ACCOUNTING FOR COMPLEMENTARITIES IN HOSPITAL MERGERS: IS A SUBSTITUTE NEEDED FOR CURRENT APPROACHES?

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Hospitals mergers are common and increasingly frequent occurrences in the United States. Between 2010 and 2015, there were an average of 93 hospital mergers announced per year, substantially more than the annual average of 58 between 2004 and 2009.[1] Policymakers have challenged several recent proposed mergers with the concern that they would lead to a loss of competition,

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[1] Am. Hosp. Ass'n, *TrendWatch Chartbook 2016*, at 27 Chart 2.9, www.aha.org/research/reports/tw/chartbook/2016/2016chartbook.pdf.

by increasing prices and/or reducing quality.[2] Such concerns are consistent with certain theoretical economic models, which predict that mergers between close competitors increase prices,[3] and with empirical evidence on some hospital mergers.[4]

Despite this presumption that a merger between two hospitals serving the same market will reduce competition and increase prices (in the absence of other effective competition), the empirical evidence on hospital mergers is mixed. For instance, Christopher Garmon estimates the impact of 28 completed hospital mergers on prices, concluding that only nine led to statistically significant price increases.[5] Deborah Haas-Wilson and Garmon find that the merger of Evanston and Highland Hospitals in Illinois led to higher prices, while the merger of two community hospitals in the same area did not.[6] Price effects can vary for different insurers even within a single merger.[7]

Courts have also reached different opinions in their prospective assessments of the potential competitive effects of proposed hospital mergers. For example, in two recent proposed mergers, the lower courts allowed the mergers to proceed but the appellate courts overturned these decisions.[8]

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[2] John J. Miles, Ober Kaler, *The FTC's Three Current Hospital Merger Challenges: Will the FTC Ever Lose?*, LEXOLOGY (Mar. 29, 2016), www.lexology.com/library/detail.aspx?g=4988dc2d-f913-4ccf-acc7-177fa56d1124.

[3] For example, Steven Berry and Ariel Pakes characterize certain cost and demand conditions under which mergers can cause prices to increase, though they also describe the limitations of theoretical models in predicting the price effect of mergers for firms facing nonlinear demand, economies of scale, or asymmetrically heterogeneous products. Steven Berry & Ariel Pakes, *Some Applications and Limitations of Recent Advances in Empirical Industrial Organization: Merger Analysis*, 83 AM. ECON. REV. (PAPERS & PROC.) 247, 248 (1993).

[4] In the view of Martin Gaynor, Kate Ho, and Robert Town, "Mergers between rival hospitals are likely to raise the price of inpatient care and these effects are larger in concentrated markets. The estimated magnitudes are heterogeneous and differ across market settings, hospitals, and insurers." Martin Gaynor, Kate Ho & Robert J. Town, *The Industrial Organization of Health-Care Markets*, 53 J. ECON. LITERATURE 235, 262 (2015). *See also* Cory Capps, David Dranove & Mark Satterthwaite, *Competition and Market Power in Option Demand Markets*, 34 RAND J. ECON. 737 (2003); Gautam Gowrisankaran, Aviv Nevo & Robert Town, *Mergers When Prices Are Negotiated: Evidence from the Hospital Industry*, 105 AM. ECON. REV. 172 (2015).

[5] Christopher Garmon, *The Accuracy of Hospital Merger Screening Methods*, 48 RAND J. ECON. 1068, 1086 (2017). Six led to statistically significant price decreases, and 13 had no statistically significant effect on prices.

[6] Deborah Haas-Wilson & Christopher Garmon, *Hospital Mergers and Competitive Effects: Two Retrospective Analyses*, 18 INT'L J. ECON. BUS. 17 (2011).

[7] *See* Aileen Thompson, *The Effect of Hospital Mergers on Inpatient Prices: A Case Study of the New Hanover-Cape Fear Transaction*, 18 INT'L J. ECON. BUS. 91 (2011). The article finds that after the Hanover/Cape Fear hospital merger in New England, prices increased for two insurers, remained similar for a third, and decreased for a fourth.

[8] In 2016, in a preliminary injunction hearing, the U.S. District Court for the Northern District of Illinois refused to block the proposed merger between the healthcare systems NorthShore and Advocate. However, the Seventh Circuit Court of Appeals disagreed with the lower court's analysis of the set of relevant competitors and ordered that the case be retried. Similarly, the U.S. District Court for the Middle District of Pennsylvania initially allowed the Penn State Hershey

This article advances one reason why different hospital mergers can have different effects on prices that has not been widely discussed in academic literature or in merger enforcement: complementarities across hospitals in their value to insurers. Products that are complements deliver more value when consumed together than the sum of the values that they deliver alone. Complementarities are important to merger analysis in general because the merger of complementary products can lead to price decreases.[9] For hospitals, prices are determined by negotiation between hospitals and insurers. Thus, if two hospitals that are complements to an insurer merge, the insurer may actually be able to negotiate lower prices with the newly merged entity than it could when negotiating with the hospitals individually.

Why might hospitals be complements to insurers? A key role that insurers perform is in the construction of networks of hospitals and other providers. The attractiveness of a provider network, and the marketability of an insurer's plan, will depend on how well that network can deliver the medical care required by plan enrollees, who often will not know in advance what healthcare services they and their families will require. For this reason, insurers generally need a broad network of hospital providers, offering the range of health services most frequently needed, in a geographic area to successfully sell insurance products in that area. Therefore, two hospitals can be complements to insurers when each offers a critical service in a geographic area that the other does not. In the extreme, if both hospitals are required for a plan's marketability, each hospital may offer no value to the insurer on its own, but together would create a marketable plan.

Medical Center and PinnacleHealth System merger to proceed, but the Third Circuit Court of Appeals reversed the decision as it disagreed with the lower court's economic analysis of the relevant market. *See* Am. Mem. Op. & Order, FTC v. Advocate Health Care, No. 15 C 11473 (June 20, 2016); Erica Teichert, *FTC Wins Appeal to Halt Penn State Hershey/PinnacleHealth Merger*, MOD. HEALTHCARE (Sept. 27, 2016); Erica Teichert, *Appeals Court Revives FTC's Bid to Block Advocate/NorthShore Merger*, MOD. HEALTHCARE (Oct. 31, 2016); Kristin Schorsch, *The Latest Jabs in Advocate, NorthShore Fight to Merge*, MOD. HEALTHCARE (Dec. 16, 2016).

[9] *See, e.g.*, JEAN TIROLE, THE THEORY OF INDUSTRIAL ORGANIZATION 70 (1988) ("[T]he monopoly producers of complementary goods have incentive to integrate (horizontally) in order to avoid double marginalization and an excessive demand contraction." *Id.* at 175); Matteo Alvisi, Emanuela Carbonara & Francesco Parisi, *Separating Complements: The Effects of Competition and Quality Leadership*, 103 J. ECON. 107, 108 (2011) ("In fact, when complementary goods are sold by different firms, prices are higher than those set by a monopoly selling all the complementary goods. A merger would then yield a higher consumer surplus."); Aviv Nevo, Remarks as Prepared for the Stanford Institute for Economic Policy Research and Cornerstone Research Conference on Antitrust in Highly Innovative Industries: Mergers that Increase Bargaining Leverage 4–5 (2014) ("[I]f the [goods are complements] then bargaining separately the providers would get . . . more than bargaining jointly. This might seem surprising, but it is just the counterpart of two complements merging in a price setting framework.").

I. A FRAMEWORK FOR ANALYZING HOSPITAL COMPETITION

To explain how complementarities may impact hospital prices and the effect of mergers, it is first helpful to define a framework for how hospitals compete. We present a framework in which competition takes place in three stages.[10] This framework builds on models of competition used in policy settings and academic studies of hospital and insurer bargaining, often with the goal of understanding the price impacts of hospital mergers.[11]

1) In the first stage, hospitals negotiate with insurers over network inclusion and reimbursement levels. Insurers also determine enrollee cost sharing (in the form of copays or coinsurance) for care received at different hospitals, which will typically be lower at in-network hospitals. It is in this stage of competition that insurers and hospitals negotiate prices and hence in this stage that complementarities could affect prices. When modeling these negotiations, researchers commonly assume that an insurer and a hospital will split the marginal surplus[12] of each negotiation in some fixed proportion.[13]
2) In the second stage of competition, insurers set premiums that individuals pay to enroll in their plans, and individuals select insurance plans after observing each plan's hospital network, cost-sharing arrangements, and premiums.
3) In the third stage of competition, some enrollees require hospital treatment and select a hospital. Patients choose among available hospitals taking into account the network status of each hospital, the copay or

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[10] This model can be described in various numbers of stages. Katherine Ho uses five stages to describe this model, and Katherine Ho and Robin Lee use four stages, in which our first stage is divided into two subparts. *Compare* Katherine Ho, *Insurer-Provider Networks in the Medical Care Market*, 99 AM. ECON. REV. 393 (2009), *with* Kate Ho & Robin S. Lee, *Insurer Competition in Health Care Markets*, 85 ECONOMETRICA 379 (2017). Similarly, related models may abstract away from the second stage listed here. *See also* Gowrisankaran, Nevo & Town, *supra* note 4. R

[11] Initial Decision, ProMedica Health Sys., FTC Docket No. 9346 (Dec. 12, 2011), www.ftc.gov/sites/default/files/documents/cases/2012/01/120105promedicadecision.pdf; Capps, Dranove & Satterthwaite, *supra* note 4; Gowrisankaran, Nevo & Town, *supra* note 4; Ho, *supra* note 10; R
Ho & Lee, *supra* note 10; Robert Town & Greg Vistnes, *Hospital Competition in HMO Networks*, 20 J. HEALTH ECON. 733 (2001). R

[12] By "marginal surplus," we mean the value generated by forming an agreement with the counterparty, assuming that all other agreements have formed.

[13] This formulation is a generalization of the Nash bargaining solution where the model includes interrelated bargains between multiple pairs of firms. To our knowledge, this generalization was first used by Henrik Horn and Asher Wolinsky. Henrik Horn & Asher Wolinsky, *Bilateral Monopolies and Incentives for Merger*, 19 RAND J. ECON. 408 (1988); More recently, Allan Collard-Wexler, Gautam Gowrisankaran, and Robin Lee showed that, under some conditions, negotiations that are modeled as taking place through a series of simultaneous alternating offers can generate these "Nash-in-Nash" payoffs. Allan Collard-Wexler, Gautam Gowrisankaran & Robin S. Lee, *"Nash-in-Nash" Bargaining: A Microfoundation for Applied Work*, 127 J. POL. ECON. (forthcoming Feb. 2019).

coinsurance amounts (in cases where there are meaningful differences in these amounts across hospitals), a hospital's location, and its quality for treating particular conditions, among other potential factors.

