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THE IMPORTANCE OF TECHNOLOGY IN THE CONSOLIDATION OF HOSPITAL MARKETS. THE CASE OF THE UNITED STATES

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Abstract

Over the last years, technology has become a key element of competition in the hospital market. At the same time, this market in the US has experienced an enormous merger activity. In this study, we analyze the role that technology can play in this consolidation wave by focusing on how it can affect a hospital's selection of a particular target. We analyze the selection of targets in mergers that took place in the US hospital market between 1985 and 2000. Our results show that technology is an important element for the competition in the hospital market and, as such, it plays a relevant role also in M&A strategies. We find that hospitals are more likely to choose targets that complement their technological holding, specifically when these are complex technologies and with favorable cost/benefits ratios. With this, the merged entity tends to become closer to a one-stop-shop hospital.

Keywords: hospital, technology, merger, acquisition, complexity.

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The Importance of Technology in the Consolidation of Hospital Markets. The Case of the U.S.

1. INTRODUCTION

Over the last years, technology has become an essential element of competition in the hospital market (e.g. Bartlett et al., 2006). First, because quality differentiation is increasingly important in the health care industry (Devers, Brewster, and Casalino, 2003; Tay, 2003), and hospitals' quality is substantially shaped by their technology holding and adoption. Second, because technological change accounts for about half of the substantial increase in medical care expenditure over the last decades (Newhouse, 1992; Cutler and McClellan, 2001). Nonetheless, very little has been done to understand the role played by technology to affect hospitals' strategies.

At the same time, hospitals' M&A strategy has received mounting attention in the economic literature due to the intense consolidation process the U.S. hospital industry witnessed during the 1980s and the 1990s (e.g., Cuellar and Gertler, 2003). In 1990, the mean population weighted hospital Herfindahl-Hirschman Index (HHI) in a health service area was 0.19; by year 2000 it had risen to 0.26 (Town et al., 2007). Previous studies have tried to explain this phenomenon focusing on potential efficiency gains deriving from mergers (e.g., Dranove and Shanley, 1995; Town et al. 2007), and on the pressure imposed by managed care diffusion (e.g., Dranove et al., 2002; Cutler and Barro, 1997; Town et al., 2007). However, the empirical evidence on the factors underlying hospitals' merger wave is still inconclusive. For instance, while Dranove et al. (2002) find that higher levels of local managed-care penetration are associated with substantial increases in consolidation in hospital and physician markets, Town et al. (2007) show that the rise of managed care did not cause the hospital consolidation wave.

Notwithstanding the increasing importance of these two phenomena, to the best of our knowledge no attempt has been done to examine the role played by technology in the healthcare consolidation process. In this paper, we contribute to bring together these two key elements characterizing the US hospital markets.

We argue that technology is a decisive variable for the *selection* of target in M&A because of two sets of reasons. First, because through an M&A a hospital can expand its technological holding and, in doing so, increase its reputation and bargaining power – in particular with regards to managed care which is putting increasing financial pressure on hospitals (Duke, 1996; Baker and Shankarkumar, 1997; Mas and Seinfeld 2008) . Second, because through an acquisition a hospital can acquire not only new and different technologies, but also the knowledge and capabilities necessary to implement them, which are valuable and difficult to develop or acquire in the short-term, in particular for significantly complex technologies.

With our results, we contribute to the health economics literature in a number of ways. First, most of previous studies on health-care M&A have focused on the ex-post results of mergers rather than on the analysis of the ex- ante characteristics that can lead to M&A (e.g. Dafny, 2009; Huckman, 2006; Sloan et al., 2003). Second, even when analyzing the ex ante characteristics, prior literature has generally examined the probability of a hospital to be an acquirer or to be a target (e.g. Harrison, 2007), whereas very little has been done on the selection of a specific target, conditional on hospitals' decision to acquire. Evidence on target selection criteria can inform our understanding of the drivers of the consolidation process inferring acquirers' 'revealed preferences' (Graff et al., 2003). Third, to the best of our knowledge we are the first to introduce technology as a relevant factor in determining hospitals' acquisition strategy and target selection. We show that technology matters even after considering traditional measures of market power and efficiency-seeking motives.

We analyze the role of technology in the selection of a target in an M&A using data from 222 M&A that occurred in the U.S. between 1985 and 2000. Our empirical results show that hospitals prefer targets that own a different set of technologies from their own ones; furthermore, an acquiring hospital is more likely to choose a target that owns more complex technologies as well as more profitable ones.

