-1)c < 0$ and $(rm-x-m) < 0$, in order to satisfy this FOC, c_z must be smaller than zero. This implies that, with "underpayment", the hospital should operate in the phase of decreasing average costs to get the optimal number of private patients and Medicare/Medicaid patients

. ... (5)

If $r > 1$, then $(r - 1)c > 0$, thereby $(rm-x-m)\ c_z$ must be smaller than zero to get equilibrium. In this case, there are two ways of getting $(rm-x-m)\ c_z < 0$:

First is $c_z > 0$ & $(rm-x-m) < 0$ at equilibrium --i.e., relatively big number of private patients at equilibrium. Because x* are bigger than (r-1)m*. This implies that, under "cost-plus", the hospital should operate in the phase of increasing average costs to get the optimal number of private patients and Medicare/Medicaid patients .... (6)

Second is $c_z < 0$ & $rm-x-m > 0$ at eq.. --->relatively small number of private patients at equilibrium, because the absolute value of (r-1)m* is bigger than that of x*. But this is not the way of achieving equilibrium. The reason is :

From (3)-b, $(r - 1)\ c + (rm- x- m)\ c_z \leq 0$

By rewriting this:

$$(r-1)\ c + (rm-x-m)\ d(TC/z)\ /\ dz \leq 0$$

$$\text{where } TC = c^*z$$

Which can be expanded:

$$(r-1)\ c + (rm-x-m)\ (MC\ z - TC)/\ z^2$$

$$= (r-1)\ c + (rm-x-m)\ \{(MC/z)\ - (TC/z^2)\} \leq 0$$

By multiplying z:

$$(r-1)\ c\ z + (rm-x-m)\ (MC-c)$$

$$= (r-1)\ c\ z - (rm-x-m)c + (rm-x-m)\ MC$$

$$= c\ \{(r-1)z - (rm-x-m)\} + (rm-x-m)\ MC$$

$$= c\ (rz - z - rm + z) + (rm-x-m)\ MC$$

$$= c\ (rz - rm) + (rm-x-m)\ MC$$

$$= c\ rx + (rm-x-m)\ MC \quad \leq \quad 0$$

Thereby

$$(rm-x-m)MC \quad \leq \quad -\ c\ rx$$

And

$$(rm-x-m) \quad \leq \quad -(c/MC)\ rx$$

Therefore, (rm-x-m) can not be bigger than zero. (6)-a

Generally, the results of (5) and (6) can be expanded around any level of "r". We can infer that if $r_2 > r_1 > 0$, then $z_2 > z_1$--i.e., $dz/dr > 0$ as long as the hospital is operating at equilibrium. (6)-b

To ensure maximization, let's examine the second-order condition. From FOCs((2),(3) & (4)), the second partial derivatives are found to be:

$$\pi_{zz}^{U} = p_{zz}x + 2p_z - 2c_z + (rm-x-m)c_{zz} \quad (7)$$

$$\pi_{zm}^{U} = (r-2)c_z + (rm-x-m)c_{zz} \quad (8)$$

$$\pi_{mm}^{U} = 2(r-1)c_z + (rm-x-m)c_{zz} \quad (9)$$

$$\pi_{zq}^{U} = p_{zq}x + p_q - c_q + (rm-x-m)c_{zq} \quad (10)$$

$$\pi_{mq}^U = (r-1)c_q + (rm-x-m)c_{xq} \qquad (11)$$

$$\pi_{qq}^U = p_{qq}x + (rm-x-m)c_{qq} \qquad (12)$$

So that we have:

$$|H^U| = \begin{vmatrix} \pi_{xx}^U & \pi_{xm}^U & \pi_{xq}^U \\ \pi_{xm}^U & \pi_{mm}^U & \pi_{mq}^U \\ \pi_{xq}^U & \pi_{mq}^U & \pi_{qq}^U \end{vmatrix}$$

.... (13)

The second order sufficient condition will thus be duly satisfied, provided we have:

$$\pi_{xx}^U < 0, \ \pi_{mm}^U < 0 \ \& \ \pi_{qq}^U < 0 \qquad (14)$$

$$|H^U_2| = (\pi_{xx}^U \pi_{mm}^U - (\pi_{xm}^U)^2 > 0 \qquad (15)$$

$$|H^U| < 0 \qquad (16)$$

With respect to SOCs, $\pi_{xxU} < 0$, $\pi_{qq}^U < 0$, (15) and (16) can be achieved through the assumption that private patients' demand is concave and $|p_{xx}x + 2p_x|$ & $|p_{qq}x|$ are relatively big. For example, if a hospital faces a small volume of private demand(thereby (rm-x-m)>0) and cost-plus(r>1) is given to them, then $\pi_{mm}^U = 2(r-1)c_x + (rm-x-m)c_{xx}$ is always bigger than zero. This will induce the hospital to treat Medicare/Medicaid patients infinitely. Danzon(1982)'s argument[4] is supported in this example. An interior equilibrium can be surely achieved in the case of cost-plus reimbursement as long as FOCs and SOCs satisfied.The existence concave and sizable volume of private demand(x) is indispensable for a reimbursement policy to lead to an interior equilibrium.

With underpayment(r<1), if the hospital operates on the stage of increasing marginal cost, $\pi_{mm}^{U5} = 2(r-1)c_z + (rm-x-m)c_{zz}$ is always less than zero. So in this case, as long as $|p_{zz}x+2p_z|$ & $|p_{qq}x|$ are relatively big, we can get equilibrium even without making an assumption of $\pi_{mm}^{U} < 0$. And, in this context, Hay(1983)'s argument[6] is supported. But, if new "r" is given lower than "reserved reimbursement" and this always leads to $\pi_m^U = r\ c + r\ c_z\ m - MC < 0$ at any level of positive "m", then the hospital will start to dump out Medicare/Medicaid patients. Hospital would not want to treat any single number of Medicare/Medicaid patients--e.g., m=0.

C. Comparative Statics

Totally differentiating (2), (3) & (4):

---

[4] " In the absence of constraint, optimum prices -`cost' or charges - are infinitive."

[5] If MC is increasing, $MC_z > 0$ thereby$_U$ $r\ MC_z < MC_z$. this implies $rc_{zz}z + 2rc_z - c_{zz}z - 2c_z < 0$--i.e., $\pi_{mm}^{U} < -rc_{zz}x < 0$.

[6] In case of underpayment, " the hospital would make even less profit if it did not provide the government services a loss."

$$\begin{bmatrix} \pi^U_{xx} & \pi^U_{xm} & \pi^U_{xq} \\ \pi^U_{xm} & \pi^U_{mm} & \pi^U_{mq} \\ \pi^U_{xq} & \pi^U_{mq} & \pi^U_{qq} \end{bmatrix} \begin{bmatrix} dx \\ dm \\ dq \end{bmatrix} = \begin{bmatrix} E^U_x \\ E^U_m \\ E^U_q \end{bmatrix} dr$$

...........(18)

where

$E_x^U = - m c_x$ (19)

$E_m^U = - (c + m c_x)$ (20)

$E_q^U = - m c_q$ (21)

Using Cramer's rule, we can express dx/dr as

$$\frac{dx}{dr} = \frac{\begin{vmatrix} -m c_z & \pi^U_{xm} & \pi^U_{xq} \\ -(c + m c_z) & \pi^U_{mm} & \pi^U_{mq} \\ -m c_q & \pi^U_{mq} & \pi^U_{qq} \end{vmatrix}}{|H^U|}$$

..........(22)

Using Laplace Expansion, we can express dx/dr as

$$\begin{aligned} dx/dr = {} & \pi_{xq}^U \{ - (c+mc_x) \pi_{mq}^U + mc_q \pi_{mm}^U \} \ / \ |H^U| \\ & + (- \pi_{mq}^U) \{ -mc_x \pi_{mq}^U + mc_q \pi_{xm}^U \} \ / \ |H^U| \\ & + \pi_{qq}^U \{ -mc_x \pi_{mm}^U + (c+mc_x) \pi_{xm}^U \} \ / \ |H^U| \end{aligned} \qquad (23)$$

i.e., as a sum of three terms, each of which is the product of a third-column element and its corresponding cofactor.

If we assume addictive functions on price and average cost equations--e.g., $p=p(x) + @(q)$ and $c = c(x+m) + \theta(q)$, then $p_{qx} = p_{qx} = 0$ and $c_{qx} = c_{qx} = 0$.