We will refer to these three stages of competition as we discuss how hospitals can be complements and how complementarities can affect negotiated hospital prices.

II. HOSPITAL COMPLEMENTARITIES AND THE IMPACT OF MERGERS

In this section, we first review the economic definition of complements. We then discuss circumstances under which hospitals can be complements from the perspective of an insurer negotiating over network inclusion and reimbursement levels at the first stage of competition. We then analyze how complementarities can result in hospital mergers lowering prices.

A. WHAT DO WE MEAN BY COMPLEMENTS?

Formally, two products are *complements* when they provide *more* value together than the sum of the values that each product provides on its own. An example of two products that are complements is a left shoe and a right shoe. Individuals usually derive more value from their left shoes because they also have matching right shoes; one shoe on its own is not useful in most circumstances. In comparison, two products are *substitutes* when they provide *less* value together than the sum of the value that each product provides on its own. An example of two substitute products is butter and margarine. Consumers who have already chosen to buy butter will derive less value from buying margarine, since butter can frequently take the place of margarine.

B. HOW CAN HOSPITALS BE COMPLEMENTS TO INSURERS?

It is easy to envision how two hospitals can be substitutes for one another at each stage of competition. Consider an extreme case where two hospitals, A and B, offer the same services and amenities, the same quality of care, and are also located right next to each other. From the perspective of a patient seeking care at the third stage of competition, the two hospitals are interchangeable. For an employer or an individual purchasing health insurance at the second stage of competition, a plan with either hospital is equally valuable as a plan with both. Finally, from the insurer's perspective at the first stage of competition, a plan that included either hospital A or B would be more marketable and increase profits relative to a plan without either hospital in-network, but a plan that included both A and B would be no more valuable than a plan that included just one. Enrollees (or employers) would not be willing to pay any more for plans that included the second, perfectly interchangeable hospital,

which means that the addition of the second hospital to a network that already included one would add no value to the insurer. In this case, hospitals A and B are *perfect* substitutes.

More generally, most research and policy applications assume, through their modeling framework, that hospitals are substitutes (albeit imperfect ones) rather than complements at the first stage of competition.[14] This derives from the assumption in these applications that (1) a hospital's value to an insurer at the first stage of competition is proportional to the average value of the hospital to patients at the third stage of competition (where the average is taken over all possible health conditions), that is, insurers' preferences and patients' preferences are perfectly aligned; and (2) patients must select a single hospital for treating each condition at the third stage of competition. Together, these assumptions imply that hospitals are at least weak substitutes; they rule out any possibility that having two hospitals in-network together would add more value to the insurer than the values the insurer receives from having either hospital in-network alone. This typical empirical model simply does not allow for complementarities in the first stage; and this is true even if the hospitals have differences in services, quality, and location—unlike our extreme example above.

Despite this feature of the standard empirical model used to predict merger effects, it is possible for real-world hospitals to be complements in the first stage of competition, where prices are negotiated. By definition, two hospitals are complements at this stage if the value to an insurer from including both hospitals is higher than the sum of the values of including either hospital individually. That is, they are complements if an insurer that includes the two hospitals in-network will be able to add more profits than the sum of the profits it would add from including just one or the other hospital in its network. Two hospitals would have this effect on insurer profits if their joint inclusion increases the marketability of the insurer's health plans more than the sum of what either one would add alone, which might allow the insurer to attract more enrollees and/or charge higher premiums. Because the impact of additional hospitals on plan marketability and profitability is not necessarily proportional to the average patient value at the third stage, the value that a

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[14] *See* Kate Ho & Robin S. Lee, *Insurer Competition in Health Care Markets* 7–8 (Nat'l Bureau of Econ., Working Paper 19401, June 2015), www.aeaweb.org/conference/2016/retrieve.php?pdfid=444 ("Relative bargaining leverage between [hospitals and insurers] depends crucially on consumer demand and the extent to which other insurers and/or hospitals in the market are good substitutes for the bargaining firms."). Garmon discusses different methods to estimate post-merger price effects that build upon patient choice models, including analyses of diversion ratios, estimation of the change in willingness-to-pay, and merger simulations. Garmon, *supra* note 5. Both articles implicitly assume that hospitals are substitutes through its reliance on patient choice models in which a single hospital must be chosen—such choice models are incapable of concluding that hospitals are complements. R

hospital brings to an insurer from being in-network at the first stage of competition is not always perfectly aligned with the average value that it brings to patients from being in-network at the third stage. Thus, the value generated to plans cannot be derived by simply aggregating patients' values for hospitals at the third stage of competition, as the standard model does.

To understand how complementarities might occur, and how they may create a disconnect between value at the insurer stage of competition and the aggregate value across patients seeking care, consider a second extreme example where there are again only two hospitals in an area—C and D. In this example, hospital C provides treatment for half of all diseases and hospital D provides treatment for the other half. These two hospitals have no overlap in services.

Considering these hospitals first from the perspective of a patient seeking care at the third stage of competition, these two hospitals are unlikely to be complements, even in this extreme case. Patients typically select one hospital at which to receive treatment for a specific episode of care; finding hospitals that cover all medical services is not necessary at that decision point. Complementarity between products simply cannot occur when consumers must make a single discrete choice across products.[15] Thus, even in this extreme example, for the patient seeking care, hospitals C and D are neither substitutes nor complements in the third stage of competition.

However, these same two hospitals C and D may very well be complements at the second stage of competition for most employers and enrollees. Because employers are likely to purchase health plans to meet the heterogeneous health needs of all of their employees,[16] and because different employees are sure to need services from both hospitals C and D, a plan with only hospital C or D may offer very limited value compared to a plan with both hospitals in-network. This would then generate complementarities across the hospitals to employers selecting an insurance plan to offer their employees. This is also likely true for individuals purchasing plans, as they also do not know which diseases they may contract and thus will want to purchase a single health plan that covers a broad array of healthcare needs. Hence, purchasing a plan that offers both hospitals in-network would add more value for many purchasers

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[15] It is still possible that hospitals could be complements at the third stage. Imagine one hospital that has a surgery center, but no rehabilitation unit, and a rehabilitation hospital that is across the street. A patient deciding where to get surgery may be more likely to choose this hospital for surgery, knowing there is a rehabilitation unit nearby.

[16] John R. Moran, Michael E. Chernew & Richard A. Hirth, *Preference Diversity and the Breadth of Employee Health Insurance Options*, 36 HEALTH SERVS. RES. 911 (2001).

of insurance than the sum of the value of purchasing only a plan that offers hospital C and the value of purchasing only a plan that offers hospital D.[17]

Complementarity between hospitals at the second stage of competition in turn drives complementarity at the first stage. If employers and individuals do not derive much value from a plan with only one of the hospitals in-network, then an insurer could not successfully market a plan to employers without both hospitals C and D in-network. Thus, one hospital on its own would bring little value to the insurer since either C or D alone would not yield a marketable plan. The two together, however, would create a plan that the insurer could profitably sell, and thus are complements from the point of view of the insurer in the first stage of competition. Because this first stage of competition is the stage at which insurers negotiate prices with hospitals, it is complementarities at this stage of competition (and not at the third) that matter when determining whether a hospital merger would increase prices.

In practice, we rarely, if ever, observe cases as extreme as the above stylized example. More realistically, hospitals are likely to be complements at the first two stages of competition when each hospital offers some critical specialty services that the other does not, but also offers some overlapping services such that they are substitutes for some patients in the third stage of competition. Insurers could still have a hard time marketing a plan that did not cover specialty services that employers and enrollees value. Even if the plan met the healthcare needs of most employees, most of the time, an employer would be reluctant to choose the plan if it omitted specialty services that a significant share of employees were likely to need.

Suppose now that, instead of having no overlap, hospital C offered pediatric care and hospital D offered oncology services. Further suppose that both offer all other services, which we will call general acute care (GAC) services, and are completely interchangeable for these services. At the third stage of competition, hospitals C and D would now be substitutes overall, based on their substitutability for patients in need of GAC services, though for individual patients seeking either pediatric or oncology care they would be neither substitutes nor complements since only one hospital is a realistic option. Because pediatrics and oncology are both key services, which many employers and individuals would want in-network, these hospitals would still likely be

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[17] Purchasing two separate single-hospital health insurance plans, each at a fraction of the premium that would be charged for a single plan with both hospitals, would be unlikely to deliver the same value as the single unified plan. First, if some individuals choose to buy only one of the two plans, depending on their specific health risks, health expenditures per enrollee may increase, driving up premiums for the individual plans and raising the cost of the two plans for those who wish to purchase insurance for both hospitals. Even if the two plans were purchased together for all enrollees, the increased administrative burden on insurers, plan sponsors, and enrollees would make a two-plan option more costly than a single plan.

complements from the perspective of insurers forming a comprehensive network and enrollees selecting plans.

The key question for determining whether hospitals C and D are, on balance, complements to insurers—even though they may be substitutes for many patient services—is whether the insurer's profits from including both hospitals in-network exceed the sum of the profits from including just one hospital in-network. For this to happen, access to both service lines must be important enough to employers and prospective enrollees that insurers can gain significantly more enrollees and/or charge sufficiently higher premiums when both hospitals are in-network than they can when only one or the other is in-network.

The presence of complementarity of hospitals to insurers would result in a number of testable implications for the pricing and market behavior of plan sponsors, insurers, and hospitals. In particular, suppose we see a market with two hospitals. If they are complements, employers may explicitly refuse to purchase plans that do not include both hospitals in their network. Insurers would also be expected to view both hospitals as "must haves" and not use one as leverage against the other in negotiations. Deviations from this expectation should be driven by circumstances that can be understood as an exception to the complementarities, such as plans marketed to specific populations that would not expect to need the services of one or the other hospital, or plans with access to regulated prices in the absence of a contract (e.g., Medicare Advantage plans).[18] Hospitals would be expected to leverage their status as complements in negotiations with insurers, and prices may be higher than otherwise expected given predictions based on the standard model (which assumes that the value of the hospital to the insurer at the first stage of competition is proportional to the average values to the patients at the third stage of competition). Hospitals may also seek to confirm the inclusion of their complement in an insurer's network before agreeing to negotiate their own inclusion in a new plan. Finally, in cases where one complementary hospital is excluded, we would expect to see plans that have only minimal enrollment.

