Hospital competition with soft budgets

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1 Introduction

- Hospital deficits and government bailouts are widespread phenomena in most countries with a publicly funded health care system.

- Example from the UK:

  Taxpayers will face a £5billion bill to bail out failing NHS hospitals over the next few years unless radical action is taken, a former health adviser (Paul Corrigan) to Tony Blair warns today (*The Telegraph, 15 Sep 2011*).

- We analyse theoretically the effect of budget softness on **quality** and **cost efficiency** for publicly funded hospitals that compete for patients under an activity-based payment system.

- Our model includes three potential sources of hospital deficits:
  - Diseconomies of scale + high demand
  - Low cost efficiency
  - Excessive quality investments

2 Model

- 2 hospitals are located at the endpoints on $S = [0, 1]$.

- Consumers (patients) are uniformly distributed on S.

- Each patient demands one treatment from the most preferred hospital.

- The utility of a patient located at $x \in S$ and seeking treatment at Hospital i is given by

$$U(x) = \begin{cases} v + q_1 - tx & if \quad i = 1 \\ v + q_2 - t(1 - x) & if \quad i = 2 \end{cases} .$$

- The hospitals face demand uncertainty:
  - The distribution of patients is known, but the density can take one of two values:
    * In State L, the density is 1.
    * In State H, the density is $n > 1$.
  - State L occurs with probability μ.

- Demand for hospital treatments:
  - Hospital 1:

$$D_1 = \begin{cases} \widehat{x} & \text{in } \textit{State L} \\ n\widehat{x} & \text{in } \textit{State H} \end{cases},$$

  - Hospital 2:

$$D_2 = \begin{cases} 1 - \widehat{x} & \text{in } \textit{State L} \\ n\left(1 - \widehat{x}\right) & \text{in } \textit{State H} \end{cases},$$

where

$$\widehat{x} = \frac{1}{2} + \frac{q_1 - q_2}{2t}.$$

- Hospitals are assumed to be profit-maximisers

- The profit of Hospital i in State j is

$$\pi_i^j = pD_i^j - \frac{c_i}{2}\left(D_i^j\right)^2 - \frac{k}{2}q_i^2.$$

- The hospitals are paid a fixed price p per treatment (DRG pricing).

- Each hospital can reduce its treatment costs my making an ex ante investment in cost containment (e_i):

$$c_i := \sigma - e_i.$$

- Cost-containment effort imposes a non-monetary disutility $\frac{w}{2}e_i^2$.

- One-shot game: each hospital chooses q_i and e_i to maximise profits.
- Decisions are made before the state of demand is revealed.
- Candidate equilibrium: $\pi_i^L > 0$ and $\pi_i^H < 0$.
- A share θ of any positive profits will be confiscated.
- A deficit will be covered with probability β.
- Expected payoff of Hospital i:

$$\Pi_i = \mu (1 - \theta) \pi_i^L + (1 - \mu) (1 - \beta) \pi_i^H - \frac{w}{2} e_i^2.$$

3 The Nash Equilibrium

- In the candidate symmetric Nash equilibrium, quality and cost containment are given by

$$q^* = \frac{\mu(1-\theta)\left(p - \frac{c^*}{2}\right) + (1-\mu)(1-\beta)\, n \left(p - \frac{nc^*}{2}\right)}{2kt\,(1-\beta+\mu(\beta-\theta))}$$

and

$$e^* = \frac{\mu(1-\theta) + n^2(1-\mu)(1-\beta)}{8w},$$

where $c^* := \sigma - e^*$.

Proposition 1 *(Equilibrium existence). If*

$$\mu > \frac{n(1-\beta)}{n(1-\beta)+1-\theta}$$

and

$$w > (n+1)\frac{\mu(1-\theta)+n^2(1-\mu)(1-\beta)}{8(\sigma(1+n)-4p)},$$

there always exists a $\sigma \in (\underline{\sigma}, \overline{\sigma})$ *and a* $t \in (\underline{t}, \overline{t})$ *that ensure the existence of a symmetric Nash equilibrium with interior solutions for* q^* *and* e^**.*

- Two reasons why hospitals may run a deficit in equilibrium:

  1. They cannot increase the price when demand is high.

  2. They cannot turn down patients that demand treatment.

- Key equilibrium features:

$$\frac{\partial \pi_i^L}{\partial D_i^L} > 0 \text{ and } \frac{\partial \pi_i^H}{\partial D_i^H} < 0.$$

4 Equilibrium quality and cost efficiency

- How do quality and cost efficiency depend on
  - the degree of budget softness?
  - the degree of profit confiscation?
  - the degree of competition?
  - the treatment price?