2. CONCEPTUAL AND EMPIRICAL MODEL

2.1. Predictions

Traditionally, two main theoretical reasons have been put forward to explain hospitals' decision to merge: improved economic efficiency through the exploitation economies of scale or smaller excess capacity, and increased market power. Whereas the pure horizontal model – based on increased market power and greater efficiency – has profound roots in the I.O. literature, Huckman (2006) has recently pointed out that it is not sufficient to fully explain the impact of hospital consolidation in markets for services that are getting increasingly complex. In fact, the empirical evidence in health care markets is mixed in this respect. For instance, Dranove and Lindrooth (2003) found no evidence of hospital consolidation yielding synergistic cost savings.

In this study, we take into consideration the strategic role that technology holding can play, by focusing on how it can affect the hospital's probability of selecting a given target. M&A allow hospitals to access new valuable resources such as patients, physicians, physical assets, as well as technologies. There is mounting evidence indicating that obtaining technological know-how is an increasingly critical reason for corporate acquisitions (e.g., Ahuja and Katila, 2001; Ruckman, 2005; Graff et al., 2003). Similarly, we argue that the same holds for hospitals.

There are several reasons why hospitals might take into account other hospitals' technology holding when deciding the selection of their acquisition targets. More specifically, we contend the following:

Targets with technologies that do not overlap with those of the acquirer are more likely to be chosen

There are two main reasons for this. First, when combined under a single corporate umbrella, sellers can reduce informational problems for consumers by standardizing product offerings and quality. If customers perceive that a merged entity provides uniform product attributes across locations, they will devote a lower effort monitoring providers, and perceive themselves to be at lower risk when purchasing from a seller with which they have no previous experience. By facilitating monitoring, simplifying search, and reducing uncertainty, the merged entity thus lowers consumers' transaction and search costs (Scherer and Ross, 1990). Dranove and Shanley (1995), examining the formation of local multihospital systems in California, find that multihospital systems achieve a superior reputation, which in turn translates into a better ability to exploit of economies of promotion and reduce consumers' search cost.

The same process can hold for hospitals that acquire other hospitals with non-overlapping technology holdings, which can therefore enlarge their offering and get closer to the concept of a “one-stop-shop” hospital, reducing search costs for both patients and managed care organizations. Even if technologies might not be physically transferred from one hospital to the other, the merged entity will be better able to deal with managed care organizations, providing an increased number of solutions of standardized reliability, and therefore acquiring a more powerful position to face contractual agreements with HMOs (Mas and Seinfeld, 2008).

Second, antitrust agencies might be concerned about the welfare implications of hospitals that merge if their consolidation leads to a rise in their monopoly power in a particular technology. Future potential bans from an antitrust agency might act as a deterrent for a hospital acquiring another hospital that owns a set of technologies that overlap with its own ones. On the flipside, one might intuitively think that merging with similar hospitals in terms of technology holding might favor economies of scale. This has been recognized by the DOJ and the FTC in their merger guidelines for hospitals that have less than 100 beds. Still, the large literature examining the presence of scale economies for hospital mergers[1] has generally reached inconclusive results.

If hospitals will prefer potential targets with non overlapping technologies, is this the only criterion they follow? How will they decide amongst different non-overlapping technological holdings?

Targets with more complex additional technologies are more likely to be chosen

[1] For a detailed analysis see Gaynor and Vogt (2000) on scale economies in antitrust and competition in health care markets

Modern hospitals produce health care services using a combination of both sophisticated technologies and highly specific knowledge and skills, which resides not only in individuals. For instance, Huckman and Pisano (2006) have shown that a surgeon's performance is not fully portable across hospitals; that is to say, some portion of performance is hospital-specific. Huckman and Pisano suggest that this result may be driven by the familiarity that a surgeon develops with the assets of a given organization.

If knowledge and skills reside also in organizational routines, when a hospital acquires another hospital it can actually gain access not only to its technological holding, but also to the complementary knowledge needed for the related medical services. Because some of these capabilities are embedded in the organization, the same knowledge could not be obtained by simply hiring specialists away. Kogut and Zander (1993), for instance, have shown that the attributes of knowledge to be transferred influence the decisions of where to draw the boundaries of organizations, and in particular that multinational companies are more likely to transfer knowledge through wholly owned operations when the technology is complex and hard to teach. Notice that because some of these capabilities are embedded in the organization, the same knowledge could not be obtained by simply hiring specialists away.

