EXPLORING THE IMPACT OF INTRODUCING A REIMBURSEMENT POLICY OF HOSPITAL COSTS

OH, CHEE-JU*

I. Introduction

With the opening of the Korea's agricultural market there is an expected decline in the average rural agricultural income. An anticipated decline in income is seen by some as the beginning of an erosion in the standard of living and welfare of Korea's populace engaged in the agricultural sector. This probable and unfavorable change in rural income and welfare would be a result of importing decisions recently made in an environment of international market pressure. In this light, some compensation for farmers needs to be considered if such negative repercussions to opening Korea's agricultural market actually appear.

One avenue of compensation is to introduce a reimbursement program to provide government-funded health care coverage for a certain category of the farmers and fishermen. The possible impacts of introducing this reimbursement policy on hospital services to farmers and fishermen is explored below.

To begin I will introduce theoretical positions on government reimbursement of hospital costs for selected low income populations in the United States. Following this, I will outline an unconstrained price-discrimination monopoly model useful for explaining hospital administrative choices of types of patients, private and public. The conditions for the existence of equilibrium are constructed and utilized below to deal with the above issus. Finally, I will offer some possible scenarios if a reimbursement policy is introduced.

II. Cost-shift vs. Cross-subsidy

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

Cost-shift ($dp/dr < 0$)
Reduction in government payment leads to increases in the prices 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., Foster(1985) & Gertler(1989).

Strange as it may seem, there are always arguments and counter arguments related to the issue. 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? To answer these questions I will introduce an unconstrained price discriminating monopoly model.

III. 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 "$r \times c$"[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

[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.*

therefore choose x, m & q to maximize profits:

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

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

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 a hospital's price for private patients, the reimbursed price for Medicare/Medicaid patients and the number of private patients and government paid patients when the reimbursement rate is "r_1": p_2, r_2c_2, x_2 and m_2 are defined similarly. When the reimbursement rate is "r_1", 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, then

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

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, we have

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

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 $(r_2 - r_1) > 0$, $c_2m_2 \geq c_1m_1$ (1)-c
and $r_2c_2m_2 > r_1c_1m_1$. (1)-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 larger than m_1 in order to get $c_2m_2 \geq c_1m_1$. (1)-e

2. Hospital Profit

An alternative is 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, then

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

An alternative illustration is if the hospital treats the same number of patients even in the case of increasing reimbursement--i.e., from r_1 to r_2, then

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

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.

IV. Equilibrium Conditions

With non-negativity restrictions, the first order conditions(Kuhn-

Tucker) of (1) are:

$$\pi_x^U = p_x x + p + rc_z{}^3 m - MC \leq 0 \qquad (2)\text{-a}$$

or $p(1 - 1 / |\varepsilon|) + rc_z m - MC \leq 0$ (2)-b

or $MR(x) - c + (rm - x - m)c_x \leq 0$ (2)-c

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

$$\pi_m^U = rc + rc_z m - MC \leq 0 \qquad (3)\text{-a}$$

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

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

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 and 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), $(r - 1)c + (rm - x - m)\, c_z = 0$:

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 a phase of *decreasing average costs* to get the optimal number of private patients and Medicare / Medicaid patients. (5)

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

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

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

Second, $c_z < 0$ and $(rm - x - m) > 0$ are at equilibrium – i.e., a relatively small number of private patients at equilibrium, because the absolute value of (r – 1)m* is larger than that of x*. But this is not the way to achieve equilibrium. The reason is :

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

By rewriting this:

$$(r-1)c + (rm - x - m)d(TC/z)/dz \leq 0$$
$$\text{where } TC = cz$$

And expanding it we have:

$$\begin{aligned} & (r-1)c + (rm - x - m)\,(MCz - TC)/z^2 \\ = & (r-1)c + (rm - x - m)\{(MC/z) - (TC/z^2)\} \leq 0 \end{aligned}$$

By multiplying z:

$$\begin{aligned} & (r-1)cz + (rm - x - m)\,(MC - c) \\ = & (r-1)cz - (rm - x - m)c + (rm - x - m)MC \\ = & c\{(r-1)z - (rm - x - m)\} + (rm - x - m)MC \\ = & c(rz - z - rm + z) + (rm - x - m)MC \\ = & c(rz - rm) + (rm - x - m)MC \\ = & crx + (rm - x - m)MC \leq 0 \end{aligned}$$

