CROSS-MARKET HOSPITAL MERGERS: A HOLISTIC APPROACH

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APPENDIX 1

This appendix provides a simple model for studying the effects of holes in a health plan’s profitability. Suppose that there are two competing health plans, A and B. There is also an employer who is comparing the relative attractiveness of the two plans and chooses the more attractive of the two. We assume that both health plans charge the same fixed price and, hence, the price does not enter into the employer’s decision.

From the perspective of the health plans, in the absence of any holes, the attractiveness of plan \( i \) in the eyes of the employer, denoted by \( V_i \), is a random variable distributed normally with mean \( \mu_i \) and variance \( \sigma_i^2 \). The attractiveness of each plan \( V_i \) is meant to capture, in reduced-form, how the employer perceives the plan in terms of its core characteristics, such as ease-of-working with the plan, speed of claims processing, quality of participating hospitals and physicians, etc. We also assume that the two attractiveness scores, \( V_A \) and \( V_B \), are independent.

We introduce the negative impact inflicted to a health plan by a hole in its network by assuming that each hole reduces the attractiveness of the plan by an amount \( c > 0 \). For example, suppose that a plan with no holes in its network is perceived by the employer as having an attractiveness score of \( V \). Then, if the same plan suffers from \( h \) holes, then its attractiveness \( U \) is reduced to \( V - c \cdot h \).

We now characterize how the probability that a plan will be chosen by the employer depends on the number of holes in the plan’s network. Without loss of generality, we assume that Plan B does not have any holes in its network and focus on the probability that Plan A will be chosen as a function of the number of holes, \( h \), of Plan A.

Plan A is chosen when it has a higher attractiveness score, that is \( U_A - U_B > 0 \). The difference in the attractiveness scores \( U_A - U_B \) is also normally distributed with mean \( \mu_A - \mu_B - c \cdot h \) and variance \( \sigma_A^2 + \sigma_B^2 = \sigma^2 \). It will be convenient to denote by \( D \) the difference in the means between the health plans, i.e., \( D = \mu_A - \mu_B \).

Thus, the probability that Plan A is chosen can be written as:

\[
\Pr(U_A - U_B > 0) = \Pr\left(\frac{(V_A - V_B) - (D - c \cdot h)}{\sigma} > \frac{0 - (D - c \cdot h)}{\sigma}\right) = \Pr\{z > \frac{-D + c \cdot h}{\sigma}\}
\]

where \( z \) denotes the random variable distributed according to the standard normal distribution. Hence, the probability that Plan A is chosen is equal to \( 1 - \Phi\left(\frac{-D + c \cdot h}{\sigma}\right) \), where \( \Phi(\cdot) \) denotes the cumulative density function of the standard normal distribution. This probability function is plotted as a function of \( D \) in Figure 2 in the text.
APPENDIX 2

A. THE SET UP

There is a single employer that employs individuals that live in two distinct regions, North (N) and South (S), with half of its employees living in each region. Each region is served by a distinct set of hospitals. The employer offers two health plans (A and B) that its employees can choose between. To simplify the exposition of the model (but without loss of generality), assume that the employee faces the full price that the health plan charges.

Each plan’s quality, from the perspective of employees living in the North (South) is a function of the number of hospitals located in the North (South) that are available in the plan’s network. Let $q_i^r$ denote the quality of plan $i = A, B$ from the perspective of employees living in region $r = N, S$. We consider only two cases: (i) plan $i$ is not missing any hospitals (“no-holes”) in a given region $r$, in which case the plan’s quality from the perspective of employees living in this region is $q_i^r = 1$; or (ii) plan $i$ is missing one hospital (“one hole”) in a given region $r$, in which case the plan’s quality from the perspective of employees living in this region is $q_i^r = q < 1$. This includes the possibility that a plan is missing one hospital in each of the two regions (“two holes”).

The two plans set their prices (per-employee) in a static simultaneous move game. Let $p_A$ and $p_B$ denote the prices of plans A and B, respectively. Moreover, each plan faces a constant marginal cost (per employee) denoted by $c$. This may represent, for example, costs associated with processing claims or providing other types of customer service.

Each employee receives an independent draw $z$ (i.e., her type) from a standard normal distribution, which measures the extent to which she has an “intrinsic preference” for Plan A. This may represent, for example, the fact that she finds it easier/harder to work with Plan A’s customer service representatives, or that she has been exposed to more/less advertising from Plan A. Then, each employee living in a region $r$ compares the quality-adjusted price of each plan, denoted by $p_i / q_i^r$, and chooses to participate in Plan A if the difference between the quality adjusted price of Plan A and Plan B in this region is less than her type $z$. That is,

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1 The plans are not allowed to price discriminate. In particular, they are not allowed to offer different prices to different employees (e.g., north- vs. south-residents) of the same employer.

2 If the draw $z$ is positive, then the employee has an intrinsic preference for Plan A. If the draw $z$ is negative, then the employee has an intrinsic preference for Plan B.
an employee living in region \( r \) chooses Plan A if and only if \( p_A / q_A^r - p_B / q_B^r < z \).