C. MERGERS OF COMPLEMENTS MAY REDUCE PRICES

In general, the merger of firms that offer complementary products can lead to lower rather than higher prices. In the case of two complementary hospitals, an insurer may be able to negotiate *lower* prices if two hospitals that are complements at the first stage of competition merge. As we detail below, this is

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[18] Medicare Advantage plans have been shown to pay very similar prices to hospitals as Traditional Medicare. *See* Vilsa Curto et al., *Healthcare Spending and Utilization in Public and Private Medicare* (Nat'l Bureau of Econ. Research, Working Paper No. 23090, 2017), www.nber.org/papers/w23090.

because the post-merger entity has less negotiating leverage with the insurer than the total amount of the leverage that each hospital had separately.

Independently, two hospitals that are complements at the first stage of competition could each threaten to remove itself from the insurer's network.[19] Each hospital's leverage when negotiating with insurers is then based on the value of completing the network and delivering the additional value from the combination of the two hospitals. Because the two hospitals are complements, this value, computed when the other hospital is already in the insurer's network, is higher than the value that the hospital would bring without the other hospital in the network. In other words, each hospital adds more value when the other hospital is in the network then it would add when the other hospital is not in the network, and can negotiate on this basis. Hence, a hospital's bargaining leverage is increased by having a complementary hospital in network.

However, if two complementary hospitals merge, the combined system could not threaten to remove the complementary pair twice. The worst threat that the combined system could make would be to not contract with the insurer at all, which would lower the value of the provider network to the insurer, but not by twice the amount that removing each hospital independently would. To summarize, since the entire hospital system generates less value than the sum of each individual hospital added under the assumption that the other hospital is already in-network, the combined system has less leverage in negotiations with the insurer than the combined leverage of the two hospitals negotiating separately.

To understand the intuition of how a merger of complementary hospitals might result in price decreases, we turn to numerical examples. We first consider the case of mergers between hospitals which are substitutes to insurers and then consider the case of mergers between hospitals which are complements to insurers.

Table 1 walks through a numerical example of the substitutes case. Suppose now that our two substitute hospitals, A and B, are located on opposite sides of a small city, rather than being indistinguishable from each other. Suppose that an insurer places a value of 10 on a hospital network that includes both hospitals A and B, based on the number of customers it could enroll and the premiums it could charge, and a value of 0 on a network with no hospitals. The insurer needs at least one hospital to have a marketable plan. The second hospital is still valuable, since individuals who live near that hospital are more likely to enroll in the plan if it is included in the network, but it is less valua-

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[19] We focus on the first stage of competition since this is the stage that matters for the determination of prices.

ble than the first hospital to the insurer because individuals could use the hospital across town in the case they choose a plan with only one of the two hospitals in-network. Consistent with these facts, suppose that the insurer places a value of 6 on a network with just one hospital, either A or B. In this case, the marginal value of the second hospital is 4 (= 10 – 6) and hence less than the marginal value of the first hospital. Based on these values, hospitals A and B are substitutes to insurers—the value of having both of them in the network (10) is less the sum of the values of having only A or only B in the network (6 + 6 = 12).

What prices would the parties negotiate in this situation? As noted above, the marginal value of each hospital in this example is 4. Assuming the hospital and insurer evenly split this value, as is commonly done,[20] each hospital receives 2 and the insurer pays a total of 4 to both hospitals when they are separate entities.

In this example, the negotiated price would increase if the hospitals merged. As mentioned, together the hospitals are worth 10 to an insurer. Without either hospital, the insurer earns 0, so the value of reaching an agreement is 10 (= 10 – 0). The insurer and the merged hospital system will split the surplus of 10 evenly, and the hospital will receive 5. Hence, this stylized example suggests that if hospitals A and B merged, total payments to the hospital would rise from 4 to 5.[21]

TABLE 1: PRICES WHEN HOSPITALS ARE SUBSTITUTES

		Separate Hospitals		Merged Entity
		Hospital A	**Hospital B**	**Hospitals A and B**
1. Network Value without Hospital(s)		6	6	0
2. Network Value with Hospital(s)		10	10	10
3. Surplus from Network Inclusion	(= [2] - [1])	4	4	10
4. Hospital Price	(= [3]/2)	2	2	5
5. Total Paid to Hospitals, When Separate		2 + 2 = 4		5

[20] The intuition remains the same if we assume that hospitals capture a higher proportion of the surplus than insurers. John Brooks, Avi Dor, and Herbert Wong estimate that 68% of the surplus goes to hospitals; Kate Ho and Robin Lee estimate that about three-quarters of the surplus goes to hospitals. *See* John M. Brooks, Avi Dor & Herbert S. Wong, *Hospital-Insurer Bargaining: An Empirical Investigation of Appendectomy Pricing*, 16 J. HEALTH ECON. 417 (1997); Ho & Lee, *supra* note 10. R

[21] For simplicity, this analysis exposits price as the total revenue paid to the hospital and not the per-person revenue. The number of patients from the insurer may also change based on which hospitals are in-network, implying that an analysis of per-person revenues would be more involved. Nonetheless, the same basic points, that mergers of substitutes can raise prices and mergers of complements can lower prices, apply when considering per-person revenues as well.

Next, Table 2 walks through a numerical example of the case when hospitals are complements to an insurer. Consider again the example where only hospital C has pediatric care and only hospital D offers oncology services. As discussed above, these hospitals are very likely to be complements for insurers, though not for particular patients.

Suppose that the insurer places a value of 4 on a network with only hospital C or D, since it would have to charge a lower premium and would enroll fewer individuals. Based on these values, hospitals C and D are complements for the insurer—the value of having both of them in the network (10) exceeds the sum of the values of having only C or only D in the network (4 + 4 = 8).

As above, the insurer and hospital split this surplus evenly, so each hospital receives a price of 3, and the insurance company pays the hospitals a total of 6. If these hospitals merged and everything else remained the same, the insurer would value an agreement with the system at 10 (= 10 – 0), and the hospitals together would only be able to negotiate a price of 5. In this example of complementary hospitals, prices would have decreased from 6 to 5 as a result of the merger.[22]

TABLE 2: PRICES WHEN HOSPITALS ARE COMPLEMENTS

		Separate Hospitals		Merged Entity
		Hospital C (pediatric)	**Hospital D (oncology)**	**Hospitals C and D**
1. Network Value without Hospital(s)		4	4	0
2. Network Value with Hospital(s)		10	10	10
3. Surplus from Network Inclusion	(= [2] - [1])	6	6	10
4. Hospital Price	(= [3]/2)	3	3	5
5. Total Paid to Hospitals		3 + 3 = 6		5

Outside of stylized examples like the ones presented in Tables 1 and 2, many factors will influence the overall effect of a merger on price, quality, and other outcomes. Insurer concentration, interactions with hospitals not a party to the merger, operational efficiencies, and other factors could all affect post-merger outcomes. In some instances, these and other factors may outweigh a reduction in bargaining leverage due to the merger of complements, or in other instances, may lead to lower post-merger prices separate from hos-

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[22] Gregory Vistnes and Yianis Sarafidis, and Craig Peters, provide similar examples to this and also make the point that if the sum of the surpluses to the insurer from having each hospital is less than the surplus from both hospitals, then a hospital merger will lower prices. However, neither article explicitly considers why hospitals may be complements to insurers and, indeed, Vistnes & Sarafidis state that this is a "perhaps unlikely situation." Gregory S. Vistnes & Yianis Sarafidis, *Cross-Market Hospital Mergers: A Holistic Approach*, 79 ANTITRUST L.J. 253, 272–73 (2013); Craig T. Peters, *Bargaining Power and the Effects of Joint Negotiation: The "Recapture Effect"* 8–9 (Econ. Analysis Grp. Discussion Paper, EAG 14-3, 2014).

pital complementarities. For example, Haas-Wilson and Garmon found that the merger between Victory Memorial Hospital and Provena St. Therese Medical Center did not raise prices.[23] Neither Haas-Wilson and Garmon or the FTC—in its statement closing the investigation of this merger—mentioned complementarities as a potential cause for the lack of a price increase.[24] Instead, the FTC statement is consistent with a better management team at the merged hospital realizing that revenues would be increased with lower quality-adjusted prices due to increased patient volume or with the merged hospital system capturing a smaller part of the surplus than did the hospitals individually.[25]

However, the general point remains: changes in bargaining leverage will tend to increase the prices hospitals are able to negotiate with insurers for hospitals that are substitutes and reduce prices for hospitals that are complements to an insurer building a provider network. Even when post-merger prices are expected to fall as a result of decreased bargaining leverage, hospitals that are complements may still wish to merge for a number of reasons. For example, there may be offsetting cost efficiencies to the merger that would lower the cost of delivering care for most patients, including Medicare and Medicaid, while the reduction in price would apply only to commercial patients. Or, one of the merging parties may not be independently financially viable, and the degradation or loss of its services may reduce not only the value that that hospital offers to the network, but also the value that the financially strong hospital offers as a part of the complementary pair. As another example, a merged hospital offering a wide range of services might be more attractive to patients and expand the downstream market, increasing value through higher volume. In addition, as payment systems move toward value-based care models, hospitals with differentiated services may be better able to manage the risk of such contracting or better coordinate patients' care as a merged entity.

III. WHEN DIFFERENTIATED SERVICES LEAD TO COMPLEMENTARITIES

As discussed in Part II, hospitals with differentiated services may be complements for insurers. However, differentiation is not sufficient for two hospitals to be complements, and hospitals that focus on different services can still

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[23] *See* Haas-Wilson & Garmon, s*upra* note 6, at 18. R

[24] Public Statement, Victory Mem'l Hosp./Provena St. Therese Med. Ctr., FTC Docket No. 011 0225 (July 1, 2004), www.ftc.gov/sites/default/files/documents/closing_letters/vista-health-acquisition-provena-st.therese-medical-center/040630ftcstatement0110225.pdf.

[25] The FTC stated: "[T]here is . . . some evidence . . . that St. Therese was pursuing a non-sustainable strategy. . . . [T]here is also evidence that St. Therese and Victory were steadily losing market share to their rivals prior to the merger." *Id.* at 1.

be substitutes to an insurer in forming a provider network. A key predictor of whether two hospitals are complements is whether each hospital offers an important service that the other does not and that other comparable in-network hospitals—with similar quality and location—do not offer.[26] In this case, both hospitals may be needed to form a complete network, particularly if the services are important enough that enrollees or the insurer could not simply pay out-of-network costs for these services. Under these conditions, insurers will likely not be able to offer a marketable plan without a complete network, which will limit the value of including only one of the hospitals, in turn generating complementarities.