Then (7), (8) & (9) are intact and by assumptions on SOCs

$$\pi_{xx}^{U} = p_{xx}x + 2p_x - 2c_x + (rm-x-m)c_{xx} \quad < 0 \qquad (7)\text{-a}$$

$$\pi_{xm}^{U} = (r-2)c_x + (rm-x-m)c_{xx} \qquad (8)$$

$$\pi_{mm}^{U} = 2(r-1)c_x + (rm-x-m)c_{xx} \quad < 0 \qquad (9)\text{-a}$$

But

$$\pi_{xq}^{U} = p_q - c_q \qquad (10)\text{-a}$$

$$\pi_{mq}^{U} = (r-1)c_q \qquad (11)\text{-a}$$

$$\pi_{qq}^{U} = p_{qq}x + (rm-x-m)c_{qq} \quad < 0 \qquad (12)\text{-a}$$

1. In Case of Cost-Plus Reimbursement($r>1$)

With cost-plus($r > 1$) reimbursement, $c_x > 0$ by (6).

Thereby $\pi_{xm}^{U} = (\pi_{mm} - r\, c_x) < 0$ (8)-a

From (4), $p_q - c_q = -(r-1)\,(m\, c_q)/x$

$r > 1$ & $c_q > 0$ by assumption,

$$\pi_{xq}^{U} = (p_q - c_q) \quad < 0 \qquad (10)\text{-b}$$

and $\pi_{mq}^{U} = (r-1)\, c_q \quad > 0$ (11)-b

By rewriting (23)

$$dx/dr\ |H^U| = \pi_{xq}^U \{ \Phi \} + (-\pi_{mq}^U)\{ \Theta \} + \pi_{qq}^U \{ \Omega \} \qquad (23)\text{-a}$$

where

$\Phi = -(c+m\,c_z)\,\pi_{mq}^U + m\,c_q\,\pi_{mm}^U < 0$ (cf., $c_z > 0$,(9)-a, (11)-b & $c_q > 0$)

$\Theta = -\,m\,c_z\,\pi_{mq}^U + m\,c_q\,\pi_{xm}^U < 0$ (cf., $c_z > 0$, (8)-a, (11)-b & $c_q > 0$),

$$\begin{aligned}\Omega &= -\,m\,c_z\,\pi_{mm}^U + (c+mc_z)\,\pi_{xm}^U \\ &= -\,m\,c_z\,(\pi_{mm}^U - \pi_{xm}^U) + c\,\pi_{xm}^U \\ &= -\,m\,c_z\,(\,r\,c_z) + c\,\pi_{xm}^U \\ &= -\,r\,m\,(c_z)^2 + c\,\pi_{xm}^U < 0 \quad \text{(cf., (8)-a))}\end{aligned}$$

Thereby dx/dr = (sum of all positive terms)/$|H^U|$

where $|H^U| < 0$ by SOC

Therefore, $dx/dr_{\text{cost-plus}} < 0$ (24)

Using Cramer's rule, we can express dm/dr as

$$\frac{dm}{dr} = \frac{\begin{vmatrix} \pi_{xx}^U & -m\,c_z & \pi_{xq}^U \\ \pi_{xm}^U & -(c + m\,c_z) & \pi_{mq}^U \\ \pi_{xq}^U & -m\,c_q & \pi_{qq}^U \end{vmatrix}}{|H^U|}$$

..........(25)

Using Laplace Expansion, we can express dm/dr as

$$\begin{aligned} dm/dr = {} & \pi_{xq}^U \{ (c+mc_z)\,\pi_{xq}^U - mc_q\,\pi_{xm}^U \} \;/\; |H^U| \\ & + (-\pi_{mq}^U) \{ mc_z\,\pi_{xq}^U - mc_q\,\pi_{xx}^U \} \;/\; |H^U| \qquad (26) \\ & + \pi_{qq}^U \{ mc_z\,\pi_{xm}^U - (c+mc_z)\,\pi_{xx}^U \} \;/\; |H^U| \end{aligned}$$

i.e., as a sum of three terms, each of which is the product of a third-column element and its corresponding cofactor. But (26) is too complicated to interpret directly. However, we can infer that dm/dr > 0 in case of cost-plus. Let the reimbursement rate be increased from r_1 to r_2 in cost-plus case: $r_2 > r_1 > 1$.

From (1)-c, $c_2 m_2 \geq c_1 m_1$ and from (24), $x_2 < x_1$

If $m_2 < m_1$, then $z_2 < z_1$ thereby $c_2 < c_1$ (because $c_z > 0$ in case $r > 1$ (cf.,(6)). This implies that if $m_2 < m_1$, then $c_2 m_2 < c_1 m_1$. But this is contradictory to (1)-c: i.e., $c_2 m_2 \geq c_1 m_1$.

<u>Therefore, at equilibrium, m_2 must be bigger than m_1 in case of increasing "r"--i.e., $dm/dr_{\text{cost-plus}} > 0$ (27)</u>

Using Cramer's rule, we can express dq/dr as

$$\frac{dq}{dr} = \frac{\begin{vmatrix} \pi^U_{xx} & \pi^U_{xm} & -m\,c_z \\ \pi^U_{xm} & \pi^U_{mm} & -(c + m\,c_z) \\ \pi^U_{xq} & \pi^U_{mq} & -m\,c_q \end{vmatrix}}{|H^U|} \qquad \text{...........(28)}$$

Using Laplace Expansion, we can express dq/dr as

$$\begin{aligned} dq/dr = & - m\,c_z\,(\pi_{xm}^U \pi_{mq}^U - \pi_{xq}^U \pi_{mm}^U) \;/\; |H^U| \\ & + (c + m\,c_z)(\pi_{xx}^U \pi_{mq}^U - \pi_{xq}^U \pi_{xm}^U) \;/\; |H^U| \qquad (29) \\ & - m\,c_q\,\{\pi_{xx}^U \pi_{mm}^U - (\pi_{xm}^U)^2\} \;/\; |H^U| \end{aligned}$$

i.e., as a sum of three terms, each of which is the product of a third-column element and its corresponding cofactor.

By rewriting (29)

$$dq/dr\ |H^{U}| = -\ m\ c_{I}\ \{\ \Phi'\ \} + (c + m\ c_{I})\ \{\ \Theta'\ \} - m\ c_{q}\ \{\ \Omega'\ \}$$

$$= -\ m\ c_{I}\ (\ \Phi' - \Theta') + c\ \Theta' - m\ c_{q}\ \Omega' \qquad (29)\text{-a}$$

where

$\Phi' = (\pi_{IB}^{U}\ \pi_{Bq}^{U} - \pi_{Iq}^{U}\ \pi_{BB}^{U}) < 0$ (cf. (8)-a, (9)-a, (10)-b, (11)-b),

$\Theta' = (\pi_{II}^{U}\ \pi_{Bq}^{U} - \pi_{Iq}^{U}\ \pi_{IB}^{U}) < 0$ (cf. (7)-a, (8)-a & (10)-b),

$\Omega' = \{\pi_{II}^{U}\ \pi_{BB}^{U} - (\pi_{IB}^{U})^{2}\} > 0$ (by (15))

$$\Phi' - \Theta' = \pi_{IB}^{U}\ \pi_{Bq}^{U} - \pi_{Iq}^{U}\ \pi_{BB}^{U} - \pi_{II}^{U}\ \pi_{Bq}^{U} + \pi_{Iq}^{U}\ \pi_{IB}^{U}$$

$$= \pi_{Bq}^{U}\ (\pi_{IB}^{U} - \pi_{II}^{U}) + \pi_{Iq}^{U}\ (\pi_{IB}^{U} - \pi_{BB}^{U})$$

where

$\pi_{IB}^{U} - \pi_{BB}^{U} = -\ r\ c_{I} < 0$. This means $|\pi_{IB}^{U}| > |\pi_{BB}^{U}|$ since both π_{IB}^{U} and π_{BB}^{U} are less than zero. Also, since $\pi_{II}^{U} < 0$, we can infer that $|\pi_{II}^{U}|$ should be bigger than $|\pi_{IB}^{U}|$ to get $\pi_{II}^{U}\ \pi_{BB}^{U} - (\pi_{IB}^{U})^{2} > 0$ (cf.(15)). So, $|\pi_{II}^{U}| > |\pi_{IB}^{U}| > |\pi_{BB}^{U}|$ and thereby $\pi_{II}^{U} < \pi_{IB}^{U} < \pi_{BB}^{U} < 0$.

Thus $\Phi' - \Theta' > 0$.

Therefore, dq/dr = (sum of all negative terms)/$|H^{U}|$

where $|H^{U}| < 0$ by SOC

Therefore, $dq/dr_{cost\text{-}plus} > 0$ (30)

2. In Case of Full-Pay Reimbursement(r=1)

With full-pay(r = 1) reimbursement, $c_x = 0$ by (3)-b.