Thereby

$$(rm - x - m)MC \leq -crx$$

And

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

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:

$$\pi_{xx}^U = p_{xx}x + 2p_x - 2c_z + (rm - x - m)c_{zz} \quad (7)$$
$$\pi_{xm}^U = (r - 2)c_z + (rm - x - m)c_{zz} \quad (8)$$
$$\pi_{mm}^U = 2(r - 1)c_z + (rm - x - m)c_{zz} \quad (9)$$
$$\pi_{xq}^U = p_{xq} + p_q - c_q + (rm - x - m)c_{zq} \quad (10)$$
$$\pi_{mq}^U = (r - 1)c_q + (rm - x - m)c_{zq} \quad (11)$$
$$\pi_{qq}^U = p_{qq}x + (rm - x - m)c_{qq} \quad (12)$$

So that we have

$$|H^U| = \begin{vmatrix} \pi_{xx}^U & \pi_{xm}^U & \pi_{xq}^U \\ \pi_{xm}^U & \pi_{mm}^U & \pi_{mq}^U \\ \pi_{xq}^U & \pi_{mq}^U & \pi_{qq}^U \end{vmatrix} \quad (13)$$

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

$$\pi_{xx}^U < 0, \pi_{mm}^U < 0 \text{ and } \pi_{qq}^U < 0 \quad (14)$$
$$|H_2^U| = \{\pi_{xx}^U \pi_{mm}^U - (\pi_{xm}^U)^2\} > 0 \quad (15)$$
$$|H^U| < 0 \quad (16)$$

With respect to SOCs, $\pi_{xx}^U<0$, $\pi_{qq}^U<0$, (15) and (16) can be achieved through the assumption that private patient's demand is concave and $|p_{xx}x + 2p_x|$ & $|p_{qq}x|$ are relatively large. 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 $\pi_{mm}^U = 2(r - 1)c_z + (rm - x - m)c_{zz}$ 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 are satisfied. The existence of 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 in a phase of increasing marginal cost, π_{mm}^{U}[5] $= 2(r-1)c_z + (rm - x - m)c_{zz}$ is always less than zero. So in this case, as long as $|p_{xx}x + 2p_x|$ & $|p_{qq}x|$ are relatively large, 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 a new "r" is given and is lower than the "reserved reimbursement" and this always leads to $\pi_{m}^{U} = rc + rc_z m - MC < 0$ at any level of positive "m", then the hospital will start to dump Medicare/Medicaid patients. The hospital would not want to treat any single number of Medicare/Medicaid patients – e.g., $m = 0$.

V. Comparative Statics

Using Laplace Expansion, we can express dx/dr as

$$
\begin{aligned}
dx/dr = {} & \pi_{xq}^{U}\{-(c + mc_z)\pi_{mq}^{U} + mc_q\,\pi_{mm}^{U}\} / |H^U| \\
& + (-\pi_{mq}^{U})\,\{-mc_z\,\pi_{mq}^{U} + mc_q\,\pi_{xm}^{U}\} / |H^U| \\
& + \pi_{qq}^{U}\{-mc_z\,\pi_{mm}^{U} + (c + mc_z)\,\pi_{xm}^{U}\} / |H^U|
\end{aligned}
\qquad (17)
$$

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

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

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

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

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

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

$$\pi_{xx}^{U} = p_{xx}x + 2p_x - 2c_z + (rm - x - m)c_{zz} < 0 \quad (7)\text{-a}$$
$$\pi_{xm}^{U} = (r - 2)c_z + (rm - x - m)c_{zz} \quad (8)$$
$$\pi_{mm}^{U} = 2(r - 1)c_z + (rm - x - m)c_{zz} < 0 \quad (9)\text{-a}$$

But

$$\pi_{xq}^{U} = p_q - c_q \quad (10)\text{-a}$$
$$\pi_{mq}^{U} = (r - 1)c_q \quad (11)\text{-a}$$
$$\pi_{qq}^{U} = p_{qq}x + (rm - x - m)c_{qq} < 0 \quad (12)\text{-a}$$