Hospitals that focus on different services will *not* be complements for insurers, at least not as a result of the differentiation, if one hospital offers all the services offered at the other. For example, a specialty hospital, such as a cardiac hospital, will not be a complement from the point of view of insurers to a GAC hospital if the GAC hospital also offers comprehensive cardiac care of similar quality. This example is not just hypothetical. MedCath, a hospital chain that specialized in cardiac treatments, had lower cost and better outcomes than other hospitals, according to a Harvard Business School case study.[27] Yet, managed care organizations did not contract with MedCath because of their long-standing relationships with GAC hospitals.[28] Local hospitals resisted MedCath's inclusion in insurer networks, with the common criticism that "MedCath was doing nothing more than 'skimming' hospitals' most profitable line of business, cardiac care . . . ."[29]

MedCath hospitals were substitutable with the cardiac services offered at other GAC hospitals, and insurers could and did exclude MedCath hospitals from their networks.[30] For instance, one former MedCath hospital, Tucson Heart Hospital, offered open-heart surgeries and a variety of cardiac services.[31] Other nearby hospitals in Tucson, Arizona, such as University Medi-

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[26] Important services that lead to complementarities need not just be different types of care, though that is our focus. Hospitals may also be complements if they cover two geographic areas that enrollees or employers would want covered, such as a city center where the employer is located and an adjacent area where many employees live.

[27] *See* Regina E. Herzlinger & Peter Stavros, *MedCath Corporation (A)*[a], HARV. BUS. SCH. (Jan. 7, 2013).

[28] *Id.* at 11.

[29] *Id.* at 16.

[30] Some insurers accused MedCath of cream-skimming and claimed that may have contributed to insurers dropping MedCath. *See* Regina E. Herzlinger, *Why Innovation in Health Care Is So Hard*, 84 HARV. BUS. REV. 58 (2006). Herzlinger & Stavros find these claims to be untrue—based on their analysis, MedCath patients had higher case mix and better outcomes. Herzlinger & Stavros, *supra* note 27, at 20. R

[31] A majority stake of Tucson Heart Hospital was sold to Carondelet in 2006, and Carondelet became the 100% owner in 2010. *See* Stephanie Innes, *Agreement Calls for Selling Carondelet*

cal Center[32] and Tucson Medical Center offered similar services, even though cardiology was not their focus.[33] Tucson Heart Hospital ultimately was not "financially sustainable" and was shut down.[34]

In contrast to the MedCath example, hospitals that each provide services that the other does not can be complements. St. Mary's and Cabell in Huntington, West Virginia, may provide an example of two such hospitals. St. Mary's is a GAC hospital with a cardiac unit where many complex cardiology procedures are performed. Cabell, also a GAC hospital, does not have the capabilities to perform many of the cardiac procedures that St. Mary's does.[35] Conversely, Cabell provides intensive neonatal and obstetrical care, which St. Mary's does not have the capabilities to perform.[36]

In 2014, Cabell proposed an acquisition of St. Mary's, bringing the nature of their competition to the forefront. The parties argued that they were complements to insurers. The FTC challenged the parties' view, stating that St. Mary's and Cabell were close competitors instead of complements based on "the overwhelming majority of inpatient GAC and outpatient surgical services that both hospitals offer."[37] A state regulatory agency charged with overseeing West Virginia's hospitals agreed with the parties that they were complements to insurers.[38] In its decision, the West Virginia Health Care Authority wrote:

> [W]hen a payor is assembling a hospital network . . . it needs to have all of the services that are required to make a health plan marketable. This includes critical services like open-heart surgery, high-risk obstetrics, and pediatric intensive care, even though most enrollees will never need those services.[39]

Hospitals, ARIZ. DAILY STAR (July 22, 2014), tucson.com/news/local/agreement-calls-for-selling-carondelet-hospitals/article_0d974ff9-a6af-535f-a58d-dbd451d144bb.html.

[32] AM. HOSP. DIRECTORY, *University Medical Center Tucson*, www.ahd.com/free_profile/030064/Banner_-__University_Medical_Center_Tucson_/Tucson/Arizona/.

[33] AM. HOSP. DIRECTORY, *Free Profile for Tucson Medical Center*, , www.ahd.com/ (follow "FREE Search" hyperlink; then enter "Tucson Medical Center" in hospital name field and "AZ" in state field).

[34] *See* Jamar Younger & Carmen Duarte, *Carondelet to Move Its Heart Hospital*, ARIZ. DAILY STAR (Apr. 20, 2012), tucson.com/news/science/health-med-fit/carondelet-to-move-its-heart-hospital/article_ec5d6732-9180-55ba-84b9-413cb0750e61.html; Innes, *supra* note 31. R

[35] Decision at 66–67, Cabell Huntington Hosp., Inc., Cooperative Agreement No. 16-2/3-001 (W. Va. Health Care Auth. June 22, 2016) (*Cabell Huntington Agreement No. 16-2/3-001*), hca.wv.gov/About/Documents/Decision.pdf.

[36] *Id.*

[37] *See* Fed. Trade Comm'n Bureau of Competition Staff Submission to the West Virginia Health Care Authority Regarding Cooperative Agreement Application of Cabell Huntington Hospital at 27 (Apr. 18, 2016), www.ftc.gov/system/files/documents/public_statements/945863/160418virginiahealthcare.pdf.

[38] Decision at 75, *Cabell Huntington Agreement No. 16-2/3-001* (". . .based upon the specialty services offered by each hospital, they are [complements] at the payor level.").

[39] *Id.* at 72. (internal quotations omitted)

> [I]n order for an insurer successfully to market a health plan, it is necessary that the plan be able to offer a full array of hospital services. As noted above, neither [Cabell nor St. Mary's] provides that full range of services. Thus, both hospitals are necessary for payors to be able to successfully market a health plan.[40]

In sum, the regulatory body found Cabell and St. Mary's to be complements because they each provided critical unique services the other did not, which then made them necessary for insurers to be able to successfully market a health plan.

If Cabell and St. Mary's were indeed complements to insurers and if this complementarity implied that they might have to lower prices following a merger, it may seem that the parties would choose to remain separate. Thus, it is useful to consider why they might have wanted to merge. In this instance, the Pallottine Missionary Sisters, the religious group that founded St. Mary's, sought a new owner for the facility.[41] Cabell stated that by acquiring St. Mary's, it could achieve the scale necessary to implement population health management tools, improve access to care (including by offering specialized tertiary services), and address other health needs of the community, and that the acquisition could also ensure that both hospitals maintained their clinical training programs and support for the Marshall University School of Medicine, along with other reasons.[42] These motivations could outweigh a potential reduction in the combined entity's bargaining leverage (with some payors) by increasing quality and patient demand sufficiently to improve the overall value of the combined entity.

IV. AN EMPIRICAL ANALYSIS OF HOSPITAL COMPLEMENTARITIES

In this Part, we examine empirically whether hospital pricing in the real world supports the implications of hospital complementarities noted in the stylized examples above. Our maintained hypothesis is that two types of specialty care hospitals are likely to be complements to other hospitals from insurers' point of view: children's hospitals and orthopedic hospitals. We examine whether stand-alone children's hospitals and orthopedic hospitals have higher prices than GAC hospitals, as predicted by our model. We also consider prices at hospital systems with both GAC and children's facilities. These systems are analogous to a hospital created from the merger between GAC and children's hospitals and hence our model predicts lower prices for

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[40] *Id.* at 78.

[41] Complaint at 5–6, Cabell Huntington Hosp., Inc., FTC Docket No. 9366 (Nov. 5, 2015).

[42] W. Va. Health Care Auth., Application for Approval of Cooperative Agreement for Cabell Huntington Hospital, Inc., Cooperative Agreement File No. 16-2/3-001 (Mar. 25, 2016), www.hca.wv.gov/About/Documents/CHHI.pdf (acquisition of St. Mary's Medical Center).

these hospitals. Accordingly, we examine whether such systems have lower prices than GAC hospitals or stand-alone children's hospitals. Our empirical approach controls for overall market concentration but nonetheless has many limitations that we discuss at the end of this Part.

A. CHILDREN'S HOSPITALS AND ORTHOPEDIC HOSPITALS AS POTENTIAL REAL-WORLD EXAMPLES OF COMPLEMENTARITIES

We believe that children's hospitals and orthopedic hospitals are likely to be complementary to local GAC hospitals from the point of view of insurers in many markets. Both of these two specialty hospital types offer high-value hospital services that GAC hospitals are less likely to offer, but lack the breadth of services of a GAC hospital.

In particular, a stand-alone children's hospital will likely be the only provider of high-level neonatal intensive care units (NICUs) in many localities.[43] For a plan to be marketable to employers and individuals who value NICU or other high-intensity services for young patients, an insurer needs to include NICUs and facilities for pediatric patients in-network, especially if there is competition from other plans with these services in-network. If stand-alone children's hospitals provide valuable services that are not otherwise available nearby, they will tend to be viewed by insurers as complements to GAC hospitals, which provide a broad range of services not available at a children's hospital.

Similarly, orthopedic hospitals may provide specialized orthopedic care that may not be otherwise available at nearby GAC hospitals, such as procedures to correct congenital deformities in children and specialized procedures to correct adult deformities, such as severe scoliosis.[44] For this reason, orthopedic hospitals may be complements to GAC hospitals in certain situations.

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[43] According to the 2015 American Hospital Association Annual Survey of Hospitals, approximately 75% of hospitals with a primary service of "Children's General" offer NICU beds. This compares with only 19% of hospitals classified as "General Medical and Surgical." When examining hospitals with more than ten NICU beds, the proportions change to 73% and 13% of hospitals, respectively. In approximately 40% of counties with children's hospitals (either stand-alone or part of an integrated system), children's hospitals contain more than 60% of the total NICU beds. *See* AM. HOSP. ASS'N, SELECT PROFILE OF HOSPITALS IN U.S. & AFFILIATED TERRITORIES FY2015 (AHADataviewer.com proprietary database FY2015 AHA Annual Survey Database) (report created June 26, 2017 by Diana Culbertson, on file with authors).