Thereby $\pi_{xm}^U = \pi_{mm} < 0$ (8)-c

From (4), $\pi_{xq}^U = p_q - c_q = -(r-1)\ (m\ c_q)/x$

where r = 1, so

$$\pi_{xq}^U = (p_q - c_q) = 0 \qquad (10)\text{-c}$$

and $\pi_{mq}^U = (r-1)\ c_q = 0$ (11)-c

From (23)-a

$$dx/dr\ |H^U| = \pi_{qq}^U\ \{\ \Omega\ \} \qquad (23)\text{-c}$$

$$\Omega = -\ m\ c_x\ \pi_{mm}^U + (c + mc_x)\ \pi_{xm}^U$$

$$= -\ m\ c_x\ (\pi_{mm}^U - \pi_{xm}^U) + c\ \pi_{xm}^U$$

$$= -\ m\ c_x\ (\ r\ c_x) + c\ \pi_{xm}^U$$

$$= -\ r\ m\ (c_x)^2 + c\ \pi_{xm}^U < 0 \text{ (cf., (8)-a))}$$

Thereby $dx/dr = \pi_{qq}^U\ \{\ \Omega\ \}\ /|H^U| < 0$

where $|H^U| < 0$ by SOC

<u>Therefore, $dx/dr_{full\text{-}pay} < 0$ (24)-c</u>

And by similar procedure(cf. (27)),

<u>$dm/dr_{full\text{-}pay} > 0$ (27)-c</u>

From (29)-a

$$dq/dr\ |H^U| = -\ m\ c_x\ \{\ \Phi'\ \} + (c + m\ c_x)\ \{\ \Theta'\ \} - m\ c_q\ \{\ \Omega'\ \}$$

$$= - m\, c_x\, (\, \Phi' - \Theta') + c\, \Theta' - m\, c_q\, \Omega'$$

where

$$\Phi' = (\pi_{xm}^{U}\, \pi_{mq}^{U} - \pi_{xq}^{U}\, \pi_{mm}^{U}) \quad = 0 \quad (cf.\, \pi_{mq}^{U} = \pi_{xq}^{U} = 0\,),$$

$$\Theta' = (\pi_{xx}^{U}\, \pi_{mq}^{U} - \pi_{xq}^{U}\, \pi_{xm}^{U}) \quad = 0 \quad (cf.\, \pi_{mq}^{U} = \pi_{xq}^{U} = 0\,),$$

$$\Omega' = \{\pi_{xx}^{U}\, \pi_{mm}^{U} - (\pi_{xm}^{U})^2\} \quad > 0 \qquad (\text{ by } (15)\,)$$

Thereby $dq/dr = \; - m\, c_q\, \Omega' \;\; / |H^U|$

where $|H^U| < 0$ by SOC

<u>Therefore, $dq/dr_{full\text{-}pay} \;\; > \;\; 0$ (30)-c</u>

3. In Case of Underpayment($r < 1$)

With underpayment($r < 1$) reimbursement, $c_x < 0$ by (5).

Thereby $\quad \pi_{xm}^{U} = (\pi_{mm} - r\, c_x)$: uncertain (8)-d

From (4), $\quad p_q - c_q = -\,(r-1)\,(m\, c_q)/x$

$r < 1$ & $c_q > 0$ by assumption,

$$\pi_{xq}^{U} = (p_q - c_q) \;\; > 0 \qquad (10)\text{-d}$$

and $\quad \pi_{mq}^{U} = (r-1)\, c_q \quad < 0$ (11)-d

From (23)-a

$$dx/dr\; |H^U| = \pi_{xq}^{U}\, \{\, \Phi\, \} + (-\, \pi_{mq}^{U})\, \{\, \Theta\, \} + \pi_{qq}^{U}\, \{\, \Omega\, \}$$

where

$\Phi = -\,(c+m\, c_x)\, \pi_{mq}^{U} + m\, c_q\, \pi_{mm}^{U}$ uncertain (cf., $c_x < 0$, (9)-a, (11)-d & $c_q > 0$)

$\Theta = - m\ c_z\ \pi_{mq}^{\,U} + m\ c_q\ \pi_{zm}^{\,U}$ uncertain (cf., $c_z < 0$, (8)-d, (11)-d & $c_q > 0$),

$$\Omega = - m\ c_z\ \pi_{mm}^{\,U} + (c+mc_z)\ \pi_{zm}^{\,U}$$

$$= - m\ c_z\ (\pi_{mm}^{\,U} - \pi_{zm}^{\,U}) + c\ \pi_{zm}^{\,U}$$

$$= - m\ c_z\ (\ r\ c_z) + c\ \pi_{zm}^{\,U}$$

$$= - r\ m\ (c_z)^2 + c\ \pi_{zm}^{\,U} \quad \text{uncertain} \quad (\text{cf., (8)-d})$$

The sign of $dx/dr_{underpayment}$ may be bigger, smaller or equal to zero (24)-d

and from similar procedure,

The sign of $dq/dr_{underpayment}$ may be bigger, smaller or equal to zero (29)-d

Unlike the cases of cost-plus or full-pay, the sign of dx/dr, and dq/dr are uncertain here. But, as far as dm/dr is concerned, we can utilize (1)-c --i.e., $c_2m_2 \geq c_1m_1$ in case of $r_2 > r_1 > 0$. From (6)-b, $dz/dr > 0$ thereby $c_2 < c_1$ (because the hospital is operating on the stage of decreasing average costs here). Therefore, in order to get $c_2m_2 \geq c_1m_1$, m_2 should be bigger than m_1--i.e, $dm/dr_{underpayment} > 0$.

Therefore, the sign of $dq/dr_{underpayment} > 0$ (27)-d

If we introduce some restrictions to the model, dx/dr can be explained in detail.

a. Fixed Quality Model: $q = \bar{q}$(fixed)

If we introduce "fixed quality[7]" into the unconstrained model(1), it becomes the same model of Hay(1983) and Foster (1985):

$$\max_{x,m} \pi^H = p(x)*x + r*c(x+m)*m - c(x+m,)*(x+m) \qquad (1)H$$

The first order conditions of (1)H are:

$$\pi_x^H = (p_x\, x + p) - c + (rm-x-m)\, c_x$$
$$= MR(x) - c + (rm-x-m)\, c_x = 0 \qquad (2)H\text{-}a$$

$$\pi_m^H = (r-1)c + (rm-x-m)c_x = 0 \qquad (3)H\text{-}b$$

From (2)H-a & (3)H-b, the second partial derivatives are found to be:

$$\pi_{xx}^H = p_{xx}x + 2p_x - 2c_x + (rm-x-m)c_{xx} \qquad (7)H$$
$$\pi_{xm}^H = (r-2)c_x + (rm-x-m)c_{xx} \qquad (8)H$$
$$\pi_{mm}^H = 2(r-1)c_x + (rm-x-m)c_{xx} \qquad (9)H$$

Totally differentiating (2)H-a and (3)H-b:

[7] In order to guarantee the minimum quality of care, some country can impose minimum quality law as a package policy with underpayment.

$$\begin{bmatrix} \pi^H_{xx} & \pi^H_{xm} \\ \pi^H_{xm} & \pi^H_{mm} \end{bmatrix} \begin{bmatrix} dx \\ dm \end{bmatrix} = \begin{bmatrix} E^H_x \\ E^H_m \end{bmatrix} [dr]$$

.............(18)H

where

$E_x^H = - m\ c_x$ (19)H

$E_m^H = - (c + m\ c_x)$ (20)H

$dx/dr_{|quality\ fixed} = \{-m\ c_x\ \pi_{mm}^H + (c + m\ c_x)\ \pi_{xm}^H\} / |D^H|$

Let $\Omega^H = -m\ c_x\ \pi_{mm}^H + (c + m\ c_x)\ \pi_{xm}^H$

Thus $dx/dr_{|quality\ fixed} = \Omega^H / |D^H|$ (23)H

For the comparison with the unconstrained model, from (23)-a

$dx/dr\ |H^U| = \pi_{xq}^U \{ \Phi \} + (- \pi_{mq}^U) \{ \Theta \} + \pi_{qq}^U \{ \Omega \}$

where

$\Omega = - m\ c_x\ \pi_{mm}^U + (c + m\ c_x)\ \pi_{xm}^U$

Since the signs of $c_{x\ unconstrained}$ & $c_{x\ |quality\ fixed}$, π_{mm}^U & π_{mm}^H and π_{xm}^U & π_{xm}^H are same, the signs of Ω and Ω^H are always equal. And the sign of $dx/dr_{unconstrained}$ = the sign of $dx/dr_{|quality\ fixed}$ + " impacts from quality change".