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

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

$$\pi_{xm}^{U} = (\pi_{mm} - rc_z) < 0 \quad (8)\text{-b}$$

From (4),

$$p_q - c_q = -(r - 1)\,(mc_q) / x$$
$r > 1$ & $c_q > 0$ by assumption,
$$\pi_{xq}^{U} = (p_q - c_q) < 0 \quad (10)\text{-b}$$

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

By rewriting (17)

$$dx / dr\,|H^U| = \pi_{xq}^{U}\{\phi\} + (-\pi_{mq}^{U})\{\Theta\} + \pi_{qq}^{U}\{\Omega\} \quad (17)\text{-b}$$

where

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

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

$\Omega = -rm(c_z)^2 + c\pi_{xm}^{U} < 0$ (cf., (8)-a))

Thereby dx / dr = (sum of all positive terms) / $|H^U|$
where $|H^U| < 0$ by SOC

Therefore, $dx / dr_{\text{cost-plus}} < 0$ (18)

Using Laplace Expansion, we can express dm/dr as

$$\begin{aligned} dm/dr = {} & \pi_{xq}^U\{(c + mc_z)\,\pi_{xq}^U - mc_q\,\pi_{xm}^U\} / |H^U| \\ & +(-\pi_{mq}^U)\,\{mc_z\,\pi_{xq}^U - mc_q\,\pi_{xx}^U\} / |H^U| \\ & +\pi_{qq}^U\{mc_z\,\pi_{xm}^U - (c + mc_z)\,\pi_{xx}^U\} / |H^U| \end{aligned} \quad (19)$$

i.e., as a sum of three terms, each of which is the product of a third-column element and its corresponding cofactor. But (19) is too complicated to interpret directly. However, we can infer that $dm/dr > 0$ in the 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, $c_2m_2 \geq c_1 m_1$ and from (18), $x_2 < x_1$

If $m_2 < m_1$, then $z_2 < z_1$ thereby $c_2 < c_1$ (because $c_z > 0$ in the case where $r > 1$ (cf.,(6)). This implies that if $m_2 < m_1$, then $c_2m_2 < c_1m_1$ But this is contradictory to (1)-c: i.e., $c_2m_2 \geq c_1m_1$

Therefore, at equilibrium, m_2 must be larger than m_1 in case of increasing "r" – i.e., $dm/dr_{\text{cost-plus}} > 0$ (20)

Using Cramer's rule & Laplace Expansion,

$$dq/dr\,|H^U| = -mc_z(\phi' - \theta') + c\theta' - mc_q\Omega' \quad (21)$$

where

$\phi' = (\pi_{xm}^U\,\pi_{mq}^U - \pi_{xq}^U\,\pi_{mm}^U) < 0$ (cf.(8)-a, (9)-a, (10)-b-, (11)-b),

$\theta' = \pi_{xx}^U\pi_{mq}^U - \pi_{xq}^U\pi_{xm}^U) < 0$ (cf. (7)-a, (8)-a, (10)-b),

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

$\phi' - \theta' = \pi_{mq}^U(\pi_{xm}^U - \pi_{xx}^U) + \pi_{xq}^U(\pi_{xm}^U - \pi_{mm}^U)$

where $\pi_{xm}^U - \pi_{mm}^U = -rc_z < 0$. This means $|\pi_{xm}^U| > |\pi_{mm}^U|$ since both π_{xm}^U and π_{mm}^U are less than zero. Also, since $\pi_{xx}^U < 0$, we can infer that $|\pi_{xx}^U|$ should be larger than $|\pi_{xm}^U|$ to get $\pi_{xx}^U\pi_{mm}^U - (\pi_{xm}^U)^2 > 0$(cf. (15)). So, $|\pi_{xx}^U| > |\pi_{xm}^U| > |\pi_{mm}^U|$ and thereby $\pi_{xx}^U < \pi_{xm}^U < \pi_{mm}^U < 0$. Thus $\phi' - \theta' > 0$.