Acquiring also this complementary knowledge is particularly valuable for technologies that are highly complex – i.e., technologies that involve the knowledge of many different people that work in very different teams, and that are difficult to teach. Meyer and Goes (1988) have shown that complex innovations that require specialist expertise and skill are more difficult to adopt. We therefore expect that the probability of an acquiring hospital to choose a given target with non-overlapping technologies increases with the complexity of the new technologies owned by the target itself.

Targets with more profitable technologies are more likely to be chosen

Technologies vary greatly in their cost-benefits ratio, and hospitals' position in this respect plays a fundamental role when an HMO has to decide whether to include or not a hospital in its network (Mas and Seinfeld, 2008). Given that technologies account for a significant share of the increase in medical care expenditure (Cutler and McClellan, 2001) and HMO presence is putting pressure on hospitals' costs control, we expect that, ceteris paribus, a hospital is more likely to be acquired when it holds technologies that have an advantageous cost-benefits ratio. Hence, the probability of an acquiring hospital to choose a given target should increase with the profitability of the technologies held by the target.

2.2. Empirical Model

In more formal terms, and building upon Hall (1988) model, we assume that the value V of a hospital is a function of hospital characteristics **X**. Acquiring hospital j can acquire any other hospital i. If an acquisition occurs, the increment to the value of hospital j is defined as $V_j(\mathbf{X}_i)$. Thus, j acquires i if j's gain from acquiring hospital i is positive and larger than the gain from a merger with any other target k:

$$V_j(\mathbf{X}_i) - P_i > 0 \quad \text{and} \quad V_j(\mathbf{X}_i) - P_i > V_j(\mathbf{X}_k) - P_k \qquad \text{for any } k \in \mathbf{C}$$

where P_i is the price of i's assets and **C** is the entire pool of hospitals.

Prices are endogenous, assuming that hospital j acts as a bidder. The price at which hospitals evaluate the acquisition is assumed to be an unobservable function of the firm characteristics V ($\mathbf{X}_i$). Separating j's profit from the acquisition into observable and unobservable components yields:

$$V_j(\mathbf{X}_i) - P_i = f(\mathbf{X}_i, \mathbf{X}_j) + \varepsilon_{ij}$$

where ε_{ij} is independent and follows an extreme value distribution by assumption.

This leads to a conditional logit probability that an acquisition takes place:

$$\text{Probability (j buys i } | \mathbf{C}) = \frac{e^{f(X_j, X_i)}}{\sum_{k \in C} e^{f(X_j, X_k)}}$$

In essence, we therefore assume that a hospital j acquires another hospital i if that increases its value, and if acquiring hospital i is preferred to acquiring any other hospital k belonging to the choice set **C**. The explicit hypothesis we make is that the set of relevant variables **X** that determine hospital j's decision includes also (a) the overlap between the technologies owned by the set of potential targets and those owned by the acquirer, (b) the profitability of new target technologies, and (c) the complexity of the new technologies owned by the targets.

To estimate the model, we take advantage of the variation in technological holding between the acquired hospital and other hospitals in the same MSA (Metropolitan Statistical Area) with which the acquirer decided *not* to merge. Specifically, for every pair of hospitals that merged in the US between 1985 and 2000, we randomly select a set of 4 additional hospitals in the same MSA. These four additional pairs act as counterfactuals and they will allow us to contrast the characteristics of the hospital eventually chosen as a target with those of other *potential targets*. In other words, we assume that the choice set **C** is restricted to four hospitals located in the same MSA of the acquiring hospital (if there are not at least four other hospitals in the same MSA, we consider all of the hospitals located therein). Considering potential target only in the same MSA of the acquirer is a reasonable assumption as most of the M&A activities observed in the US healthcare market occur within the same MSA. The choice model is then estimated through a conditional logit (Jones, 2006)[2].

4. DATA

4.1 Dependent variable: Hospital mergers in the US

In this study, our unit of analysis is the M&A deal. Data about the mergers is obtained from the American Hospital Association (AHA) Annual Survey. The AHA explicitly identifies the hospitals that have merged in the Summary of Registered Hospitals and it gives them a new identifier. Following Dranove and Lindroth (2003), we limit our sample to local one-to-one acquisitions. We consider the years between 1985 and 2000, because they contain the period during which the main merger wave in the U.S. hospital market took place[3]. Since we are concerned about the role of technology on M&A, we have eliminated from our sample those hospitals that typically do not offer the set of technologies that we are going to consider, such as psychiatric hospital, institution hospitals, or rehabilitation hospitals.