[44] According to a position statement from the American Academy of Orthopaedic Surgeons and American Association of Orthopaedic Surgeons, "Specialty hospitals have an important role for treating patients who need musculoskeletal care offering high quality care and safety and enhancing access. These facilities complement other sites of patient care, included acute care hospitals, academic medical centers, and [ambulatory surgery centers]." *See* Position Statement, Am. Ass'n of Orthopedic Surgeons, Specialty Hospitals (June 2016), www.aaos.org/uploadedFiles/PreProduction/About/Opinion_Statements/position/1167%20Specialty%20Hospitals.pdf. Orthopedic hospitals may offer services unavailable at other hospitals. For example, "Surgeons

We obtain testable implications of hospital complementarity by comparing hospital systems with both GAC and children's facilities, or with both GAC and orthopedic facilities, to similar stand-alone GAC, children's hospitals, and orthopedic hospitals. Specifically, a hospital system that includes both GAC and children's (or orthopedic) facilities is analogous to a GAC hospital and a children's (or orthopedic) hospital that have merged.[45] Compared to stand-alone GAC and children's (or orthopedic) hospitals, an integrated entity cannot leverage complementarity when negotiating with insurers and would be predicted to negotiate lower prices than what the individual hospitals could separately negotiate. Hence, if stand-alone children's hospitals or orthopedic hospitals are complements to GAC hospitals that lack these facilities and if mergers of complementary hospitals lower prices, then, all else equal, we should expect to see higher prices for stand-alone children's or orthopedic hospitals than for children's or orthopedic hospitals that are part of an integrated hospital systems but otherwise similar. In this section, we empirically test whether these predictions hold in the data.[46]

B. EMPIRICAL EVIDENCE ON PRICING AND COMPLEMENTARY HOSPITALS

Following the above discussion, we test for whether stand-alone specialty hospitals—i.e., children's hospitals and orthopedic hospitals—have higher prices than other hospitals. We also test for whether hospital systems with integrated children's hospitals—which can be viewed as "merged" entities of GAC hospitals and children's hospitals—have lower prices than stand-alone GAC and children's hospitals. These predictions would be consistent with mergers among complementary hospitals lowering prices.

We obtain price data from the Medicare Cost Reports data for 2015. We follow Leemore Dafny and Christopher Garmon and construct a proxy for the price for an inpatient hospital stay that is equal to commercial revenue per

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at Ingham performed the first artificial disc surgery in mid-Michigan and one of the first arthroscopic procedures performed in North America. The hospital is home to the Osteopathic National Center for Orthopedic Research, a partnership between the hospital and Michigan State University which aims to advance orthopedic research and treatment." Additionally, "[Neurologic and Orthopedic Hospital of Chicago] is unique because it is perhaps the only facility to focus exclusively on neurosurgical and orthopedic care." *10 Orthopedic Specialty Hospitals to Know*, BECKER'S HOSP. REV., June 23, 2009. As another example, Shriners Hospitals for Children views itself as "unique in its ability to provide exceptional, specialized pediatric orthopaedic, rheumatology and cleft lip and palate care using the latest innovations in diagnosis and treatment." *See About Us*, SHRINERS HOSPS. FOR CHILDREN––SPRINGFIELD, www.shriners hospitalsforchildren.org/springfield/about-us; *About Us*, SHRINERS HOSPS. FOR CHILDREN—PORTLAND, www.shrinersinternational.org/SHC/Locations/portland/About/About-Us.

[45] An example is U.C. Davis Medical Center and U.C. Davis Children's Hospital.

[46] If the hospitals were substitutes and merged, with no other changes, we would expect upward pressure on prices. If the hospitals each had bargaining leverage but did not compete with one another, a merger would not be expected to affect prices.

discharge adjusted for patient case mix.[47] We compute 2015 prices for 2,832 GAC hospitals, 53 stand-alone children's hospitals, 97 hospital systems that include subordinate children's hospitals, and 21 orthopedic hospitals.[48] Some of the prices in our dataset are extremely high and may reflect measurement error. To avoid bias from outliers, we drop hospitals with prices in the top percentile from our analysis dataset. We derive our results tables below from this censored dataset.[49]

Table 3 compares prices across GAC facilities, children's hospitals, and orthopedic hospitals and shows that stand-alone specialized hospitals—which likely complement GAC hospitals—have higher prices. Specifically, the median price is $18,392 for stand-alone children's hospitals and $11,372 for orthopedic hospitals, both of which are higher than the median price for GAC hospitals, which is $9,904. These higher prices are consistent with the theory that these hospitals are often complements to GAC hospitals in an insurer's

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[47] Leemore Dafny, *Estimation and Identification of Merger Effects: An Application to Hospital Mergers*, 52 J. L. & ECON. 523 (2009); Christopher Garmon, *The Accuracy of Hospital Merger Screening Methods* (Fed. Trade Comm'n Bureau of Econ., Working Paper No. 326, 2015) [hereinafter Garmon, *FTC Working Paper 2015*]. *See infra* Appendix Part A for details on the price construction and on the robustness of this price measure.

This measure has limitations. The financial information used to compute hospital prices comes from the Healthcare Cost Report Information System (HCRIS). Because only Medicare-participating hospitals are required to submit the cost reports to CMS, we can only construct prices for a subset of children's hospitals that voluntarily submit cost reports. Further, CMS Impact Files often are missing the case mix for children's hospitals. Additionally, the proxy for price includes revenue and discharges for Medicaid and Medicare Advantage patients, uses case mix data based on Medicare patients instead of commercial patients, and is subject to other data restrictions.

Despite the first two limitations, we are able to compute prices for most children's hospitals observed in the AHA Annual Survey Data. We computed prices for 53 out of 74 stand-alone children's hospitals and for 97 out of 105 hospital systems with integrated GAC and children's hospitals. Moreover, Garmon finds that, despite the last limitation, this measure is a reasonable proxy. Specifically, Garmon also excludes Medicare revenues and discharges, but not Medicaid revenues and charges, and finds that this price measure highly correlates to "commercial price measures calculated with state-level financial data for hospitals with at least 200 commercial patients per year." Garmon concludes that this price measure "is likely an unbiased, but somewhat noisy measure of the hospital's actual commercial price" and is appropriate to use with a relatively large sample. Garmon, *supra*, at 17.

[48] Our categorization of hospitals is based on primary service reported in the AHA data. *See infra* Appendix Part B for details on the categorization of hospitals. We identify hospital systems with GAC and children's facilities by looking at the members of Children's Hospital Association that are not stand-alone children's hospitals. UC Davis Medical Center and UC Davis Children's Hospital provide one example. Each hospital system reports discharge and financial information as one entity in the AHA data.

Our data from 2015 include 3,036 GAC hospitals, 74 stand-alone children's hospitals, 105 hospital systems with integrated GAC and children's hospitals, and 30 orthopedic hospitals. We have information to compute prices for 2,832 GAC hospitals, 53 stand-alone children's hospitals, 97 hospital systems with integrated GAC and children's hospitals, and 21 orthopedic hospitals, while we cannot compute prices for the remaining hospitals due to missing information.

[49] We also have estimated analogous specifications that keep the outlier observations. The results, which are available upon request to the authors, are very similar, though some coefficients lack statistical significance and the R^2 measures of regression fit are much lower.

network because insurers are unlikely to have ready substitutes for their services. We believe that the effect is more pronounced for children's hospitals because the unique services that they offer, notably NICUs, are comparatively more important for plan marketability than are the unique services offered by orthopedic hospitals.

TABLE 3: PRICE SUMMARY STATISTICS BY HOSPITAL TYPE (2015)

Hospital Type	# of Hospitals with Prices Calculated	Mean	Standard Deviation	25th Percentile	Median	75th Percentile
1. All Hospitals	2,973	$10,691	$4,185	$7,952	$9,943	$12,559
2. GAC Hospitals	2,811	$10,597	$4,041	$7,945	$9,904	$12,501
3. Stand-alone Children's Hospitals	45	$17,620	$6,028	$12,377	$18,392	$22,062
4. Hospital Systems with Integrated Children's Hospitals	96	$9,826	$4,491	$6,914	$8,810	$10,517
5. Stand-alone Orthopedic Hospitals	21	$12,385	$3,997	$10,773	$11,372	$12,684

Sources: Healthcare Cost Report Information System 2015; AHA Annual Survey of Hospitals 2015; CMS Impact Files 2015; Children's Hosp. Ass'n.

Notes: See Appendix Part A for the method used to calculate price. Hospitals with prices above the 99th percentile are excluded.

We compare these prices to prices at hospital systems with both integrated GAC hospitals and children's hospitals.[50] As Table 3 shows, these hospital systems have lower prices than GAC hospitals or stand-alone children's hospitals, with a median price of $8,810 and an average price of $9,826. (Integrated systems have lower prices than GAC or stand-alone children's hospitals where evaluated at the median, the 25th or 75th percentiles, or the mean.) While these results do not control for other confounding factors, they are consistent with the theory that hospital systems with integrated children's and GAC hospitals cannot leverage complementarities when negotiating with insurers.[51] To confirm that stand-alone children's hospitals and hospital systems with integrated children's hospitals are comparable in terms of specialty children's care, Table 4 compares these two types of hospitals in terms of both neonatal intensive care and pediatric intensive case. As Table 4 shows, they have similar availability of neonatal and pediatric intensive care, although

[50] We have not looked at hospital systems with integrated orthopedic hospitals due to lack of data.

[51] We also calculated prices in 2014 using AHA data from 2015, HCRIS data from 2014, and CMS Impact Files from 2014. The comparison of prices across hospital types is similar qualitatively and quantitatively using prices in 2014.

stand-alone children's hospitals have more NICU and pediatric ICU beds on average.

TABLE 4: NEONATAL AND INTENSIVE CARE BY HOSPITAL TYPE (2015)

Hospital Type	# of Hospitals with Prices Calculated	Share with NICU	Average Number of NICU Beds	Share with Pediatric ICU	Average Number of Pediatric ICU Beds
1. Stand-alone Children's Hospitals	45	89%	54	87%	29
2. Hospital Systems with Integrated Children's Hospitals	96	88%	38	86%	14

Sources: Healthcare Cost Report Information System 2015; AHA Annual Survey of Hospitals 2015; CMS Impact Files 2015; Children's Hosp. Ass'n.

Notes: Share of hospitals with NICU or pediatric ICU are the hospitals with at least one NICU or pediatric ICU bed. Hospitals with prices above the 99th percentile are excluded.