4.1 Budget softness

- The effect of budget softness on quality is given by:

$$\frac{dq^*}{d\beta} = \frac{\partial q^*}{\partial \beta} + \frac{\partial q^*}{\partial e}\frac{\partial e^*}{\partial \beta}.$$

- The direct effect is positive:

$$\frac{\partial q^*}{\partial \beta} = \frac{\mu(1-\theta)(1-\mu)(n-1)((n+1)c^* - 2p)}{4kt(1-\beta+\mu(\beta-\theta))^2} > 0.$$

- But budget softness leads to less cost efficiency:

$$\frac{\partial e^*}{\partial \beta} = -\frac{(1-\mu)n^2}{8w} < 0.$$

- So the indirect effect is negative, since

$$\frac{\partial q^*}{\partial e} = \frac{\mu(1-\theta) + n^2(1-\beta)(1-\mu)}{4kt(1-\beta+\mu(\beta-\theta))} > 0.$$

- The overall effect of budget softness on quality is a priori ambiguous, but positive if w is sufficiently high.

4.2 Profit confiscation

- The effect of profit confiscation on quality is given by:

$$\frac{dq^*}{d\theta} = \frac{\partial q^*}{\partial \theta} + \frac{\partial q^*}{\partial e}\frac{\partial e^*}{\partial \theta}.$$

- The direct effect is negative:

$$\frac{\partial q^*}{\partial \theta} = -\frac{\mu\,(1-\beta)\,(1-\mu)\,(n-1)\,((n+1)\,c^* - 2p)}{4kt\,(1-\beta+\mu\,(\beta-\theta))^2} < 0.$$

- The indirect effect is also negative, since $\frac{\partial e^*}{\partial \theta} = -\frac{\mu}{8w} < 0$.

- Thus, profit confiscation leads to lower quality and less cost efficiency.

4.3 Competition intensity

- The degree of competition does not affect incentives for cost efficiency.

- Increased competition leads to higher quality

$$\frac{\partial q^*}{\partial t} = \frac{-\mu(1-\theta)\left(p - \frac{c^*}{2}\right) - n(1-\mu)(1-\beta)\left(p - \frac{nc^*}{2}\right)}{2kt^2(1-\beta+\mu(\beta-\theta))} < 0.$$

4.4 Treatment price

- The price level does not affect incentives for cost efficiency.

- A higher price leads to higher quality:

$$\frac{\partial q^*}{\partial p} = \frac{n(1-\mu)(1-\beta)+\mu(1-\theta)}{2kt(1-\beta+\mu(\beta-\theta))} > 0.$$

5 Expected hospital deficit

- What determines the expected hospital deficit in equilibrium?

- **Softer budgets** affect the size of deficits via two channels:
  - Less cost efficiency $\longrightarrow$ higher treatment costs $\longrightarrow$ higher deficits
  - Higher/lower quality $\longrightarrow$ higher/lower costs $\longrightarrow$ higher/lower deficits

- **Profit confiscation** has two counteracting effects on the size of deficits:
  - Less cost efficiency $\longrightarrow$ higher treatment costs $\longrightarrow$ higher deficits
  - Lower quality $\longrightarrow$ lower quality costs $\longrightarrow$ lower deficits

- **Increased competition:**
  - Higher quality $\longrightarrow$ higher quality costs $\longrightarrow$ higher deficits

- A higher **treatment price** has two counteracting effects:
  - Increased revenues $\longrightarrow$ lower deficits
  - Higher quality $\longrightarrow$ higher quality costs $\longrightarrow$ higher deficits

6 Flexible quality and cost-containtment effort

- Suppose that the hospitals make all decisions after observing the state of demand.

- Quality and cost efficiency will differ according to the state of demand.

- In State H, the candidate equilibrium outcome is given by

$$e^H = \frac{n^2(1-\beta)}{8w},$$

$$q^H = \frac{n\left(p - \frac{nc^H}{2}\right)}{2kt},$$

where $c^H := \sigma - e^H$.

- Negative profits in equilibrium + interior solution $\Longrightarrow$ *positive profit margin*.