In other words:

The sign of $dx/dr_{unconstrained}$ = " Pure Effect" + " Quality Effect"

Pure Effect

From (23)H

$$dx/dr|_{\text{quality fixed}} = \{-m\ c_z\ \pi_{mm}^H + (c + m\ c_z)\ \pi_{zm}^H\} \ / \ |D^H| \qquad (23)H$$

Let $dx/dr|_{\text{quality fixed}} = dx/dr^H$

So
$$\begin{aligned} dx/dr^H * |D^H| &= -\ m\ c_z\ \pi_{mm}^H + (c + mc_z)\ \pi_{zm}^H \\ &= -\ m\ c_z\ (\pi_{mm}^H - \pi_{zm}^H) + c\ \pi_{zm}^H \\ &= -\ m\ c_z\ (\ r\ c_z) + c\ \pi_{zm}^H \\ &= -\ r\ m\ (c_z)^2 + c\ \pi_{zm}^H \end{aligned}$$

Now define:

$$\phi \equiv \left| \frac{C_{zz}\ Z}{C_z} \right|$$

which measures the degree of convexity. Given that $c_{zz} > 0$, $\phi = -(c_{zz}\ z)/c_z$ since $r < 1$ and thereby $c_z < 0$ (cf. (5)).

and $\delta =$ m/z means the share of Medicare/Medicaid patient of total and represents patient-mix at equilibrium.

Then

$$\begin{aligned} \pi_{zm}^H &= (r-2)c_z + (rm-x-m)c_{zz} \qquad \text{(cf.(8)H)} \\ &= c_z\ \{\ (r-2) + c_{zz}z/c_z\ (rm/z - 1)\} \\ &= c_z\ \{\ (r-2) - \phi\ (r\delta - 1)\} \end{aligned} \qquad (8)H\text{-a}$$

Similarly

$$\pi_{mm}^H = c_z\ \{\ 2(r-1) - \phi\ (r\delta - 1)\} \qquad (9)H\text{-a}$$

and from (3)H-b

$$c = -\ \{c_z/(r-1)\}\ (rm-x-m) = -\ \{c_z/(r-1)\}\ (r\delta - 1)z$$

where $(rm-x-m)=z(r\delta-1) < 0$ by (6)-a. Thereby $1 - r\delta > 0$ for all "r" and for any $\delta \in (0,1)$.

Hence

$$dx/dr^H * |D^H| = - rm\,(c_z)^2 + c\,\pi_{xm}{}^H = - rm\,(c_z)^2 + c\,\pi_{mm}{}^H - rc_z\,c$$

$$= c\,\pi_{mm}{}^H + r(c_z)^2\,z\,\{(r\delta-1)/(r-1)\} - (c_z)^2\,z\,r\delta$$

$$= c\,\pi_{mm}{}^H + r/(r-1)\,(c_z)^2\,z\,\{(r\delta-1) -(r-1)\delta\}$$

$$= c\,\pi_{mm}{}^H - r/(r-1)\,(c_z)^2\,z\,(1-\delta)$$

By plugging c & $\pi_{mm}{}^H$

$$= [\{-c_z/(1-r)\}\,(1-r\delta)z]\,[-c_z\,\{\,2(1-r) - \phi\,(1-r\delta)\}] + r/(1-r)\,(c_z)^2\,z\,(1-\delta)$$

$$= \{c_z{}^2/(1-r)\}z\,\,[(1-r\delta)\{\,2(1-r) - \phi\,(1-r\delta)\}] + r/(1-r)\,(c_z)^2\,z\,(1-\delta)$$

$$=1/(1-r)\,(c_z)^2\,z\,[(1-r\delta)\{\,2(1-r) - \phi(1-r\delta)\} + r(1-\delta)]$$

where $[\ \dots\ ] = - \phi(1-r\delta)^2 + 2(1-r\delta)(1-r) + r(1-\delta)$

Therefore

$$dx/dr^H \;\begin{matrix} > \\ = \\ < \end{matrix}\; 0 \qquad \text{iff} \quad [\ \dots\ ] \;\begin{matrix} > \\ = \\ < \end{matrix}\; 0$$

Hence

$$dx/dr^H > 0 \quad \text{if } \phi < 1/(1-r\delta)^2\,\{\,2(1-r\delta)(1-r) + r(1-\delta)\}$$

$$\frac{dx}{dr} > 0 \quad \text{if} \quad \phi < \frac{2(1-r)}{(1-r\delta)} + \frac{r(1-\delta)}{(1-r\delta)^2} \qquad \text{............(a)}$$

Now, for SOC to hold, $\pi_{mm}{}^H < 0$

$$\pi_{mm}{}^H = c_z\,\{\,2(r-1) - \phi\,(r\delta - 1)\} < 0:$$

Thereby

$$\phi > \frac{2(1-r)}{(1-r\delta)} = 2 - \frac{2r(1-\delta)}{(1-r\delta)}$$

.............(b)

From (a) & (b), the interval of ϕ which satisfies dx/dr > 0 and SOC is:

$$\frac{2(1-r)}{(1-r\delta)} < \phi < \frac{2(1-r)}{(1-r\delta)} + \frac{r(1-\delta)}{(1-r\delta)^2}$$

.............(c)

or

$$2 - \frac{2r(1-\delta)}{(1-r\delta)} < \phi < 2 - \frac{2r(1-\delta)}{(1-r\delta)} + \frac{r(1-\delta)}{(1-r\delta)^2}$$

.............(d)

or

$$2 - \frac{2r(1-\delta)}{(1-r\delta)} < \phi < 2 + \frac{r(1-\delta)(2r\delta-1)}{(1-r\delta)^2}$$

.............(e)

From total cost(TC=cz), marginal cost(MC) = $c + c_z z$ and

$$MC_z = 2c_z + c_{zz} z = (2 - \phi) c_z.$$

where $\phi \gtreqless 2$, iff $MC_z \gtreqless 0$

Therefore, the sign of dx/dr would be changed around MC_x = 0. But we cannot say that the sign will be changed exactly at MC_x = 0. For an example, if MC_x = 0 (thereby $\phi = 2$) and $r\delta > \frac{1}{2}$, then $dx/dr^H > 0$ at minimum marginal cost. But, if MC_x = 0 (thereby $\phi = 2$) and $r\delta < \frac{1}{2}$, then $dx/dr < 0$ at minimum marginal cost.

Here, the operating situation of hospitals with under-payment can be divided largely into three categories:

1) "Dumping": If "r" is given lower than "reserved reimbursement rate" of the hospital, then m=0.

2) Cost-Shifting: If "r" is given higher than "reserved reimbursement rate" of the hospital and ϕ satisfies the condition "(e)", then $dx/dr > 0$ thereby $dp/dr < 0$. In this case, marginal costs may be in the phase of decreasing, minimum or increasing.

3) Cross-Subsidy: If "r" is given higher than the "reserved reimbursement rate" of the hospital and $\phi > 2 + r(1-\delta)(2r\delta-1) / (1-r\delta)^2$, then $dx/dr < 0$ thereby $dp/dr > 0$. In this case, marginal cost may be in the stage of decreasing, minimum or increasing.

Hay(1983) and Foster(1985) observed "cross-subsidy" only in the increasing marginal cost.

In the case of introducing adjustment cost(Foster (1985))-- e.g., $a(m-\bar{m})^2$, the only change with respect to the analysis of comparative statics will be the additional term of "-2a" to the (9)H:

$$\pi_{mm}^{H}{}_{\text{adjustment cost}} = 2(r-1)c_x + (rm-x-m)c_{xx} - 2a \qquad (9)H\text{-}b$$

and the "-2a" is added as "negative" term($2a*m*c_x$) in the process of calculating $dx/dr_{\text{underpayment}}$. Therefore, the possibility of getting "cross-subsidy" is increased by the introduction of "adjustment cost" with underpayment. However,if the coefficient("a") of $a(m-\bar{m})^2$ is relatively small[8], the basic results discussed above are intact.

[8] Since "-2a" is added as "positive" term($2a*m*c_x$) in the calculation of dx/dr under cost-plus reimbursement. therefore, with too big "a", "cost-shift(dp/dr < 0)" instead of "cross-subsidy(dp /dr > 0)" would be expected in case of cost-plus reimbursement.

CHAPTER II--Applications

In the previous chapter, we have shown how a hospital selects the optimal number of private and Medicare/Medicaid patients when certain reimbursement rates are given. In this chapter, we will explore the possibility of applying our results to other models, and providing the answers to fundamental issues.

A. Sloan(1980) Model: q=q(m)

By introducing q=q(m)[9] into the unconstrained model (1):

$$\max_{x,m} \pi^S = p(x,q(m))*x + r*c(x+m,q(m))*m - c(x+m,q(m))*(x+m) \quad \text{...........(1)s}$$

We can argue that <u>π^U(Unconstrained) ≥ π^S(restriction of q=q(m))</u> at equilibrium. As long as π^U and π^S have the same functions of p=p(x,q) and c=c(x+m,q), any optimal choice in π^S can always be in the choice set of π^U.