The fact that stand-alone children's hospitals and orthopedic hospitals have higher prices than GAC hospitals is consistent with these specialty hospitals having increased leverage in insurer negotiations either (1) from their status as complements and/or (2) as a result of having relatively few substitutes for their services. Yet, the combination of higher prices for stand-alone specialty hospitals and lower prices for integrated systems together suggests that the integration of hospitals with complementarities can lower prices. The combination further suggests that GAC hospitals and stand-alone children's hospitals generally are not substitutes for one another from the point of view of insurers. If they were, their integration would be expected to lead to higher negotiated prices all else equal, through the elimination of potential alternatives to which an insurer could substitute.

We also investigate if the comparisons above are robust to controlling for hospital concentration. Stand-alone children's hospitals may achieve high reimbursement rates because they are complements to GAC hospitals or simply because they are the only provider of such services in an area. Thus, the observation of higher prices at children's hospitals, while consistent with complementarities, is also consistent with children's hospitals having greater bargaining leverage simply because there are fewer competitors offering these unique services.

We first test whether the price differences across hospital types are statistically significant in a regression of hospital prices on dummies for hospital type with controls for county population density, year fixed effects, and Hos-

pital Referral Region (HRR) fixed effects.[52] The results, in the first column of Table 5, show that children's hospitals and orthopedic hospitals have higher prices than GAC hospitals at a statistically significant level (GAC hospitals are the benchmark category omitted in the table), while hospital systems with integrated children's hospitals have lower prices than GAC hospitals.[53]

The next three columns report results for regressions including controls for the number of hospitals, the number of the same type of hospitals, and the number of hospital systems within an HRR, respectively. The regressions reported in the last two columns control for the Herfindahl-Hirschman Index (HHI) measured within an HRR at the hospital level and the hospital system level, respectively. As these results show, even after accounting for hospital concentration, hospitals that are potential complements to GAC hospitals have higher prices, while hospital systems with both GAC and children's hospitals have lower prices.[54] These price comparisons are again consistent with the prediction that the integration of hospitals with complementarities lowers prices.

There are limitations to this analysis that imply that our results are suggestive, but not dispositive, of complementarities leading to price decreases. First, our analysis is a cross-sectional comparison of pricing and as such does not directly measure changes in hospital prices with and without integration. Controls such as HHIs may be related to unobserved factors that predict price, and the coefficients on HHI may reflect the relationship between these unobserved factors and price, not the relationship between HHI and price.[55] In addition, there are many factors that could affect hospital prices for which we do not account, such as insurer concentration, demand for medical services, and quality of care. It is possible that these or other unobserved factors may be leading to the higher prices that we observe at stand-alone facilities. Nonetheless, the observed empirical pattern is consistent with complementarities leading to lower prices when the complementary services are negotiated jointly.

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[52] Hospital Referral Regions are geographic areas defined by the Dartmouth Atlas of Health Care, and "represent regional health care markets for tertiary medical care that generally requires the services of a major referral center." *See About Our Regions*, DARTMOUTH ATLAS OF HEALTH CARE, www.dartmouthatlas.org/data/region/.

[53] The full regression results are reported, *infra*, in Appendix Part C. Our findings are robust to weighting the observations by the number of non-Medicare discharges.

[54] Stand-alone children's hospitals and stand-alone orthopedic hospitals have higher prices than GAC hospitals at a statistically significant level. Hospital systems with integrated children's facilities have lower prices than GAC hospitals, but not at a statistically significant level.

[55] More precisely, HHI may be endogenous in these regressions. By endogeneity, we mean that some unobserved factor such as high quality may cause both high prices and concentration. In this case, the regression coefficients will not be consistent. *See* David Dranove et al., *Is the Impact of Managed Care on Hospital Prices Decreasing?*, 27 J. HEALTH ECON. 362 (2008).

TABLE 5: ASSOCIATION BETWEEN HOSPITAL PRICES AND HOSPITAL TYPES, CONTROLLING FOR CONCENTRATION

Hospital Price	No Controls	Control for Number of Hospitals			Control for HHI	
		All Hospitals	Same-type Hospitals	Systems	Hospital-level	System-level
Stand-alone Children's Hospitals	7,460*** (832.0)	7,458*** (832.4)	6,316*** (1,148)	7,458*** (832.5)	7,461*** (832.1)	7,460*** (832.1)
Stand-alone Orthopedic Hospitals	1,694** (738.3)	1,689** (738.1)	749.5 (946.0)	1,693** (738.5)	1,693** (738.5)	1,694** (738.2)
Hospital Systems with Integrated Children's Hospitals	-1,127*** (432.7)	-1,128*** (432.7)	-1,834*** (513.6)	-1,127*** (432.7)	-1,127*** (432.7)	-1,127*** (432.7)

Sources: Healthcare Cost Report Information System 2014–2015; AHA Annual Survey of Hospitals 2015; CMS Impact Files 2014–2015; Children's Hosp. Ass'n; Census Summary File 2010 and Population Estimates 2014–2015, U.S. Census Bureau.

Notes: See Appendix Part A for the method used to calculate price. See Appendix Part C for coefficient estimates for other control variables. Hospitals with prices above the 99th percentile in each year are excluded. HHI is calculated based on non-Medicare discharges, but the regression results are robust to using total discharges instead. Numbers of hospitals, number of hospital systems, and HHI are calculated within each HRR, or an exogenouly defined region. Hospital systems are identified by the System ID in the AHA Annual Survey of Hospitals. HHI is calculated based on hospital or system share of non-Medicare discharges. County-level population density is calculated by dividing the U.S. Census Bureau's population estimates by the 2010 Census land area per county. We control for county-level population density, year fixed effects, and HRR fixed effects in all specifications. Robust standard errors in parentheses, clustered at the HRR level. Asterisks denote the following significance levels: *** p<0.01, ** p<0.05, * p<0.1.

V. CURRENT HOSPITAL MERGER SCREENING TOOLS DO NOT ACCOUNT FOR COMPLEMENTARITIES

While economic theories imply that mergers of complements can generally result in lower prices, and we have presented both anecdotal and empirical evidence that complementarity between hospitals can be an important factor in understanding the potential price effects of hospital integration, current methods for estimating the impact of hospital mergers—even state-of-the-art methods—do not account for the possibility that two hospitals are complements to insurers. This is because current methods, even those that model hospital-insurer negotiations, are dependent on measures of hospital competition for patients seeking care. This is the stage of hospital competition when hospitals are least likely to be complements.

It is important to understand the limitations of both classic and newer methods of merger analysis because of their widespread use in antitrust analysis. Regulators have successfully employed newer empirical methods—diversion ratios, patient willingness-to-pay models, and merger simulation—when investigating hospital mergers. In two recent challenged mergers, between ProMedica and St. Luke's and between OSF Healthcare and Rockford Health,

the government's economic experts analyzed diversion ratios and patient willingness-to-pay models. When evaluating the ProMedica merger, the government's expert also used merger simulation. In the Rockford case, the hospitals abandoned the merger, and in the ProMedica case, the court agreed with the government and blocked the merger.[56]

The remainder of this Part summarizes these techniques and elaborates on their limitations in capturing the effects of hospital complementarity. We conclude by discussing some ways to address these limitations.

A. Measures of Concentration

Historically, regulators have used changes in market concentration to estimate the effect of a merger on prices. The expectation under this measure is that mergers that would cause a greater increase in market concentration would also be more likely to result in greater increases in prices than mergers that would generate smaller increases in concentration. A traditional measure of market concentration is the Herfindahl-Hirschman Index, under which the market share of each seller is squared and the squares are then added together (e.g., if two participants each have 50 percent share, the HHI is equal to 2500 plus 2500, or 5000). The Horizontal Merger Guidelines suggest that regulators pay particular attention to mergers that increase the HHI in a market by more than 200 points.[57]

Market shares and HHIs have significant limitations in determining the pricing impact, if any, of a hospital merger. To calculate an HHI, one must determine a hospital's share in the relevant market. However, the first issue with HHIs is that the boundaries of the relevant market or markets are not always clear, nor is the way to measure appropriately a hospital's share. In addition, to calculate HHI, regulators often rely on the share of patients that a hospital receives, in the third stage of competition. However, hospitals and insurers negotiate prices in the first stage. A hospital with a specialized oncology clinic may have a great deal of bargaining leverage in a market without any other hospitals with a good oncology center, but may only receive a small fraction of patients. HHIs based on total patient shares could overstate the effect of a merger by understating the hospital's existing pre-merger negotiating power.

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[56] *See* Garmon, *supra* note 5, at 1088–89; ProMedica Health Sys., Inc. v. FTC, 749 F.3d 559, 573 (6th Cir. 2014); Press Release, Fed. Trade Comm'n, OSF Healthcare System Abandons Plan to Buy Rockford in Light of FTC Lawsuit; FTC Dismisses its Complaint Seeking to Block the Transaction (Apr. 13, 2012). R

[57] U.S. Dep't of Justice & Fed. Trade Comm'n, Horizontal Merger Guidelines § 5.3 (2010), ftc.gov/os/2010/08/100819hmg.pdf.

More generally, HHIs based on total patient discharges fail to capture differentiation across hospitals, which may make hospitals closer or more distant substitutes at the patient level, and as we have discussed, may also make them complements at the insurer level. When calculating an HHI, a hospital is either in the relevant market, and its share is measured and squared to calculate the HHI—or the hospital is not in the market and is irrelevant to the calculation of HHI. They do not capture complementarity from the point of view of insurers, let alone the service differentiation that could create such complementarities. They are therefore of more limited value in predicting post-merger price changes in markets where hospital differentiation, such as the kind that could create complementarities, is a significant factor affecting competition and insurer negotiations.

B. DIVERSION RATIOS

Newer techniques for evaluating the potential impact of hospital mergers address some of the limitations of the traditional HHI measure. One such technique is to estimate what is called a "diversion ratio" for each of the hospitals that are party to a proposed merger. A diversion ratio from hospital A to hospital B is defined as the percentage of hospital A's patients that would be predicted to choose hospital B if hospital A were not available. The calculation of a diversion ratio requires a model to explain where patients seek care (a "patient choice model") and to estimate where patients who selected a particular hospital would seek care if that hospital were not available. Based on those predicted choices, diversion ratios can shed light on how substitutable two hospitals are from the point of view of patients seeking care. If many patients from hospital A would select hospital B if A were not available, then hospitals A and B are likely to be close competitors and viable substitutes at the point that patients seek care (they are at least closer substitutes than other hospitals that patients could select in the absence of hospital A). In contrast, if few patients from hospital A would switch to hospital B, the two hospitals are not close substitutes. Hence, unlike HHIs, diversion ratios can differentiate between closer and more distant competitors at the point at which patients seek care.