Our final sample consists of 222 M&A. For each and every deal we have identified the acquirer and the target. The AHA survey provides data for each hospital including their exact location, size, and technology characteristics. After two hospitals have merged

[2] In order to prove the necessary condition of independence of irrelevant alternatives, all regressions have been repeated using an alternative random sample of potential targets. All the results encountered are robust

[3] This is the usual period considered in related literature as well. For instance, Dranove, and Lindroth (2003) analyze the period between 1988 and 2000. Dafny (2005) considers the period 1989-1996. Spang et al. (2001) study mergers that occurred between 1989 and 1997.

they are treated as a single hospital in the AHA data. We consider as the acquirer the hospital with the pre-merger address that became the new headquarter address after the merger. In case of a completely new address after merging, we have considered as the acquirer the largest hospital of the two. For each of these pairs that result from a merger, the dependent variable – *merger* – has been given the value of one. Conversely, for the control group of potential targets the *merger* dummy assumes the value of zero.

Table 1 summarizes the characteristics the actual targets and those of the randomly selected potential targets that had not been finally chosen. Selected targets and the control group present significant differences in the profitability of their technologies (*totalincrcbr*), with control group hospitals owning additional technologies that are less profitable than those of the hospitals that were acquired. There are also significant differences in the complexity of their technologies and on the use of their capacity, non-selected targets having a more intense usage.

4.2 Explanatory variables

In this paper, we are interested in understanding if and how technology shapes a hospital's acquisition strategy. Technology data comes from the AHA survey. We use data on the year prior to the merger to determine the set of technologies owned by the acquirer, the actual target, and the potential targets (i.e. the control group). Our data contains information on the thirteen different technologies reported in Table 2[4]. The choice of these specific technologies was driven by data availability in the AHA survey.

[4] Notice that not all technologies appear in the Survey for all the years since they differ in the time of their diffusion and hence, some of them only appear in the data later on. Moreover, from 1995 the AHA survey instead of asking whether a hospital had each of the five radiation therapy technologies, it only asked about whether it had *any* of them. Hence, from 1996 to 2000 we do not include information on the ownership of the different radiation therapy technologies.

We consider as medical technology a set of procedures or devices owned by hospitals and devoted to medical care. In some case, technology refers to specific infrastructures owned by the hospital (like Ct-Scanners, MRIs, etc) and in some other cases, they refer to certain procedures (angioplasty, open heart surgery, etc). Though the technologies we consider vary considerably in terms of breadth of application, diffusion, and complexity, this variance is actually helpful for identification.

We have argued that the probability of an acquiring hospital to choose a given target decreases with the overlap of technological holding between the two hospitals. We measure overlap through a variable (*overlap*) that equals the total number of technologies that coincide between the target and the acquirer.

To account for the fact that an acquirer might prefer a target that owns technologies that are relatively more profitable, we use cost-benefit data for each technology from Mas and Seinfeld (2008). In particular, we create a variable called *incrcbr* that corresponds to the sum of all the additional (i.e. different) technologies owned by the target weighted by their cost-benefit ranking (CBR). The higher this variable, the less profitable are the technologies contributed by the target. We thus expect the sign of *incrcbr* to be negative, indicating that an acquirer is less likely to merge with a target that owns less profitable technologies.

As discussed in Section 2, technological complexity is a key independent variable for our study. Since it is hard to measure it, we use three different alternative measures to ensure robustness of results. These measures are summarized in Table 3, and they are highly correlated. The first measure we consider is the number of Medicare Relative Value Units (RVUs) associated to each technology. RVUs assign numerical values to health care services taking into account the resources they use and they have been generally accepted as a measure of the complexity of a procedure. For each physician service, Medicare determines three types of RVUs: (1) physician work RVUs, which take into account the time, skill training and intensity to provide a given service, (2) Practice expense RVUs, which account for non-physician costs of running a practice such as rent, office supplies, non-clinical staff, etc., and (3) Personal liability RVUs: these are the smallest part of the RVUs and take into account the malpractice expenses. RVUs allow for geographic variation to reflect cost and wage differences across different areas. There are also global fees that take into account post-operative and follow-up costs.

The second measure of complexity is based on the ranking assigned to each technology by a group of specialists in a survey that we distributed to 25 different hospitals as well as to the Catalan Agency of Technology Evaluation. In the survey, the specialists were asked first to present a list of all the personnel involved in the procedure and their numbers (e.g., 4 nurses, 1 anesthesiologist, 1 cardiac surgeon, ½ administrative person, etc). Then they were also asked to think about the complexity of the technological equipment required. Finally, they were asked to rank the technologies according to their complexity taking both elements into account.