Notice also that, given prices and qualities, the probability that a randomly chosen employee in region \( r \) will choose Plan A is:

\[
\Pr\{ p_A / q_A^r - p_B / q_B^r < z \} = 1 - \Phi(p_A / q_A^r - p_B / q_B^r)
\]

where \( \Phi(\cdot) \) stands for the c.d.f. of the standard normal distribution. For example, if the two plans have equal prices and qualities, then a randomly chosen employee is equally likely to choose either plan.

This completes the description of the game.

**B. NO-HOLES EQUILIBRIUM**

We now consider the equilibrium of the game when, in both regions, neither plan has any holes. Thus, in both regions \( r = N, S \), we have \( q_A^r = q_B^r = 1 \).

Plan \( i \) maximizes its profit taking as given the price of plan \( j \):\(^3\)

\[
\max_{p_i} \frac{1}{2} (p_i - c) \cdot [1 - \phi(p_i - p_j) + 1 - \Phi(p_i - p_j)]
\]

The first order condition (“FOC”) for profit maximization is:

\[
[2 - 2\Phi(p_i - p_j)] - (p_i - c)[\phi(p_i - p_j) + \phi(p_i - p_j)] = 0
\]

where \( \phi(\cdot) \) denotes the p.d.f. of the standard normal distribution.

In a symmetric equilibrium we have \( p_i = p_j = p \) and the FOC can be further reduced to:\(^4\)

\[
1 - 2(p - c)(\phi(0)) = 0 \iff p = \frac{1}{2\phi(0)} + c
\]

For example, for the case \( c = 2 \), we have \( p = 3.25 \). Moreover, in this case, the equilibrium profits of each plan are equal to \( \pi = 0.627 \).

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\(^3\) The term \( \frac{1}{2} \) comes from the fact that half of the employees live in each region; the term \( 1 - \Phi(p_i - p_j) \) denotes the fraction of employees in a region choosing plan \( i \). We have omitted the qualities because they are all equal to 1.

\(^4\) We used the fact that \( \Phi(0) = 0.5 \).
C. ONE-HOLE EQUILIBRIUM

We now consider the equilibrium of the game when Plan A suffers one hole in only one region (“one hole”). Without loss of generality, let Plan A have the one hole in the North. We assume that Plan B does not have any holes. Thus, we have: \( q_A^N = q; \ q_A^S = q_B^S = q_B^N = 1 \).

Plan A takes as given the price of Plan B, \( p_B \), and maximizes its profit given by:

\[
\max_{p_A} \frac{1}{2} (p_A - c) \cdot [1 - \Phi(p_A / q - p_B) + 1 - \Phi(p_A - p_B)]
\]

Similarly, Plan B takes as given the price of Plan A, \( p_A \), and maximizes its profit given by:

\[
\max_{p_B} \frac{1}{2} (p_B - c) \cdot [1 - \Phi(-p_A / q + p_B) + 1 - \Phi(-p_A + p_B)]
\]

The FOCs for plans A and B, respectively, are given by:

\[
[2 - \Phi(p_A / q - p_B) - \Phi(p_A - p_B)] - \frac{p_A - c}{q} \phi(p_A / q - p_B) - (p_A - c) \phi(p_A - p_B) = 0
\]

\[
[2 - \Phi(-p_A / q + p_B) - \Phi(-p_A + p_B)] - (p_B - c) \phi(-p_A / q + p_B) - (p_B - c) \phi(-p_A + p_B) = 0
\]

For given values of the cost parameters \( c \) and the quality parameter \( q \) we can solve the system of FOCs numerically and obtain the equilibrium prices, with illustrative results shown in Table 2.

D. TWO-HOLES EQUILIBRIUM

We now consider the equilibrium of the game when Plan A suffers two holes, i.e., one hole in each region. As before, we assume that Plan B does not have any holes. Thus, we have: \( q_A^N = q_A^S = q; \ q_B^S = q_B^N = 1 \).

We are particularly interested if this second hole in Plan A’s network will reduce Plan A’s profits by more or less than 0.095, i.e., the amount by which the first hole decreased Plan A’s profits.

Plan A takes as given the price of Plan B, \( p_B \), and maximizes its profit given by:

\[
\max_{p_A} \frac{1}{2} (p_A - c) \cdot [1 - \Phi(p_A / q - p_B) + 1 - \Phi(p_A / q - p_B)]
\]
Similarly, Plan B takes as given the price of Plan A, \( p_A \), and maximizes its profit given by:

\[
\max_{p_B} \frac{1}{2} (p_B - c) \cdot [1 - \Phi(-p_A / q + p_B) + 1 - \Phi(-p_A / q + p_B)]
\]

The FOCs for plans A and B, respectively, are given by:

\[
[2 - 2\Phi(p_A / q - p_B)] - \frac{2(p_A - c)}{q} \phi(p_A / q - p_B) = 0
\]

\[
[2 - 2\Phi(-p_A / q + p_B)] - 2(p_B - c)\phi(-p_A / q + p_B) = 0
\]

For given values of the cost parameters \( c \) and the quality parameter \( q \) we can solve the system of FOCs numerically and obtain the equilibrium prices, with illustrative results provided in Table 2.

E. MULTI-MARKET MODEL

Although we have not derived a closed-form solution for the case of more than two markets, results can be readily extended through simulation techniques. Details are available upon request.