Therefore, dq/dr = (sum of all negative terms)/ $|H^U|$
where $|H^U| < 0$ by SOC

Therefore, $dq/dr_{\text{cost-plus}} > 0$ (22)

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

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

Thereby

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

From (4),

$$\pi_{xq}^{U} = p_q - c_q = -(r-1)(mc_q)/x$$
where r = 1, so
$$\pi_{xq}^{U} = (p_q - c_q) = 0 \quad (10)\text{-c}$$
and $$\pi_{mq}^{U} = (r-1)c_q = 0 \quad (11)\text{-c}$$

From (17)-b

$$dx/dr\,|H^{U}| = \pi_{qq}^{U}(\Omega\} \quad (17)\text{-c}$$
$$\Omega = -rm(c_z)^2 + c\,\pi_{xm}^{U} < 0 \text{ (cf., (8)-a))}$$

Thereby

$$dx/dr = \pi_{qq}^{U}(\Omega\}/|H^{U}| < 0$$
where $|H^{U}| < 0$ by SOC

Therefore,

$$dx/dr_{\text{full-pay}} < 0 \quad (18)\text{-c}$$

And by similar procedure (cf. (20)),

$$dm/dr_{\text{full-pay}} > 0 \quad (20)\text{-c}$$

From (21)

$$dq/dr\,|H^{U}| = -mc_z\{\phi'\} + (c + m\,c_z)\{\theta'\} - m\,c_q\{\Omega'\}$$
$$= -mc_z(\phi' - \theta') + c\,\theta' - m\,c_q\,\Omega'$$

where

$$\phi' = (\pi_{xm}^U \pi_{mq}^U - \pi_{xq}^U \pi_{mm}^U) = 0(\text{cf.}\pi_{mq}^U = \pi_{xq}^U = 0),$$
$$\theta' = (\pi_{xx}^U \pi_{mq}^U - \pi_{xq}^U \pi_{xm}^U) = 0(\text{cf.}\pi_{mq}^U = \pi_{xq}^U = 0),$$
$$\Omega' = \{\pi_{xx}^U \pi_{mm}^U - (\pi_{xm}^U)^2\} > 0 \text{ (by (15))}$$

Thereby

$$dq/dr = -m\, c_q\, \Omega' / |H^U|$$
where $|H^U| < 0$ by SOC

Therefore,

$$dq/dr_{\text{full-pay}} > 0 \qquad (22)\text{-c}$$

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

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

$$\pi_{xm}^U = (\pi_{mm} - r\, c_z):\ \text{uncertain} \qquad (8)\text{-d}$$

From (4),
$p_q - c_q = -(r - 1)\,(mc_q)/x$
$r < 1$ & $c_q > 0$ by assumption,

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

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

From (17)-b

$$dx/dr\,|H^U| = \pi_{xq}^U\{\phi\} + (-\pi_{mq}^U)\,\{\theta\} + \pi_{qq}^U\{\Omega\}$$
where
$\phi = -(c + mc_z)\pi_{mq}^U + mc_q\,\pi_{mm}^U$ uncertain : (cf., $c_z < 0$, (9)-a, (11)-d & $c_q > 0$)
$\theta = -mc_z\,\pi_{mq}^U + mc_q\,\pi_{xm}^U$: uncertain(cf., $c_z < 0$, (8)-d, (11)-d & $c_q > 0$),
$\Omega = -rm(c_z)^2 + c\,\pi_{xm}^U$: uncertain (cf., (8)-d))

The sign of dx/dr $_{\text{underpayment}}$ *may be larger, smaller or equal to zero* (18)-d and from a similar procedure,

The sign of dq/dr $_{\text{underpayment}}$ *may be lagrer, smaller or equal to zero* (22)-d

Unlike the cases of cost-plus or full-payment, 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 the case where $r_2 > r_1 > 0$. From (6)-b, dz/dr > 0 thereby $c_2 < c_1$(because the hospital is operating in a phase 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 $_{\text{underpayment}} > 0$.