However, because they only analyze patient choices, diversion ratios do not account for hospital complementarities. The patient choice models at the heart of diversion ratios explicitly model the selection of a hospital for an individual episode of care (i.e., an inpatient stay). At this point, each patient selects only one hospital, making all hospitals substitutes to some degree. Diversion ratios will only reflect substitutability in the first stage of competition—when hospitals negotiate with insurers—to the extent that insurers' preferences when building a network are aligned with patients' preferences when seeking care.

We have shown above that insurers' considerations can differ from patient preferences when hospitals are complements to insurers. In this case, patient diversion ratios, measured for a hospital in aggregate, will not appropriately capture the relationship between the hospitals at the point at the first stage of competition when hospitals and insurers negotiate prices. Consider again the case of hospital C that has pediatrics and hospital D that has oncology, and both offer GAC services. These two hospitals are complements for insurers, but a diversion ratio analysis, aggregating over all patients' choices, would indicate that they are substitutes to some degree. Patients without pediatric care needs who initially select hospital C may consider hospital D as their second choice; a diversion ratio would thus show at least some substitution from hospital C to hospital D even if no pediatric patients substitute to hospital D. Similarly, a diversion ratio would show some substitution from hospital D to hospital C for patients who do not need oncology care. Hence, even when hospitals are complements to insurers, aggregate diversion ratios can show they are substitutes because of the choices of certain groups of patients.

An analysis of diversion ratios by diagnosis could reveal differentiation that may be a source of hospital complementarity, but would still not identify hospitals that are complements from the point of view of insurers. A diagnosis-level diversion analysis of hospitals C and D, for example, would reveal that the hospitals are not substitutes for certain types of patients. But even highly differentiated hospitals could not be complements to a patient making a discrete choice between hospitals, and could be either substitutes or complements from the point of view of insurers. For example, if there were a third hospital that provided pediatric services, hospitals C and D could be substitutes within an insurer's provider network, without being substitutes for pediatric patients. If, instead, there were no other nearby hospital with the quality of pediatric care provided by hospital C or oncology services provided by hospital D, such that both hospitals were "must have" facilities for a marketable plan, then they would be strong complements to an insurer forming an insurer network.

C. WILLINGNESS-TO-PAY AND MERGER SIMULATION

The willingness-to-pay (WTP) model estimates the relative attractiveness, or value, of different hospitals to patients at the time that patients choose a hospital at which to receive care. A hospital will be less valuable to a patient when there are many close substitutes and more valuable when there are fewer substitutes available. If a higher patient WTP allows hospitals to negotiate higher prices with insurers, predicted changes in WTP can be used to predict a merger's effect on prices. To evaluate the potential effects of a merger, regulators and researchers can compare patients' projected average WTP for the merged entity to the average of their WTP for each hospital separately. If the

patient WTP for the hospital system is higher than the average for the two parties separately, the model suggests that prices will tend to increase, absent any other changes from the merger.

Merger simulations relate measures of patients' WTP for hospitals to the prices that hospitals negotiate with insurers. In a merger simulation, regulators and researchers first examine the extent to which hospitals with higher WTP measures command higher prices in the region relevant to the proposed merger. Based on this estimated relationship, they predict the combined hospitals' post-merger price based on patients' projected WTP for the merged entity. Merger simulations can thus offer a predicted price change that would result from a proposed merger, which neither diversion ratios nor WTP models specify.

Like diversion ratios, WTP analyses and merger simulations based on WTP cannot capture complementarities because they are based on the same patient choice model that underlies diversion ratios. More broadly, WTP and resulting merger simulations do not yield a direct measure of hospital competition in the first stage of competition. They will accurately predict post-merger price increases only when patients' preferences when seeking care align with insurers' preferences when negotiating with hospitals.[58]

Table 6 provides a numeric example illustrating how patient WTP can fail to capture insurer WTP. We again consider hospitals C and D, which are complements from the perspective of insurers at the first stage of competition, and examine three patients' WTP for these hospitals.

Since the hospitals are perfect substitutes for patients needing GAC, we assume that a patient needing GAC services receives a value of 10 from going to either hospital or from being able to go to both hospitals. For this patient, the marginal value of having access to either hospital, if the other is in-network, is 0.

However, these hospitals are neither substitutes nor complements from the perspective of a pediatric or oncology patient. Such a patient cares greatly whether C or D is in-network. The pediatric patient, for example, could only go to hospital C. In this example, suppose the patient (or the patient's parents) get value 10 from having hospital C, the pediatric hospital, in-network, and 0 if hospital C is not in the network regardless, even when D is included. The

[58] Vistnes and Sarafidis and Peters make this same point in a different context. They both consider mergers between providers of services that are neither substitutes nor complements at the patient choice level, for example, because two hospitals are located in different geographic markets. They argue that, in some cases, these two providers may be substitutes from the point of view of the insurer, and hence that a merger between them may result in price increases. *See* Vistnes & Sarafidis, *supra* note 22; Peters, *supra* note 22. R

marginal value of including hospital C in-network is 10, and the marginal value of including D is 0. The reverse is true for the oncology patient, who would receive value 10 for including hospital D, but 0 otherwise.

To evaluate the potential effect of a merger between hospitals C and D, we calculate the average WTP across patients for each hospital separately and together. Average patient WTP for hospital C is 3.3 because the general service and oncology patient have 0 WTP, and the pediatric patient has a WTP of 10. Likewise, average patient WTP for hospital D is 3.3. However, average patient WTP for the system is 10—or 5 per hospital—since each patient has a WTP of 10 for the system relative to a network with neither hospital. The increase in average WTP for the hospitals as a system (5) versus for each hospital on its own (3.3) occurs because the hospitals are substitutes for the GAC patient. This increase implies that the WTP model would predict a price increase from a merger between hospitals C and D.

This analysis does not, however, account for insurers' WTP. As previously discussed, these hospitals are complements for insurers. Following Table 1, an insurer receives a value of 4 with only one hospital in-network and a value of 10 if both hospitals are in-network. The marginal value, or insurer WTP, of adding either hospital C or D to the network is 6. Since prices increase with insurer WTP in this stylized model, the increase in insurer WTP would predict that prices would fall if hospitals C and D merged.

As this example shows, the patient WTP model does not completely capture insurers' considerations. Current methods of estimating merger price effects draw their conclusions from *patient* choices, but it is *insurer* WTP that will determine prices, since prices are negotiated between hospitals and insurers at the first stage of competition.

TABLE 6: PRICES WHEN HOSPITALS ARE COMPLEMENTS

		Separate Hospitals		Merged Entity
	No Hospital	**Hospital C (pediatric)**	**Hospital D (oncology)**	**Hospitals C and D**
Enrollee Value Based on Type of Care She May Need				
1. General Service	0	10	10	10
2. Pediatric Care	0	10	0	10
3. Cardiac Care	0	0	10	10
Patient Willingness-to-Pay when Other Hospital Is in Network[1]				
4. General Service	0	0	0	10
5. Pediatric Care	0	10	0	10
6. Cardiac Care	0	0	10	10
7. Average Patient Willingness-to-Pay[2]	0	3.3	3.3	10
8. Proxy for Per-Hospital Price[3]	0	3.3	3.3	5
Payor Willingness-to-Pay when Other Hospital Is in Network				
9. Payor Willingness-to-Pay[4]	0	6	6	10
10. Proxy for Per-Hospital Price[3]	0	6	6	5

Notes:

[1] Patient willingness-to-pay is calculated as the marginal value a patient receives from having hospital C assuming hospitals not listed in the column header are already included in the network.

[2] Average patient willingness-to-pay is calculated assuming there are equal numbers of general service, pediatric, and oncology patients.

[3] The proxy for per-hospital price is equal to the average willingness-to-pay divided by the number of hospitals. Actual prices would be estimated to be proportional to the per-hospital willingness-to-pay, but not necessarily equal.

[4] The insurer willingness-to-pay is taken from Table 2, line 3, and assumes that the surplus from having the hospital in-network accrues entirely to the insurer.

D. IMPLICATIONS

Despite the improvements of newer merger analysis techniques, which are less dependent on market definition and can capture product differentiation at the point patients seek care—their reliance on *patient choices* to project competition between hospitals at the point when they are negotiating prices with insurers—could significantly limit their ability to predict post-merger prices. These models will fail to incorporate considerations, such as complementarities, that are present when insurers and hospitals actually negotiate prices, but are not present when patients seek care.

VI. INCORPORATING COMPLEMENTARITIES IN FUTURE MERGER EVALUATIONS

There are challenges to incorporating complementarities in merger analysis even when they are known to exist. In particular, it may be challenging to directly measure the extent of complementarities between two products. To

measure the extent of complementarities between two hospitals, researchers would ideally observe plans that have included both hospitals in-network as well as plans that include only one of the hospitals in-network. Consumer demand and profitability could be compared across both types of plans to determine complementarity. But almost all health plans may choose to include both hospitals precisely because they are complements.

A second challenge in accounting for complementarities in health care is that it requires more sophisticated modeling of how providers and insurers negotiate prices. It may be possible to add a measure of complementarities to a merger simulation model. However, to date, empirical bargaining models in health care, as used in academic research or policy settings, have not incorporated complementarities.

Overcoming these challenges would be very valuable, though, because complementarities can exist in many settings, both in health care and different industries. Primary care, specialists, and hospitals may all be complements to one another from the perspective of insurers determining a network or patients selecting a plan. In the entertainment industry, increased file-sharing online increased demand for live performances of musicians.[59] Online and print newspapers have been shown to be complements,[60] as have wired and wireless Internet connections.[61] Computers and email have increased the amount of paper used, indicating that they are complements.[62]

Despite the challenges, regulators and merging parties can take immediate steps toward incorporating complementarities in their analyses of a merger. The first step is to consider whether complementarities may exist for the merger in question, as they could impact post-merger prices. While standard empirical methods will not measure complementarities, they may suggest their presence. For example, diversion ratios broken out by specialty or patient subgroup may reveal hospitals that serve a critical role for some patients, even if there are alternatives for most of their services. A weak relationship between patient WTP and hospital prices may also suggest that patient WTP has failed to capture important insurer considerations.

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[59] *See* Felix Oberholzer-Gee & Koleman Strumpf, *File Sharing and Copyright*, 10 INNOVATION POL'Y & ECON. 19, 44–46 (2010).

[60] *See* Matthew Gentzkow, *Valuing New Goods in a Model with Complementarity: Online Newspapers*, 97 AM. ECON. REV. 713 (2007).