The first-order conditions of (1)S are:

$$\pi_x^S = (p_x\, x + p) - c + (rm-x-m\,)\, c_x = 0 \qquad (2)S\text{-a}$$

$$\pi_m^S = p_q q_m x + (rm-x-m)(c_x + c_q\, q_m) + (r - 1)\, c$$

$$= p_q q_m x + (rm-x-m)c_q\, q_m + (rm-x-m)c_x + (r - 1)c$$

---

[9] We use q=q(m) instead of m=m(q) only for convenience of comparing with other models.

$$= \{p_q\, x + (rm-x-m)c_q\}\, q_m + (r - 1)c + (rm-x-m)c_x = 0 \qquad (3)S\text{-}b$$

We observe that equation (2)-a and (2)S-a are identical. And if $p_q\, x = -(rm-x-m)c_q$ --i.e., "marginal quality neutrality" holds, (3)-b and (3)S-b are identical. The two models generate the same number of x* and m* at equilibrium under any level of reimbursement rate(r). Thus, as far as x* and m* are concerned, we can utilize the results of comparative statics of "unconstrained model" under the assumption "marginal quality neutrality", rather than that of this complicated model. But "marginal quality neutrality" may be or may not be hold. One cannot always satisfy this condition and other FOCs simultaneously. This may be possible by properly choosing "r".

B. Applications to Related Issues

From (2)-b and (3)-a:

$$p\,(\,1 - 1/|\epsilon|\,) = rc \quad \text{at equilibrium} \qquad (7)$$

where, $|\epsilon| > 1$ (because $rc > 0$)

By rewriting (7)

$$p/rc = |\epsilon| \,/\, (|\epsilon|-1)$$

Let $|\epsilon| / (|\epsilon|-1) = k$ which is not fixed, but always bigger than 1.

$$\text{Thus} \qquad p/rc = k > 1 \qquad (8)$$

Is this price($p = rc*k$) bigger than P^B (the price before the introduction of "r"--i.e., uniform price)? Before the introduction of "r":

$$\max_{p^B} \pi^B = p^B (x^B + m^B) - c^B (x^B + m^B)$$

F.O.C. $\pi_p^B = (x^B + m^B) + p^B (x_p^B + m_p^B) - MC^B(x_p^B + m_p^B) = 0$

Thereby $(p^B - MC^B) = -(x^B + m^B) / (x_p^B + m_p^B)$

by multiplying $(1/p^B)$,

$$(p^B - MC^B)/p^B = (x^B + m^B) / (x^B |\epsilon_x^B| + m^B |\epsilon_m^B|)$$

$$\text{where } |\epsilon_x^B| = |- x_p^B(p^B/x^B)|$$

$$|\epsilon_m^B| = |- m_p^B(p^B/m^B)|$$

By assumption $m^B \approx 0$[10] or $\epsilon_x^B \approx \epsilon_m^B$ at equilibrium,

$$(p^B - MC^B)/p^B = 1 / |\epsilon_x^B|$$

---

[10] For convenience. But for some countries, this assumption is plausible.

Therefore $MC^B = p^B\{ 1 - (1 / |\epsilon_z^B|)\}$ (2)-d

From (2)-b, $MC = p(1 - 1/|\epsilon|) + r\, c_z\, m$ (2)-e

From assumption of constant elasticity[11] and (2)-d & (2)-e,

$$p(1 - 1/|\epsilon|) + rc_z m \;\begin{smallmatrix}>\\=\\<\end{smallmatrix}\; p^B (1 - 1/|\epsilon|), \quad \text{iff } MC \begin{smallmatrix}>\\=\\<\end{smallmatrix} MC^B$$

So, $$(p - p^B) \;\begin{smallmatrix}>\\=\\<\end{smallmatrix}\; - rc_z m * k, \quad \text{iff } MC \begin{smallmatrix}>\\=\\<\end{smallmatrix} MC^B \qquad (2)\text{-f}$$

where $k = |\epsilon| / (|\epsilon|-1) > 1$ and constant here

So, the sign of $(p-p^B)$ depends on the sign of $(MC - MC^B)$ and the sign of c_z at equilibrium. After the introduction of reimbursement($r > 0$):

1) If marginal costs at the new equilibrium are bigger than that of the old equilibrium($MC > MC^B$)[12] and if:

a) the hospital is operating on the phase of increasing average costs($c_z > 0$) at new equilibrium, then the new price(p) for private pay patients may be bigger or smaller or equal to the uniform price(p^B: before "r" introduced). because $(p-p^B)$ > "negative value".

$$p \;\begin{smallmatrix}>\\=\\<\end{smallmatrix}\; p^B \quad \text{iff } MC > rc_{\text{at equilibrium } "z"} \;\begin{smallmatrix}>\\=\\<\end{smallmatrix}\; MC^B$$

---

[11] e.g., $p = \alpha\, x^{-\beta}$.

[12] MC_z^B can be bigger, equal or smaller than at equilibrium.

b) the hospital is operating on the phase of decreasing(or minimum) average costs--i.e., $c_I \le 0$ at new equilibrium, then the new price(p) for private pay patients is bigger than the uniform price, because $(p-p^B) > 0$.

2) If marginal costs at the new equilibrium are the same as that of old equilibrium($MC = MC^B$) and if:

a) the hospital is operating on the phase of increasing average costs($c_I > 0$) at new equilibrium, then the new price(p) for private pay patients is smaller than the uniform price(p^B), because $(p-p^B)$ = "negative value".

b) the hospital is operating on the minimum average costs ($c_I = 0$) at the new equilibrium, then the new price(p) for private pay patients is the same as the uniform price, because $(p-p^B) = 0$.

c) the hospital is operating on the phase of decreasing average costs($c_I < 0$) at new equilibrium, then the new price(p) for private pay patients is bigger than the uniform price, because $(p-p^B)$ > "positive value".

3) If marginal costs at the new equilibrium are smaller than that of the old equilibrium($MC < MC^B$) and if:

3) If marginal costs at the new equilibrium are smaller than that of the old equilibrium($MC < MC^B$) and if:

a) the hospital is operating on the phase of increasing(or minimum) average costs--i.e., $c_r \geq 0$ at the new equilibrium, then the new price(p) for private pay patients is smaller than the uniform price(p^B), because $(p-p^B) < 0$.

b) the hospital is operating on the phase of decreasing average costs ($c_r < 0$) at new equilibrium, then the new price(p) for private pay patients may be bigger or smaller or equal to the uniform price, because $(p-p^B) <$ "positive value".

$$p \gtreqless p^B \qquad \text{iff} \quad MC < rc_{\text{at equilibrium "r"}} \gtreqless MC^B$$

From the above static results and comparative statics of the previous chapter, we provide arguments related to the aforementioned controversial issues:

4) The price of private patients is higher than that of Medicare/Medicaid patients since $p/rc = k > 1$. The price differentials--e.g., $p-rc=(k-1)rc$, will increase as "rc" increases since $d(p-rc)/d(rc) = k-1 > 0$. This implies that, in case of cost-plus reimbursement, the larger the rate of reimbursement(r) is given, the higher "rc" and "the price(p)" charged to private patients are expected, thereby raising

consumer insurance premiums and out-of-pocket payments.--i.e.,hospital costs increase. This is a counter argument against private insurance carriers' cost-shift argument--e.g., government underpayment induces hospitals to impose higher charges on private-pay patients, thereby resulting in higher insurance premiums and out-of-pocket payments.

5) As shown in the previous results in case of underpayment, "rc" and "p" can be either increased or decreased by increases in "r". Therefore, either cost-shift or cross-subsidy can be observed. This is a counter argument to Hay(1983)'s and Foster(1895)'s "genuine cost shift(cross-subsidy) " argument--e.g., private patients benefit from reduction in government payment.

6) The ratio of private patients' price(p) to government paid patients' price(rc) depends on the elasticity($|\epsilon|$) faced by the hospital and has no connection with the level of reimbursement rate(r). In other words, the price differentials originate from "private demand" faced by each hospital, not from cost-plus or underpayment policy. And this can be a counter argument to Sloan(1983)'s argument--e.g., differential payment cannot be justified.

7) As shown in the introduction, there are two seemingly different arguments on the cause of increasing hospital

costs. While Enthoven(1980) and others argue that full or cost-plus reimbursement has been the cause of increasing hospital costs through increased "rc", private insurance carriers argue that underpayment reimbursement has been the cause of increasing hospital costs through increased "p". Since p/rc = k > 1, they are talking on the other side of the same coin. If "rc" increases by 1 dollar, then "p" will increase by k(>1) dollars. But we can not guarantee that "rc" is always increasing function of "r". For example, with decreasing average cost, increases in r can lead to either increases in "rc" or decreasing "rc".