Therefore, the sign of dm/dr $_{\text{underpayment}} > 0$ (20)-d

By introducing some restrictions to the model, dx/dr $_{\text{underpayment}}$ 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):

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

The first order conditions of (1)H are:

$$\pi_x^H = (p_x x + p) - c + (rm - x - m)c_z$$
$$= MR(x) - c + (rm - x - m)c_z = 0 \quad (2)\text{H-a}$$
$$\pi_m^H = (r - 1)c + (rm - x - m)c_z = 0 \quad (3)\text{H-a}$$

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

$$\pi_{xx}^H = p_{xx}x + 2p_x - 2c_z + (rm - x - m)c_{zz} \quad (7)\text{H}$$
$$\pi_{xm}^H = (r - 2)c_2 + (rm - x - m)c_{zz} \quad (8)\text{H}$$
$$\pi_{mm}^H = 2(r - 1)c_z + (rm - x - m)c_{zz} \quad (9)\text{H}$$

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

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

$$\begin{vmatrix} \pi_{xx}^H & \pi_{xx}^H \\ \pi_{xm}^H & \pi_{mm}^H \end{vmatrix} \begin{vmatrix} dx \\ dm \end{vmatrix} = \begin{vmatrix} E_x^H \\ E_m^H \end{vmatrix} |dr| \qquad (18)H$$

where

$$E_x^H = -mc_z \qquad (19)H$$

$$E_m^H = -(c + mc_z)$$

then,

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

If we let

$$\Omega^H = -mc_z \pi_{mm}^H + (c + mcz)\pi_{xm}^H$$

Then

$$dx/dr_{\text{quality fixed}} = \Omega^H / |D^H| \qquad (17)H$$

For a comparison with the unconstrained model, from(17)-b

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

where

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

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

In other words:

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

where

"Quality Effect" equals zero when $q = \bar{q}$(fixed) is introduced

Pure Effect

From (17)H

$dx/dr_{\text{quality fixed}} = \{-mc_z\,\pi_{mm}{}^H + (c + mc_z)\pi_{xm}{}^H\} \,/\, |D^H|$ (17)H

Let $ds/dr_{\text{quality fixed}} = dx \,/\, dr^H$
So $dx/dr^H{*}|D^H| = -rm(c_z)^2 + c\,\pi_{xm}{}^H$
Now define Φ as

$$\Phi = \left|\frac{c_{zz}z}{c_z}\right|$$

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

$$\pi_{xm}{}^H = c_z\{(r-2) - \Phi(r\delta - 1)\} \qquad \text{(8)H-a}$$

Similarly

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

and from (3)H-b

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

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

Hence

$$dx/dr^H{*}|D^H| = 1(1-r)(c_z)^2 z\,[(1-r\delta)\{2(1-r) - \Phi(1\text{-}r\delta)\} + r(1-\delta)]$$
$$\text{where}[\quad] = -\Phi(1\text{-}r\delta)^2 + 2(1\text{-}r\delta)(1\text{-}r) + r(1\text{-}\delta)$$

Therefore

$dx/dr^H \lesseqgtr 0 \quad \text{if}[\quad] \gtreqless 0$

Hence

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

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

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

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

Thereby

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

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

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

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 $\phi \gtreqless 2$, if $MC_z \lesseqgtr 0$

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

Here, the operating situation of hospitals with underpayment 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"(c)," then dx/dr > 0 and thereby dp/dr < 0. In this case, marginal costs may be in a phase of decreasing, minimun 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 a phase of decreasing, minimum or increasing.

Foster(1985) observed "cross-subsidy" only in the case of 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:

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

and the "–2a" is added as "negative" term(2a*m*c_z) 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 $a(m-m)^2$ is relatively small[8], the basic results discussed above are intact.

IV. Conclusion

In this paper, we have demonstrated an unconstrained model of a price discriminating hospital. Under alternative reimbrusement 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 *in the case of cost-plus(r > 1) or full-payment(r =1)*, decreases in reimbursement rates lead to:

1) decreases in private patient charges(cross-subsidy), thereby increasing the number of private patients,

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

2) decreases in number of Medicare/Medicaid Patients,
3) decreases in the quality of care.

With CBR, and *in the case of underpayment($r < 1$),* by introducing fixed quality into the model–i.e., quality effects are controlled, decreases in reimbursement rate lead to:

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

The introduction of underpayment may be or may not be the cause of private patients' price increase. It depends on the operating standpoint of each hospital when government policy is introduced. The key factors in clarifying the effects of government policy are the size of private patient market, which determines patient-mix(δ) of each hospital at equilibrium, and the operating situation, which determines the curvature(Φ) of that hospital's average cost.

In theoretical aspect, the impacts of the same policy on hospital administrative choices appear differently in the case of underpayment. Further empirical work along this line would be valuable.

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