Finally, the third measure of complexity takes into account the human and technical resources assigned to each technology, by measuring its total cost per patient. To do so, we have referred to the medical literature using PubMed and http://www.york.ac.uk and also to the estimates of Mas and Seinfeld (2008). The academic references we used are reported in Table 3.

We are interested in obtaining an aggregated measure of the complexity of all the technologies owned by the targets and potential targets that do not coincide with technologies already owned by the acquirer. To do so, we weight each one of the non-overlapping technologies owned by the targets by each of the three measures of complexity, to obtain *totalincrvu, totalinccomp* and *totalinccomp3,* respectively. The higher each of these variables is, the more complex the additional technology owned by the corresponding target. Accordingly, we expect the coefficient of all our different measures of complexity to have a positive sign in our regressions.

4.3 Control variables

In our empirical specifications, we also control for additional variables that might explain target selection in M&A. In particular, not-for-profit (NFP) hospitals that wished to merge have often argued that they would not exploit their post-merger market power, and courts have generally been receptive to this argument, increasing the chances that a NFP hospital consolidated with one of its own same type.[5] In order to take this into account, we have created the *sametype* dummy, which takes the value of one if the target is the same type of hospital (i.e., NFP, FP or government) as the acquirer, and zero otherwise.

Furthermore, we need to control for the traditional drivers of consolidation, inserting variables that capture opportunities for enhanced efficiency or increased market power. In particular, to take into account the efficiency of the targets, we follow Harrison (2007) and include a measure of length of patient staying (inpatientdays/total admissions) (*los_t*)

[5] See "Improving healthcare, a dose of competition", Report by the Federal Trade Commission and the department of justice, 2004; Ch 4, page 30.

and a measure of capacity utilization (*capacity_t,* calculated dividing inpatient days by the number of beds). A target with a high length of stay is expected to have a lower efficiency, because it is using more resources for the output. Since it is generally accepted that less efficient hospitals are a more likely target, we expect the coefficient of *los_t* to be positive and the one of *capacity*_t to be negative. Moreover, as target profitability may surely be a driver of selection, we control for targets' profits normalized over number of beds (*rob_t*). Finally, we take into account what the acquisition of a certain target might imply for the market share of the resulting hospital. To this end, in our regressions we also include the total number of beds of the target (*beds_t*) as a control variable[6].

4.4. Additional analyses

In addition to our baseline model, we also perform further empirical analyses to verify the soundness of our theoretical framework, and in particular of the relevance of technology motives for M&A. To do so, we exploit across-state variations in contextual variables. The first variable we consider is the restrictiveness of the requirements of the Certificate of Need (*CON*) in a given state. A *CON* is a legal document required in many states and some federal jurisdictions before expansions or creations of facilities and assets are allowed. Strict *CON* requirements make the purchase of new technologies more difficult and significantly less likely (Mas and Seinfeld, 2008). Since the purchase of new technologies is more difficult, we expect hospitals in areas with strict *CON* to turn more often to mergers to expand their technology holding, since this might be the only way for them to acquire them. If this is the case, then hospitals would be more likely interested in

[6] Notice that this is very correlated with the HHI resulting from the potential merger, since for every deal the acquirer is the same, and we only change the potential targets. Hence clearly the larger size of the target, the higher the increase the concentration in the market.

technology per se, and not necessarily in new technologies; hence, we expect the *overlap* coefficient to be less negative for mergers taking place in states with very restrictive *CON* than for those taking place in states with a less stringent regulation. By the same token, the opposite is expected for the coefficients corresponding to the profitability and complexity of the technologies of the target. Notice that since *CON* requirements vary only across states, they will not change across potential targets, which belong to the same MSA of the acquiring hospital. Hence we will run the same regression separating the states in two groups: those with strict *CON* regulation and those with less severe regulation. Data on *CON* requirements were collected from the AHA[7].