8) quality-access trade-off in private market:

We provide the theoretical expectation that, under cost-plus reimbursement, the increase in the rate of return on Medicaid patient care induces hospitals <u>to admit less private patients and to increase the quality of care.</u>

CHAPTER III--Prospective Payment System

In this chapter, we will demonstrate what the changes are by introducing prospective payment system instead of cost-based reimbursement.

A. Unconstrained Model with PPS

From (1), by setting rc = R(fixed) or r+c=R(fixed):

$$\max_{x,m,q} \pi^R = p(x,q)*x + R*m - c(x+m,q)*(x+m) \quad (1)R$$

subject to $x \geq 0$ and $m \geq 0$

$$\pi_x^R = p_x x + p - MC \leq 0 \quad (2)R\text{-a}$$

$$\text{or} \quad p(1 - 1/|\epsilon|) - MC \leq 0 \quad (2)R\text{-b}$$

$$\text{or} \quad MR(x) - c - (x+m)c_x \leq 0 \quad (2)R\text{-c}$$

where, $|\epsilon|$ = absolute value of elasticity

$$\pi_m^R = R - MC \leq 0 \quad (3)R\text{-a}$$

$$\text{or} \quad R - c - (x+m)c_x \leq 0 \quad (3)R\text{-b}$$

$$\pi_q^R = p_q x - (x+m) c_q \leq 0 \quad (4)R$$

The second partial derivatives are:

$$\pi_{xx}^R = p_{xx}x + 2p_x - 2c_x - (x+m)c_{xx} \quad (7)R$$

$$\pi_{xm}^R = -2c_x - (x+m)c_{xx} \quad (8)R$$

$$\pi_{mm}^R = -2c_x - (x+m)c_{xx} \quad (9)R$$

$$\pi_{xq}^R = p_{xq}x + p_q - c_q - (x+m)c_{xq} \qquad (10)R$$

$$\pi_{mq}^R = - c_q - (x+m)c_{xq} \qquad (11)R$$

$$\pi_{qq}^R = p_{qq}x - (x+m)c_{qq} \qquad (12)R$$

Totally differentiating (2)R, (3)R & (4)R:

$$\begin{bmatrix} \pi_{xx}^R & \pi_{xm}^R & \pi_{xq}^R \\ \pi_{xm}^R & \pi_{mm}^R & \pi_{mq}^R \\ \pi_{xq}^R & \pi_{mq}^R & \pi_{qq}^R \end{bmatrix} \begin{bmatrix} dx \\ dm \\ dq \end{bmatrix} = \begin{bmatrix} E_x^R \\ E_m^R \\ E_q^R \end{bmatrix} dR$$

...........(18)R

where

$$E_x^R = 0 \qquad (19)R$$

$$E_m^R = -1 \qquad (20)R$$

$$E_q^R = 0 \qquad (21)R$$

Using Cramer's rule, we can express dx/dR as

$$\frac{dx}{dR} = \frac{\begin{vmatrix} 0 & \pi_{xm}^R & \pi_{xq}^R \\ -1 & \pi_{mm}^R & \pi_{mq}^R \\ 0 & \pi_{mq}^R & \pi_{qq}^R \end{vmatrix}}{|H^R|}$$

...............(22)R

Using Laplace Expansion, we can express dx/dR as

$$dx/dR = (\pi_{xm}^R \, \pi_{qq}^R - \pi_{mq}^R \, \pi_{xq}^R) \, / \, |H^R| \qquad (23)R$$

If we assume addictive functions on price and average cost equations, e.g., $p=p(x) + @(q)$ and $c = c(x+m) + \theta(q)$, then $p_{qx} = p_{qx} = 0$ and $c_{qx} = c_{qx} = 0$.

Then (7)R, (8)R & (9)R are intact and by assumptions on SOCs

$$\pi_{xx}^{R} = p_{xx}x + 2p_{x} - 2c_{x} - (x+m)c_{xx} \quad < 0 \qquad (7)\text{R-a}$$

$$\pi_{xm}^{R} = -2c_{x} - (x+m)c_{xx} \qquad (8)\text{R}$$

$$\pi_{mm}^{R} = - 2c_{x} - (x+m)c_{xx} \quad < 0 \qquad (9)\text{R-a}$$

But

$$\pi_{xq}^{R} = p_{q} - c_{q} \qquad (10)\text{R-a}$$

$$\pi_{mq}^{R} = - c_{q} \qquad (11)\text{R-a}$$

$$\pi_{qq}^{R} = p_{qq}x - (x+m)c_{qq} \quad < 0 \qquad (12)\text{R-a}$$

From SOC, $\pi_{xm}^{R} = \pi_{mm}^{R} < 0$ (8)R-a

From (4)R, $\pi_{xq}^{R} = p_{q} - c_{q} = (m/x)\ c_{q}$

By $c_{q} > 0$ by assumption,

$$\pi_{xq}^{R} = (p_{q} - c_{q}) \quad > 0 \qquad (10)\text{R-b}$$

and $\pi_{mq}^{R} = - c_{q} < 0$ (11)R-b

Thereby dx/dR = (sum of all positive terms)/$|H^{R}|$

where $|H^{R}| < 0$

<u>In any case--i.e., cost-plus(R>c) or full-pay(R=c) or underpayment(R<c), dx/dR < 0 (24)R</u>

Using Cramer's rule, we can express dm/dR as

$$\frac{dm}{dR} = \frac{\begin{vmatrix} \pi^R_{xx} & 0 & \pi^R_{xq} \\ \pi^R_{xm} & -1 & \pi^R_{mq} \\ \pi^R_{xq} & 0 & \pi^R_{qq} \end{vmatrix}}{|H^R|}$$

..........(25)R

$$dm/dR = (-1)\ (\pi_{xx}^R\ \pi_{qq}^R - \pi_{xq}^R\ \pi_{xq}^R)\ /\ |H^R| \qquad (26)R$$

where, $(\pi_{xx}^R\ \pi_{qq}^R - \pi_{xq}^R\ \pi_{xq}^R) > 0$ from SOC.

<u>Therefore, dm/dR > 0 (27)R</u>

Using Cramer's rule, we can express dq/dR as

$$\frac{dq}{dR} = \frac{\begin{vmatrix} \pi^R_{xx} & \pi^R_{xm} & 0 \\ \pi^R_{xm} & \pi^R_{mm} & -1 \\ \pi^R_{xq} & \pi^R_{mq} & 0 \end{vmatrix}}{|H^R|}$$

..........(28)R

$$dq/dR = (\pi_{xx}^R\ \pi_{mq}^R - \pi_{xq}^R\ \pi_{xm}^R)\ /\ |H^R| \qquad (29)R$$

<u>Therefore, dq/dR < 0 (30)R</u>

B. CBR vs. PPS

1. Cross-Subsidy vs. Cost-Shifting

From p/R = k > 1, increases in R lead to increases in p, thereby only "cross-subsidy"[13] will be expected in the Prospective Payment System. But in case of Cost-Based Reimbursement, from p/rc = k, if "r" is increased, then "rc" may be increased or decreased, therefore "cross-subsidy" or "cost-shift" will be expected.

2. Quality-Access Trade-Off

With PPS, by introducing R= rc(or R=r+c), we expect quality-access trade-offs in <u>Medicare/Medicaid patients</u>-- e.g., dx/dR < 0, dm/dR > 0 and dq/dR < 0. From R = rc or R= r + c, if "R" is given and not changed for the time being-- e.g., 1 year, then the hospital wants to increase the mark-up factor "r" by decreasing average costs(c). Since average costs are a function of total volume(x+m) and quality(q), the only way of decreasing average costs is to lower the expenditure of quality because total volume(z=x+m) is a non-decreasing function(|dm/dR| > |dx/dR|) of "R". Therefore, <u>quality-access trade-off in Medicare/Medicaid patients</u> become a built-in result as soon as PPS(R=rc or R=r+c) is introduced.

---

[13] From p=p(x,q) and p/R = k, dp/dR = $(\partial p/\partial x)(dx/dR) + (\partial p/\partial q)(dq/dR)$ = k > 0. Therefore, we can infer that $|(\partial p/\partial x)(dx/dR)|$ is bigger than $|(\partial p/\partial q)(dq/dR)|$.

With CBR, <u>quality-access trade-off in private patients</u> is expected--e.g., $dx/dr < 0$, $dm/dr > 0$ & $dq/dr > 0$ in cost-plus reimbursement.

3. Introduction of Prospective Payment System

$rc + rc_z m = MC$ (cf. (3)-a: CBR)

$R = MC^R$ (cf. (3)R-a:PPS)

In order to compare the results of CBR with that of PPS, the level of "R" is set equal to "rc".