[61] *See* Julie Holland Mortimer, Chris Nosko & Alan Sorensen, *Supply Responses to Digital Distribution: Recorded Music and Live Performances*, 24 INFO. ECON. & POL'Y 3, 6 (2012); *see also* Juan Vélez, *Merger Effects with Product Complementarity: Evidence from Columbia's Telecommunications* (Banco de la República Colombia, Working Paper No. 1018, 2017).

[62] *See* ABIGAIL J. SELLEN & RICHARD H.R. HARPER, THE MYTH OF THE PAPERLESS OFFICE (2002).

Additionally, regulators may have an advantage in evaluating hospital complementarities relative to academic researchers. Regulators can review confidential business documents and testimony from hospitals and insurers to develop a more complete picture of hospital and insurer pricing negotiations. Such documents and testimony may reveal hospital-insurer behavior indicative of complementarity (or other factors not present at patient choice stage), such as: insurers failing to use one half of a complementary pair as leverage in negotiations with the other half; recognition by insurers that both hospitals are a "must have" for marketable plans; or a hospital agreeing to negotiate with an insurer only if another hospital is included in-network, since the plan will not be viable without both hospitals.

Testimony by plan sponsors, such as employers, can also shed light on the value of hospitals to a provider network individually and in combination. For example, regulators may ask if an employer would ever consider offering a plan with only one or the other hospital in-network. These and other sources of information are critical to consider in mergers where complementarities are likely to be an important factor since, as we have discussed, a merger between two complements can have precisely the opposite price effect as the canonical models predict.

APPENDIX

A. CONSTRUCTING THE PRICE MEASURE

We follow Dafny and Garmon in constructing the following price measure (P) at the hospital (h) level.[63]

$$P_h = \frac{((IPSC_h + IPIC_h + IPANC_h)\left(1 - \frac{CONTDISC_h}{GROSSREV_h}\right) - MCPRIM_h - MCAP_h)}{(DISCH_h - MDISCH_h)CMI_h} \quad (1)$$

The idea is to divide commercial revenue by commercial discharges to get the average price paid by patients with commercial insurance, and adjust it by case mix to account for cross-patient variation in diagnoses, treatment procedures, severity, complications, and comorbidities. In the formula, *h* denotes a hospital; the numerator is commercial revenue; and the denominator is non-Medicare discharges, total inpatient discharges (*DISCH*) excluding Medicare inpatient discharges (*MDISCH*), adjusted for the case mix index (*CMI*). Commercial revenue is calculated as total revenue excluding Medicare revenue. Total revenue is the sum of inpatient routine service charges (*IPSC*), inpatient intensive care charges (*IPIC*), and inpatient ancillary charges (*IPANC*), multiplied by one minus the discount rate, contractual discounts (*CONTDISC*) divided by gross revenue (*GROSSREV*). Medicare revenue is the sum of Medicare primary payer amounts (*MCPRIM*) and Medicare total amount payable (*MCAP*).[64]

We calculate hospital prices using multiple data sources. First, we use discharge and financial data from the Healthcare Cost Report Information System (HCRIS). Second, we use the Annual Survey of Hospitals administered by the American Hospital Association (AHA Survey Data) to categorize hospitals. Finally, we use case mix index for Medicare patients from CMS Impact Files, California Health and Human Services Open Data, and the American Hospital Directory website.[65] Because of data restrictions, we can only use

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[63] *See* Dafny, *supra* note 47; Garmon, *supra* note 5. R

[64] We calculate price using the case mix index (CMI) from the CMS Impact Files and the following variables from the HCRIS data: Hospital Inpatient Routine Service Charges (IPSC), Hospital Intensive Care Charges (IPIC), Hospital Inpatient Ancillary Charges (IPANC), Contractual Discounts (CONTDISC), Gross Revenue (GROSSREV), Medicare Primary Payer Amounts (MCPRIM), Medicare Total Amount Payable (MCAP), Total Discharge Excluding Swing/Skilled Nursing Facility (DISCH), and Total Medicare Discharges Excluding Swing/Skilled Nursing Facility (MDISCH). We replace missing IPIC with zero and combine information from duplicate observations, but the price summary statistics are robust to alternative ways of treating the missing IPIC and duplicates.

[65] We use the transfer-adjusted case mix index from the CMS Impact Files wherever available. However, because the Impact Files do not include case mix for children's hospitals, we use California Health and Human Services Open Data on children's hospitals case mix to get case mix for Californian children's hospitals, and also look up case mix for the remaining children's hospitals on the American Hospital Directory website.

case mix among Medicare patients instead of case mix among commercial patients to calculate prices for all hospitals. However, we use California inpatient discharge data to compute commercial case mix and to evaluate the robustness of our price comparison to the case mix measure. We find that our measure is robust to using either commercial case mix or Medicare case mix.

Our price measure is robust to alternative ways of treating missing intensive care charges and to adjusting for case mix. When intensive care charges are missing, we either replace missing values with zero (in the baseline results) or treat them as missing and drop the observation (for robustness). When children's hospitals have missing case mix index, we either replace it with the sample average CMI (in the baseline results) or complement that with external sources wherever applicable (for robustness). As Table 7 shows, both median price and the price comparison across hospital types are robust across alternative price measures.

TABLE 7: ROBUSTNESS OF PRICE MEASURE (2015)

	All Hospitals		Median Price by Hospital Type			
Price Variations	**% of Hospitals with Missing Prices**	**Median Price**	**GAC Hospitals**	**Stand-alone Children's Hospitals**	**Hospitals with Integrated Children's Hospitals**	**Stand-alone Orthopedic Hospitals**
1. Baseline[1]	7.52%	$9,943	$9,904	$18,392	$8,810	$11,372
2. Intensive Care Charges (IPIC) Not Modified[2]	18.30%	$9,963	$9,953	$17,776	$8,716	$11,372
3. Case-Mix Index (CMI) from CHHS or AHD Children's Hospitals[3]	7.53%	$9,926	$9,897	$16,152	$8,805	$11,372

Source: Healthcare Cost Report Information System 2015; AHA Annual Survey of Hospitals 2015; CMS Impact Files 2015; Children's Hospital Ass'n; California Health & Human Services (CHHS) Open Data; American Hospital Directory (AHD)

Notes: Hospitals with prices above the 99th percentile are excluded.

[1] Intensive Care Charges set to zero when missing and duplicate observations combined. Case mix index for children's hospitals are set to be the sample average case mix index.

[2] Case mix index for children's hospitals is set to be the sample average case mix index.

[3] Intensive Care Charges set to zero when missing and duplicate observations combined. Case mix index for children's hospitals comes from CHHS or AHD where available. Missing CMI values for children's hospitals are set to the average CMI for children's hospitals based on AHD data as of Feb. 6, 2017.

B. CATEGORIZING TYPES OF HOSPITALS

Hospitals are categorized based on the "primary service" they provide according to the AHA Survey Data and on the "type of facility" in the HCRIS

data. To focus on the effect of complementarity on hospital prices, we restrict the sample to GAC facilities, children's hospitals, and orthopedic facilities.[66] We identify stand-alone children's hospitals that primarily provide pediatric care based on AHA's "primary service" variable. In comparison, we also identify health care systems that include integrated children's hospitals based on the list of members of the Children's Hospital Association. The hospitals in this list include both stand-alone children's hospitals and children's hospitals that are integrated in another hospital system.

[66] GAC facilities are hospitals whose primary service is "general medical and surgical" according to the AHA Survey Data, excluding rural health clinics according to the HCRIS data. Children's hospitals are facilities whose primary service is one of the following based on AHA Survey Data: "Children's general," "Children's orthopedic," "Children's other specialty," and "Children's chronic disease." Orthopedics facilities are facilities whose primary service is "orthopedics" according to the AHA Survey Data.

C. FULL REGRESSION ESTIMATES FOR TABLE 5

TABLE 8: ASSOCIATION BETWEEN HOSPITAL PRICES AND HOSPITAL TYPES, CONTROLLING FOR CONCENTRATION

		Control for Number of Hospitals			Control for HHI	
Hospital Price	**No Controls**	**All Hospitals**	**Same-type Hospitals**	**Systems**	**Hospital-level**	**System-level**
Stand-alone Children's Hospitals	7,460*** (832.0)	7,458*** (832.4)	6,316*** (1,148)	7,458*** (832.5)	7,461*** (832.1)	7,460*** (832.1)
Stand-alone Orthopedic Hospitals	1,694** (738.3)	1,689** (738.1)	749.5 (946.0)	1,693** (738.5)	1,693** (738.5)	1,694** (738.2)
Hospital Systems with Integrated Children's Hospitals	-1,127*** (432.7)	-1,128*** (432.7)	-1,834*** (513.6)	-1,127*** (432.7)	-1,127*** (432.7)	-1,127*** (432.7)
# Hospitals		243.7* (133.5)	-47.61** (21.11)			
# Hospital Systems				7.305 (107.5)		
# Independent Hospitals				379.9** (151.7)		
Herfindahl-Hirschman Index (HHI)					0.0774 (0.255)	-0.125 (0.288)
County-level population density	0.0276 (0.0230)	0.0276 (0.0230)	0.0255 (0.0229)	0.0276 (0.0230)	0.0276 (0.0230)	0.0277 (0.0230)
Constant	10,806*** (51.56)	5,878** (2,697)	11,706*** (402.4)	8,465*** (1,296)	10,653*** (508.3)	11,163*** (821.3)
Observations	5,799	5,799	5,799	5,799	5,799	5,799
R-squared	0.339	0.339	0.340	0.339	0.339	0.339

Sources: Healthcare Cost Report Information System 2014–2015; AHA Annual Survey of Hospitals 2015; CMS Impact Files 2014–2015; Children's Hosp. Ass'n; Census Summary File 2010 and Population Estimates 2014–2015, U.S. Census Bureau.

Notes: See Appendix Part A for the method used to calculate price. Hospitals with prices above the 99th percentile in each year are excluded. HHI is calculated based on non-Medicare discharges, but the regression results are robust to using total discharges instead. Numbers of hospitals, number of hospital systems, and HHI are calculated within each HRR, or an exogenouly defined region. Hospital systems are identified by the System ID in the AHA Annual Survey of Hospitals. HHI is calculated based on hospital or system share of non-Medicare discharges. County-level population density is calculated by dividing the U.S. Census Bureau's population estimates by the 2010 Census land area per county. We control for county-level population density, year fixed effects, and HRR fixed effects in all specifications. Robust standard errors in parentheses, clustered at the HRR level. Asterisks denote the following significance levels: *** p<0.01, ** p<0.05, * p<0.1.