Managed care has also been shown to discourage the adoption of less profitable technologies, because of the increased pressure on hospitals' efficiency (Mas and Seinfeld, 2008). If technology holding matters in M&A target selection, we expect that in states where managed care enrollment is particularly high, hospitals will even more likely look for targets with a technology holding characterized by a favorable cost-benefit ratio. We therefore run the same regression separately for those MSA that have high managed care enrollment, and for those with low managed care enrollment. To determine which are the areas with high and low managed care penetration, we look at the median managed care penetration for the corresponding year. Those MSAs above the median are considered to have high penetration and those below the median have low penetration. We expect the *incrcbr* coefficient to be more negative for the former subsample. Managed care data at the MSA level has been generously provided by Lawrence Baker

[7] Certificate of need (CON): Back to the future?, AHA, Washington, DC, October 1993.

following the methodology used in Baker (1997), which has been broadly used in the health care empirical literature.

5. RESULTS

5.1. The role of technology when selecting a target

Table 4 presents the results of our conditional logit estimations using the three different measures for complexity to ensure robustness, as well as different regression specifications. As hypothesized, the probability of an acquiring hospital to choose a given target decreases with the overlap of technological holding between the two hospitals (*overlap*). For instance, considering specifications 2a, 2b and 2c, a one standard deviation increase in *overlap* reduces the probability of being selected for the merger by 0.11, 0.11, and 0.24 respectively.[8]

The negative sign of the parameter estimate of *totalincrcbr* also shows that, ceteris paribus, an acquirer is more likely to choose a target that owns more profitable technologies. A one standard deviation increase in the cost-benefit ratio would reduce the probability of this target being selected for consolidation by 0.16, 015 and 0.15 using models 2a, 2b and 2c, respectively. Yet direct profitability variables such as return on beds of the target (*rob_t*) do not appear to be significant.

[8] We have also run the same specifications including a dummy equal to one if the potential target belongs to the same hospital system as the acquirer prior to the merger and zero otherwise. Due to data availability, the number of observations has been severely reduced, yet also for this subsample the sign of the parameter estimates are robust and indicate that belonging to the same system before the merger increases the probability of the target being selected. Results are available from the authors.

Importantly, our results confirm that a hospital is more likely to merge with a target that owns more complex technologies, and results are robust across different specifications and with measures of complexity. The parameter estimate of the three different measures of complexity are consistently highly significant and positive. Taking specifications 2a, 2b and 2c as a benchmark, a one standard deviation increase in the complexity of the technologies owned by the target, increases the probability of being selected for the merger by 0.25, 0.28 and 0.23 for the first, second and third definitions of complexity, respectively.

5.2 The role of the targets' technologies in mergers across different regulatory and insurance environments

We now report the results of the additional analyses we conducted. Table 5 presents the specifications that compare acquisitions of hospitals that are located in states with very restrictive certificate of need (CON) regulations to those with less restrictive CON, as well as hospitals located in MSA with high HMO penetration to hospitals with low HMO penetration. As previously discussed, these are variables do not present variations across the set of potential targets and hence, we can only compare coefficients of one group of hospitals with the other, but not exploit variation within a given deal.

Specifications (1) and (2) also confirm that in areas where managed care presence is more intense, and where it might have shaped more significantly the competition in the market place, the profitability of the technologies of the target is more relevant and, as a consequence, the coefficient of *incrcbr* is more negative.

As expected the *overlap* coefficient is less important for mergers taking place in states with very restrictive *CON* (specification 4) than for those taking place in states with a less stringent regulation (specification 3). The opposite is true for the coefficients corresponding to the profitability and complexity of the technologies of the target. This could indicate that hospitals in areas with stricter *CON* regulation might turn more often to mergers when they want to adopt a technology, and hence complexity is a less relevant issue in the decision process, whereas profitability becomes relatively more significant, because of the clear state pressures on efficiency.

Finally, as an additional check,, since the antitrust legislation does not apply to those hospitals that have more than 100 beds, we expect the coefficient of *overlap* to be more positive for smaller hospitals. Our results in specifications (1) and (2) in Table 5 show that this is precisely the case, and acquirers with less than 100 beds are less concerned about the overlap of their technology and that of the potential target. The other variables maintain their expected sign also in these specifications.

DISCUSSION

Departing significantly from extant literature, in this study we have shown that technology matters in shaping hospitals' acquisition strategy. We have found that hospitals are more likely to choose targets that complement their technological holding, specifically when these are complex technologies and with favorable cost/benefits ratios. With this, the merged entity tends to become closer to a one-stop-shop hospital.