- Budget softness affects quality only indirectly through the choice of cost-containment effort:

$$\frac{\partial e^H}{\partial \beta} = -\frac{n^2}{8w} < 0, \quad \frac{\partial q^H}{\partial \beta} = \frac{\partial q^H}{\partial e}\frac{\partial e^H}{\partial \beta} = -\frac{n^4}{32wkt} < 0.$$

- Softer budgets lead to less cost efficiency and lower quality when these are flexible, short-term choices!

- Implication: A potentially positive relationship between budget softness and quality is confined to quality dimensions that cannot easily be adjusted according to demand fluctuations.

7 Welfare

Expected social welfare:

$$W = \mu W^L + (1-\mu) W^H,$$

where

$$\begin{aligned} W^L &= \int_0^{\widehat{x}} (v + q_1 - ts)\, ds + \int_{\widehat{x}}^1 (v + q_2 - t(1-s))\, ds \\ &\quad - \frac{c_1}{2}\left(D_1^L\right)^2 - \frac{c_2}{2}\left(D_2^L\right)^2 - \frac{k}{2}q_1^2 - \frac{k}{2}q_2^2 - \frac{w}{2}e_1^2 - \frac{w}{2}e_2^2 \end{aligned}$$

and

$$\begin{aligned} W^H &= n\left(\int_0^{\widehat{x}} (v + q_1 - ts)\, ds + \int_{\widehat{x}}^1 (v + q_2 - t(1-s))\, ds\right) \\ &\quad - \frac{c_1}{2}\left(D_1^H\right)^2 - \frac{c_2}{2}\left(D_2^H\right)^2 - \frac{k}{2}q_1^2 - \frac{k}{2}q_2^2 - \frac{w}{2}e_1^2 - \frac{w}{2}e_2^2. \end{aligned}$$

7.1 The first-best solution

- First-best levels of quality and cost containment:

$$q^{fb} = \frac{n(1-\mu)+\mu}{2k}$$

and

$$e^{fb} = \frac{n^2(1-\mu)+\mu}{8w}.$$

- The first-best is implemented by setting $\beta = \theta = 0$, along with an appropriately chosen p.

- For $\beta > 0$, the first-best can only be achieved by setting $\theta < 0$.

7.2 Second-best policies

- Second-best policies are relevant because
  - in systems with DRG-pricing, p is set according to a cost-based rule that is unlikely to coincide with the first-best price level;
  - it may be difficult (for political reasons) to commit to a strict no-bailout policy.

- We ask two policy questions:
  1. For a given p, under which circumstances will a deviation from a strict no-bailout policy improve welfare?
  2. For a given β, how does the optimal price depend on the bailout probability?

7.2.1 Welfare-improving bailout policies

- The welfare effect of a higher bailout probability is given by

$$\frac{dW}{d\beta} = \frac{\partial W}{\partial q}\frac{\partial q^*}{\partial \beta} + \frac{\partial W}{\partial e}\frac{\partial e^*}{\partial \beta}.$$

- If $\beta > 0$, the second term is negative for any $\theta \geq 0$.

- Softer budgets increase welfare only if the distortion of hospitals' quality incentives is reduced, and to an extent that outweighs the welfare loss from lower cost efficiency.

- For a given p, the bailout policy that maximises expected welfare has a strictly positive bailout probability if

  1. the hospitals' profit margin is sufficiently low, and

  2. the disutility of cost-containment is sufficiently high.

- The scope for a lenient bailout policy to be welfare-improving is smaller if there are social costs of public funds.

7.2.2 Optimal treatment prices with bailouts

- The price implementing first-best quality is such that $q^*(\beta, \theta, p^*) = q^{fb}$.

- The relationship between budget softness and the optimal price is given by

$$\frac{dp^*}{d\beta} = -\frac{\partial q^* / \partial \beta}{\partial q^* / \partial p}.$$

- Increased budget softness implies a lower price whenever it also encourages quality investments.

- Implication: If the scope for increased cost efficiency is sufficiently low, a more lenient bailout policy is an optimal policy substitute to higher treatment prices.

8 Summary

- Soft budgets lead to less cost efficiency while the effect on quality is ambiguous.

- Profit confiscation has a negative effect on both cost efficiency and treatment quality.

- A potentially positive relationship between budget softness and quality is only present if quality is a sufficiently inflexible choice variable.

- The first-best optimal solution is implemented with zero profit confiscation and a strict no-bailout policy.

- A lenient bailout policy may nevertheless be welfare-optimal if the treatment price is not set at the first-best level.