Then, $MC^R = MC - rc_z m$ .... (31)

$$MC^R \begin{matrix} > \\ = \\ < \end{matrix} MC \quad \text{iff} \quad c_z \begin{matrix} < \\ = \\ > \end{matrix} 0 \quad \begin{matrix} \text{cf. underpayment} \\ \text{cf. full-payment} \\ \text{cf. cost-plus} \end{matrix}$$

and from (2)-c and (2)R-c

$MR(x) + rc_z m = MC$ (cf. (2)-c: CBR)

(2)-d

$MR(x)^R = MC^R$ (cf. (2)R-c:PPS)

(2)R-d

From (2)R-d, (31) and (2)-d

$MR(x)^R = MC^R = MC - rc_z m = MR(x)$ ..... (32)

Comparison of eqs. (31) and (32) reveal that the substitution of R for rc induces hospitals:

1) to decrease total volume($z=x+m$: x stay same), thereby raising marginal costs and average costs <u>in case of cost-plus</u>

reimbursement. However, there are no changes in private market--i.e., x and p are not changed.

2) to increase total volume($z=x+m$: x stay same), thereby reduce marginal costs and average costs in case of underpayment. However, there are no changes in private market--i.e., x and p are not changed.

From the above results, it can be readily inferred that "production efficiency" can be achieved without distorting the private sector simply by the substitution of PPS for CBR.

Assume two hospitals(A & B): "A" is operating on the phase of increasing average costs under cost-plus reimbursement($r>1$) and "B" is operating on the phase of decreasing average costs with underpayment policy($r<1$). If we introduce PPS instead of CBR, then "A" reduces Medicare/Medicaid patients, thereby decreasing average costs and "B" increases Medicare/Medicaid patients, thereby decreasing average costs. Hence some degree of production efficiency can be achieved.

If the decreased volume in "A" equal to the increased volume in "B", then "budget-saving" can also be achieved since $R^A(=r^A c^A)$ is greater than $R^B(=r^B c^B)$.

C. PPS vs. CBR with "adjustment cost"

If we introduce Foster(1985)'s adjustment cost: $c_k = c_k(m-\bar{m})$--e.g., $a(m-\bar{m})^2$.

FOCs with respect to "m",

$$\text{CBR: } rc + rc_z{}^A m^A - c_k{}'^A = MC^A$$

$$\text{PPS: } R - c_k{}'^{RA} = MC^{RA}$$

In order to compare the results of CBR with that of PPS, The level of "R" is set equal to "rc".

Then, $MC^{RA} = MC^A - rc_z{}^A m^A + (c_k{}'^A - c_k{}'^{RA})$ .... (31)A

$$MC^{RA} \begin{matrix} > \\ = \\ < \end{matrix} MC^A \quad \text{iff} \quad c_z{}^A \begin{matrix} < \\ = \\ > \end{matrix} (c_k{}'^A - c_k{}'^{RA})/rm^A$$

where $c_k' = dc_k / dm$

Since $(c_k{}'^A - c_k{}'^{RA})$ may be bigger, equal or smaller than zero, the total volume(z=x+m) would be greater, equal or less than its previous level(CBR case). Foster's argument--e.g., $MC^{RA} > MC^A$-- is supported only in the case of $(c_k{}'^A - c_k{}'^{RA})/rm^A < 0$.

From FOCs with respect to "x",

$$\text{CBR: } MR(x)^A + rc_z{}^A m^A = MC^A \quad \text{or} \quad MC^A - rc_z{}^A m^A = MR(x)^A$$

$$\text{PPS: } MR(x)^{RA} = MC^{RA}$$

Then

$$MR(x)^{RA} = MC^{RA} = MC^A - rc_z{}^A m^A + (c_k{}'^A - c_k{}'^{RA})$$

$$= MR(x)^A + (c_k{}'^A - c_k{}'^{RA})$$

So $MR(x)^{RA} = MR(x)^A + (c_k{}'^A - c_k{}'^{RA})$

Since $(c_k'^A - c_k'^{RA})$ may be bigger, equal or smaller than zero, the price of private patients would be greater, equal or less than its previous level(CBR case). Foster's argument--e.g., $p^{RA} > p^A$-- is supported only in case of $(c_k'^A - c_k'^{RA}) > 0$.

CHAPTER IV--Nursing Home Cases

Dusansky(1988) and Gertler(1989) introduced the patient capacity constraint(x+m=B) into the unconstrained model. The former treats the nursing home reimbursement method as CBR and the latter treats it as PPS. In their empirical studies, while Dusansky observed $dx/dr > 0$ and $dq/dr < 0$, Gertler observed $dm/dR > 0$ and $dq/dR < 0$ by imposing additional restraints(R=r+c). Our concern is to provide theoretical expectations to the both cases.

A. With B(fixed)= x + m

From (1),

$$\max_{x,m,q} \pi^U = p(x,q)*x + r*c(x+m,q)*m - c(x+m,q)*(x+m) \quad (1)$$

subject to $x \geq 0$ and $m \geq 0$

By introducing B(fixed) = x + m

$$\max_{x,q} \pi^B = p(x,q)*x + r*c(q)*(B - x) - c(q)*B \quad (1)B$$

$$\pi_x^B = p_x\, x + p - r\, c \leq 0 \quad (2)B\text{-}a$$

$$\text{or} \quad p(1 - 1/|\epsilon|) - r\, c \leq 0 \quad (2)B\text{-}b$$

$$\text{or} \quad MR(x) - rc \leq 0 \quad (2)B\text{-}c$$

where, $|\epsilon|$ = absolute value of elasticity

$$\pi_q^B = p_q\, x + r\, c_q\, (B - x) - c_q\, B$$

or

$$= p_q x - \{rx - (r-1)B\} \bar{c}_q \leq 0 \qquad (4)B$$

SOCs

$$\pi_{xx}^B = p_{xx} x + p_x \qquad (7)B$$

$$\pi_{xq}^B = p_{xq} x + p_q - r c_q \qquad (10)B$$

$$\pi_{qq}^B = p_{qq} x - \{rx - (r-1)B\} c_{qq} \qquad (12)B$$

Totally differentiating (2)B & (4)B:

$$\begin{bmatrix} \pi_{xx}^B & \pi_{xq}^B \\ \pi_{xq}^B & \pi_{qq}^B \end{bmatrix} \begin{bmatrix} dx \\ dq \end{bmatrix} = \begin{bmatrix} E_x^B \\ E_q^B \end{bmatrix} dr$$

............(18)B

where

$$E_x^B = c \qquad (19)B$$

$$E_q^B = - c_q (B-x) \qquad (20)B$$

Using Cramer's rule, we can express dx/dr as

$$\frac{dx}{dr} = \frac{\begin{vmatrix} c & \pi_{xq}^B \\ -c_q(B-x) & \pi_{qq}^B \end{vmatrix}}{|H^B|}$$

.............(22)B

$$dx/dr = (c\ \pi_{qq}^B + c_q(B-x)\ \pi_{xq}^B)\ /\ |H^B| \qquad (23)B$$

If we assume addictive functions on price equations-- e.g., $p=p(x) + @(q)$, then $p_{qx} = p_{qx} = 0$.

Then (7)B and (12)B are intact and by assumptions on SOCs

$$\pi_{xx}^{B} = p_{xx}x + p_{x} < 0 \qquad (7)B\text{-a}$$

$$\pi_{xq}^{B} = p_{q} - rc_{q} \qquad (10)B$$

$$\pi_{qq}^{B} = p_{qq}x - \{rx - (r-1)B\}c_{qq} < 0 \qquad (12)\text{-Ba}$$

<u>In Case of Cost-Plus Reimbursement</u>

From (4)B, $\pi_{xq}^{B} = p_{q} - rc_{q} = -(r-1)\ B\ (c_{q}/x)$

$r > 1$ & $c_{q} > 0$ by assumption,

$$\pi_{xq}^{B} = (p_{q} - rc_{q}) < 0 \qquad (10)B\text{-b}$$

Thereby dx/dr = (sum of all negative terms)/$|H^{B}|$

where $|H^{B}|>0$

<u>Therefore, $dx/dr^{B}_{cost\text{-}plus} < 0$ (24)B</u>

<u>In Case of Underpayment(r<1)</u>

$$\pi_{xq}^{B} = p_{q} - rc_{q} = -(r-1)\ B\ (c_{q}/x) > 0$$

But $dx/dr = (c\ \pi_{qq}^{B} + c_{q}(B-x)\ \pi_{xq}^{B})\ /\ |H^{B}|$

<u>Therefore, $dx/dr^{B}_{underpayment}$: uncertain (24)B-a</u>

Using Cramer's rule, we can express dq/dr as

$$\frac{dq}{dr} = \frac{\begin{vmatrix} \pi^B_{xx} & c \\ \pi^B_{xq} & -c_q(B-x) \end{vmatrix}}{|H^B|}$$

...........(28)B

$dq/dr = \{\pi_{xx}{}^B * -c_q(B-x) - c\ \pi_{xq}{}^B\} / |H^B|$ (29)B

<u>In Case Cost-Plus Reimbursement</u>

From (4)B, $\pi_{xq}{}^B = p_q - rc_q = -(r-1)\ B\ (c_q/x)$

$r > 1$ & $c_q > 0$ by assumption,

$\pi_{xq}{}^B = (p_q - rc_q) < 0$ (10)B-b

Thereby dq/dr = (sum of all positive terms)/$|H^B|$

where $|H^B|>0$

<u>Therefore, $dq/dr^B{}_{cost\text{-}plus} > 0$ (30)B</u>

<u>In Case of Underpayment(r<1)</u>

$\pi_{xq}{}^B = p_q - rc_q = -(r-1)\ B\ (c_q/x) > 0$

But $dx/dr = \{\pi_{xx}{}^B * -c_q(B-x) - c\ \pi_{xq}{}^B\} / |H^B|$

<u>Therefore, $dq/dr^B{}_{underpayment}$: uncertain (30)B-a</u>

As far as cost-plus reimbursement is concerned, our expectations of $dx/dr^B < 0$ and $dq/dr^B > 0$ are totally different from Dusansky's empirical results--e.g., $dx/dr^B > 0$ & $dq/dr^B < 0$.