Our results have important implications for public policy regarding both, the welfare implications as well as the repercussions for future hospital innovations. We are not aware of any study that has focused on what are the welfare implications of having more technologies concentrated in one hospital. Results from Huckman (2006) can shed some light. He studies 28 acquisitions in New York in which a hospital with CABG and PTCA merges with another one that does not own these services. He finds that hospitals with CABG and PTCA increased their market shares and costs and risk-adjusted mortality fell as volume increased. Antitrust scholars (e.g., Katz and Shelanski, 2004) in fact acknowledge that technology and innovation might affect not only post-merger market competition, but also the innovation adoption process. Cassiman et al. (2005) conclude that the effect of merger on future R&D depends on how different are the technologies of the two partners and that it is enhanced when the two entities are technologically complementary. Still, further research is needed to better understand the implications of technology driven hospital mergers for consumers, as well as for further technology development.

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Table 1: Descriptive Statistics: average (and standard deviation, in parenthesis) of the key variables for the sample of acquired hospitals and of the control group potential targets.

Variables	Description	Acquired	Not Acquired
gov_t	Target is a government hospital	0.077 (0.266)	0.165 (0.371)
notprof_t	Target is a not-for-frofit hospital	0.721 (0.450)	0.718 (0.450)
prof_t	Target is a for-frofit hospital	0.203 (0.403)	0.118 (0.322)
teach_t	Target is a teaching hospital	0.293 (0.456)	0.350 (0.477)
sumtech_t	Sum of total technologies of the target	3.014 (2.571)	4.543 (2.708)
bed_t	Number of beds of the target	190.958 (142.983)	231.617 (199.538)
rob_t	Retun on beds of the target	34,362.2 (86,614.29)	42,887.56 (92,572.12)
los_t	Lenght of stay: inpatientdays/admissions	6.807 (0.346)	8,217 (0,660)
capacity_t	capacity utilization: inpatientdays/beds	198.92 (5.455)	209.543 (2.757)
overlap	Number of technologies owned by this potential target also owned by the acquirer	2.324 (2.193)	3.099 (2.350)
sametype	Acquirer and target are of the same type (government, FP, NFP)	0.923 (0.267)	0.806 (0.396)
incrcbr	sum of all the additional technologies owned by the target weighted by their cost-benefit	1.014 (2.242)	2.006 (3.980)
totalinccomp	Complexity measure (complexity ranking)	2.752 (6.306)	5.219 (10.808)
totalincrvu	Complexity measure (RVU)	6.509 (16.133)	10.921 (23.367)
totalinccomp-3	Complexity measure (by total costs per patient)	1.896 (1.039)	1.741 (0.960)

In grey: statistically signifficant differences for the variable between acquired and not acquired hospitals

Table 2: Technologies considered in this study and their Cost-benefit ranking*

Diagnostic Radiology	CBR	Radiation Therapy	CBR	Cardiac	CBR
PET	5	Stereotactic Radiosurgery	5	Angioplasty	3
MRI	4	X-Ray Therapy	4	Cardiac Catheterization	2
CT-Scanner	3	Megavoltage Radiation	3	Open-heart Surgery	1
Diagnostic Radioisotope	2	Radioactive Implants	2		
Ultrasound	1	Therapeutic Radioisotope	1		

** From (Mas and Seinfeld, 2008)*

Table 3: Technological Complexity Measures

	RVU	Ranking	Total costs/patient (all prices are in 1990 $)
CARDIAC TECHNOLOGIES			
Cardiac Catheterization	4.6	4	*Lieu et al.* (1996) $17,040
Open Heart Surgery	30.3	10	*Hlatky et al. (1997)* $32,347 *Krumholz et al (1998)* $31,936
Angioplasty	19.4	8	*Hlatky et al. (1997)* $21,113 *Krumholz et al (1998)* $17,648
DIAGNOSTIC RADIOLOGY			
Diagnostic Radioisotope	0	1	*Merlino (2004)** $100.08 Avg cost of Tc-99m/dose $110.2 *Avg cost of Th-201/dose* $59.62
Ultrasound	3.7	*3*	*Leivo et al. (1996)* $102 *Saini et al. (2000)* $39.7
CT-Scanner	8.3	*5*	*Rhea et al. (1994)* $183.3 *Nisenbaum et al. (2000)* $174.3
MRI	18.3	*9*	*R. Bell (1996);* $763
PET	58.7	*13*	*Coopers and Lybrand (1991)* $3,750 *Evens & Siegel (1983)* $1,911
RADIATION THERAPY			
X-Ray Therapy	1.1	*2*	*Goitein & Jermann (2003). The cost of X-ray therapy is between 2.4 and 1.7 timeslower than the cost of megavoltage radiation*
Radioactive implants	11.3	6	*Pinilla (1997)* $2,800 *Da Silveira (2006)* $1,399 *Maguire et al. (2000)* $2,979
Therapeutic Radioisotope	0	7	*Merlino (2004) *** Avg cost and frequency of therapeutic radiopharmaceuticals:
Megavoltage Radiation	31.7	*11*	*Goddard et al (1991)* $523-548
Stereotactic Radiosurgery	11.3	*12*	*Konigsmaier et al. (1998)* $7,859-$8,972 *Rutigliano et al. (1995)* $18,948 *Ohinmaa (2003)* $6,500-$10,934