B. With B(fixed)= x + m and R= r + c

From (1),

$$\max_{x,m,q} \pi^U = p(x,q)*x + r*c(x+m,q)*m - c(x+m,q)*(x+m) \quad (1)$$

subject to $x \geq 0$ and $m \geq 0$

By introducing B(fixed) = x + m and R=r + c

$$\max_{x,q} \pi^{BR} = p(x,q)*x + R*(B-x) - c(q)*B \quad (1)BR$$

$$\pi_x^{BR} = p_x x + p - R \leq 0 \quad (2)BR\text{-a}$$

$$\text{or } p(1 - 1/|\epsilon|) - R \leq 0 \quad (2)BR\text{-b}$$

$$\text{or } MR(x) - R \leq 0 \quad (2)BR\text{-c}$$

where, $|\epsilon|$ = absolute value of elasticity

$$\pi_q^{BR} = p_q x - \bar{c}_q B \leq 0 \quad (4)BR$$

SOCs

$$\pi_{xx}^{BR} = p_{xx}x + p_x \quad (7)BR$$

$$\pi_{xq}^{BR} = p_{xq}x + p_q \quad (10)BR$$

$\pi_{qq}{}^{BR} = p_{qq}x - c_{qq}B$ (12)BR

Totally differentiating (2)BR & (4)BR:

$$\begin{bmatrix}\pi_{xx}^{BR} & \pi_{xq}^{BR}\\ \pi_{xq}^{BR} & \pi_{qq}^{BR}\end{bmatrix}\begin{bmatrix}dx\\ dq\end{bmatrix} - \begin{bmatrix}E_{x}^{BR}\\ E_{q}^{BR}\end{bmatrix} dR$$

.........(18)BR

where

$E_x^B = 1$ (19)BR

$E_q^B = 0$ (20)BR

$dx/dR = \pi_{qq}{}^{BR} / |H^{BR}| < 0$ (23)BR

<u>Therefore, $dx/dR^{BR} < 0$ in case of B=x+m & R=r+c (24)BR</u>

If we assume addictive functions on price equations, e.g., p=p(x) + @(q), then $p_{qx} = p_{qx} = 0$.

Hence (7)BR and (12)BR are intact and by assumptions on SOCs

$\pi_{xq}{}^{BR} = p_q > 0$ (10)BR-a

So

$dq/dR = - p_q / |H^{BR}| < 0$ (29)BR

<u>Therefore, $dq/dR^{BR} < 0$ in case of B=x+m & R=r+c (30)BR</u>

From p=p(x,q) and p/R =k, dp/dR = $(\partial p/\partial x)(dx/dR)$ + $(\partial p/\partial q)(dq/dR)$ k > 0. Therefore, we can infer that

$|(\partial p/\partial \pi)(d\pi/dR)|$ is bigger than $|(\partial p/\partial q)(dq/dR)|$.

Gertler's comparative statics are ambiguous. However, his empirical results correspond with our theoretical expectations.

Conclusion

In this paper, we have demonstrated an unconstrained model of a price discriminating hospital. Under alternative reimbursement methods, equilibrium conditions and theoretical expectations on the effects of changes in the rates are provided as standards to clarify the importance of past studies on fundamental issues.

With CBR and <u>in case of cost-plus(r>1) or full-payment(r=1)</u>, increases in reimbursement rates lead to:

1) decreases in the number of private patients, thereby raising private patient charges,

2) increases in number of Medicare/Medicaid patients,

3) increases in the expenditures on quality.

Therefore,

4) increases in private patient charges(cross-subsidy) since $dx/dr < 0$ and $dq/dr > 0$.

With CBR, and <u>in case of underpayment(r<1)</u>, the changes are ambiguous. However, by introducing fixed quality into the model--i.e., quality effects are controlled, and increases in reimbursement rate lead to:

1) either increases in number of private patients(decreases in private patient charges:cost-shift); or decreases in the number of private patients(increases in private patient charges:cross-subsidy),

2) increases in the number of Medicare/Medicaid patients.

From above results and static analysis:

The introduction of underpayment may be or may not be the cause of private price increase. It depends on the standpoints of hospitals when government policy is introduced. The size of the private market, which determines patient-mix(δ) at equilibrium, and the operating situation, which determines the curvature(ϕ) of average costs, are key factors in clarifying the effects of government policy.

As soon as PPS(R=rc or R=r+c) is introduced into the unconstrained model, quality-access trade-off is expected in Medicare/Medicaid patients. Increases in "R" leads to decreases in the number of private patients, increases in the number of Medicare/Medicaid patients, and decreases in expenditure on quality. If "R" is not changed for the time being--e.g., 1 year, then the hospital will want to increase the mark-up factor "r" by decreasing average costs(c). Since average costs are a function of total volume(x+m) and quality(q), the only way of decreasing average costs is to lower the expenditure of quality because total volume(z=x+m) is a non-decreasing function($|dm/dR| > |dx/dR|$) of "R". Therefore, quality-access trade-off in Medicare/Medicaid patients has become a built-in result with the introduction of PPS(R=rc or R=r+c).

In the case of PPS, from p/R = k > 1, if R is increased, then p will be increased, therefore only "cross-subsidy" will be expected. However, in case of Cost-Based Reimbursement, from p/rc = k, if "r" is increased, then "rc" may be increased or decreased, and "cross-subsidy" or "cost-shift" will be expected.

In the case of introducing B(fixed)=x+m into the unconstrained CBR model(cf. Dusansky), theoretical expectations are the same as that of the unconstrained CBR model.

In the case of introducing B(fixed)=x+m into the unconstrained PPS model(cf. Gertler), theoretical expectations are the same as that of the unconstrained PPS model.

In both nursing home cases, the imposing of restrictions (B=x+m) cannot make any differ in results from original models, as far as the signs of comparative statics are concerned.

Bibliography

Danzon, patricia Munch. "Hospital `Profits': The Effects of Reimbursement Policies." Journal of Health Economics, 1, (1982) 29-52. North-Holland Publishing Company.

Dusansky, Richard. "On the Economics of Institutional Care of the Elderly in the U.S.: The effects of a Change in Government Reimbursement." Review of Economic Studies (1989), 56, 141-150.

Feder, Judith., et al. "How did the Medicare's Prospective Payment System affects Hospitals?" The New England Journal of Medicine, Vol. 317, NO. 14, 867-873, Oct. 1, 1987.

Feldman, Roger, and Dowd Bryan. "Is There Competitive Market for Hospital Services?" Journal of Health Economics, 5, (1986) 277-292. North-Holland.

Foster, Richard W. "Cost-Shifting under Cost Reimbursement and Prospective Payment." Journal of Health Economics, 4, (1985) 261-271. North-Holland.

Gertler, Paul J. "Subsidies, Quality, and the Regulation of Nursing Homes." Journal of Public Economics 38 (1989) 33-52. North-Holland.

Grossman, Michael. "Market for Hospital Services." Unpublished. The Graduate School and University Center of The City University of New York, 1989.

Hay, Joel W. "The Impact of Public Health Care Financing Policies on Private-Sector Hospital Costs." Journal of Health Politics, Policy and Law, Vol.7, NO. 4, winter (1983) 945-952.

Sloan, Frank A. " Insurance, Regulation, and Hospital Costs Theory." D.C. Heath and Company., 1980.

Sloan, Frank A, and Becker, Edmund R. "Cross-Subsidies and Payment for Hospital Care." Journal of Health Politics, Policy and Law, Vol. 8, NO. 4, Winter (1984) 660-683.