Adapted from Mas & Seinfeld (2008).

* Taking into account the corresponding CRR weighting average (80% Tc-99 and 20% th-201)

** Has been computed using the weighted average (frequencies from Merlino, 2004) for each radiopharmaceutical

Table 4: Results of Conditional Logit estimates. Dependent variable: *merger*

Variables	RVU		Ranking		Total cost/ patient (&)	
	(1a)	**(2a)**	**(1b)**	**(2b)**	**(1c)**	**(2c)**
sametype	1.350*** (0.390)	1.410*** (0.445)	1.342*** (0.399)	1.393*** (0.461)	1.338*** (0.402)	1.390** (0.464)
overlap	-0.297*** (0.083)	-0.201** (0.098)	-0.297*** (0.083)	-0.197*** (0.095)	-0.290** (0.082)	-0.189** (0.094)
incrcbr	-0.383** (0.137)	-0.352** (0.148)	-0.428** (0.176)	-0.350** (0.179)	-0.143* (0.085)	-0.084 (0.088)
increase complexity	0.046*** (0.017)	0.046** (0.018)	0.134** (0.058)	0.117** (0.058)	0.197* (0.120)	0.143* (0.079)
los_t	0.017* (0.009)	-0.020 (0.013)	0.016* (0.010)	0.019* (0.011)	0.197* (0.120)	-0.018 (0.012)
capacity_t	0.001 (0.002)	-0.0005 (0.0023)	0.001 (0.002)	-0.0003 (0.002)	0.001 (0.002)	-0.0002 (0.002)
bed_t	0.001 (0.001)	0.0004 (0.0009)	0.001 (0.001)	0.001 (0.001)	0.001 (0.007))	0.0002 (0.0002)
rob_t	-	-3.29e-6 (2.14e-6)	-	-3.30e-6 (-2.09e-6)	-	-2.37e-6 (2.1e-6)
N	1060	673	1060	673	1060	673
Pseudo-R^2	0.119	0.098	0.108	0.078	0.103	0.072

(&) The regressions have also been run with the ranking from 1 to 13 of the total cost/ patient and they are robust

* Statistically significantly different from zero at the 10 percent level

** Statistically significantly different from zero at the 5 percent level

*** Statistically significantly different from zero at the 1 percent level

Table 5: Results of additional analyses. Dependent variable: *merger*

Variables	HMO		CON		Number of Beds	
	(1) High HMO	(2) Low HMO	(3) Less Restrictive CON	(4) More restrictive CON	(5) >100	(6) <100
sametype	1.24** (0.47)	1.66** (0.47)	1.27** (0.39)	1.88** (0.75)	0.82 (0.52)	2.68** (0.80)
overlap	0.02 (0.12)	-0.26** (0.08)	-0.25** (0.08)	-0.16 (0.11)	-0.24** (0.08)	-0.31 (0.23)
incrcbr	-0.42** (0.13)	-0.13* (0.08)	-0.38** (0.13)	-0.23 (0.15)	-0.3** (0.11)	-1.1* (0.66)
increase complexity	0.02 (0.02)	0.02 (0.02)	0.05** (0.02)	0.03 (0.02)	0.03** (2.14)	0.17** (0.09)
rob_t	-3.57e-6 (2.61e-6)	-2.1e-6 (2.08e-6)	-1.3e-6 (1.86e-6)	-5.17e-6 (5.03e-6)	-1.3e-6 (1.88 e-6)	-2.01e-6 (5.32e-6)
totcomplete	0.89* (0.5)	0.5* (0.29)	-	-	-	-
N	462	411	499	374	474	118
Pseudo R^2	0.101	0.151	0.101	0.095	0.093	0.265

* Statistically significantly different from zero at the 10 percent level

** Statistically significantly different from zero at the 5 percent level

In grey: coefficients are signifficantly different across the two regressions