DO AGGLOMERATION ECONOMIES EXIST IN THE HOSPITAL SERVICES INDUSTRY?

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INTRODUCTION

The timely diffusion of knowledge and information seems crucial for the efficient delivery of medical care given its complex nature and the considerable value-added associated with new medical technologies (Cutler and McClellan, 2001). Even in a world characterized by the electronic transmission of much information, physical location matters for knowledge flows because electronic contacts have been found to complement rather than substitute for face-to-face encounters (Gaspar and Glaeser, 1998).

Close physical contact may be of even more importance for knowledge flows in the hospital services industry because many medical procedures must be visually demonstrated. For example, Escarce (1996) shows empirically that access to information about laparoscopic cholecystectomy influenced surgeon's adoption behavior and that externalities in hospitals may have hastened the diffusion of the procedure. Perhaps reflecting the significance of medical face-to-face contact, Phelps (1992) notes that local schools of thought develop and partly account for observed geographical variations in medical practices. Given the importance of knowledge flows and the continued emphasis on face-to-face encounters especially for medical care, close proximity of hospitals may be essential for the efficient delivery of medical care. That is, hospital productivity might be greater where hospitals cluster and allow knowledge to more easily and quickly disperse among personnel in the various organizations.

In addition to the sharing of knowledge, clustering may improve productivity for a number of other reasons. For one, competition among the hospitals in a cluster may encourage efficiency improving innovations (Porter, 1990). The pressure to innovate, in turn, enhances productivity. Two, joint ventures and strategic alliances can more easily be accommodated in areas where hospitals group together. For example, a few years ago, Day Kimball Hospital and Backus Hospital, both located in eastern Connecticut, agreed to share the cost of a mobile MRI unit. Through their collaborative

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relationship, the two hospitals kept the unit operating closer to its capacity and thereby raised the overall productivity of the two organizations. As another example, Mease Health Care and Morton Plant Hospital, both located in Florida's North Pinellas County, entered into a joint venture to collectively provide outpatient care, specific types of tertiary care such as open-heart surgery, and certain administrative services like accounting, housekeeping, and laundry in 1993 (Davidson, 1994). This joint venture allowed the two hospitals to provide more hospital services with the same amount of inputs, thereby raising overall productivity.

In general, urban economists refer to the economies gained by the clustering of firms as agglomeration economies of which there are two kinds. Localization economies deal with any efficiencies resulting from the clustering of firms in the *same industry* as a result of shared suppliers, knowledge spillovers, incentives for innovation, and labor market pooling. For the same reasons, urbanization economies pertain to any productivity improvements when firms from *different industries* collect together in the same area. A sizeable amount of empirical evidence has provided evidence for agglomeration economies in the manufacturing and office sectors (e.g., Henderson, 1986; Carlino, 1979; Mun and Hutchinson, 1995).

If agglomeration economies hold in the hospital services industry, hospital productivity should be greater in metropolitan areas with more hospitals, *ceteris paribus*. However, some prior research in the hospital services industry has found contrary evidence indicating that an increased number of hospitals in the same area causes productivity losses because the various hospitals engage in a "medical arms race" (Robinson and Luft, 1985). Hospitals participate in a medical arms race when they spend unnecessarily on items such as cosmetic quality improvements, cost-enhancing technologies, and duplicate facilities as a way of attracting more physicians and patients (Robinson and Luft, 1985). As the hospitals compete among themselves, like too many crabs in a barrel may tend to do, the nonprice competition results in lower levels of productivity.

Consequently, theory alone cannot identify how the clustering of hospitals affects productivity. Agglomeration economies suggest that clustering of firms will improve hospital productivity whereas the medical arms race hypothesis points to the possibility of lower productivity in hospitals. O hUallachain and Satterthwaite (1992), the only other study on agglomeration economies in the hospital services industry, focus on employment growth in the hospital services industry across U.S. metropolitan areas. They find that urbanization economies but not localization economies characterize the hospital services industry. Their study, however, covers the period from 1977 to 1984. The hospital services industry has undergone a tremendous structural transformation since that time with changes like the Medicare DRG system, managed care competition, and new medical technologies exerting a dominant influence. The transformation may have seriously altered the underlying structure of producing hospital services. Even if the structural changes have had no influence on production arrangements in the hospital services industry, it still remains very difficult to generalize about the existence of agglomeration economies from only one study.

To add to our understanding about agglomeration economies in the hospital services sector, this study analyzes how the clustering of hospitals in the various metropolitan areas of the U.S. affects industry wide productivity. The multiple regression analysis is conducted on a cross-sectional basis for both 1993 and 1999 and by using first differencing of the data between the two years. The empirical results provide support for both static and dynamic localization economies in the hospital services industry. The next section develops the empirical model and discusses the data. Section III reviews the empirical findings. A summary and some conclusions are offered in section IV.

EMPIRICAL MODEL, SAMPLE, AND DATA

Our conceptual model assumes that the typical hospital produces a single measure of output, Q, by employing and combining two general types of inputs: beds, B, and various types of labor, L. The marginal product of each input is assumed to be positive and to decline with respect to increased usage. It follows that a generalized production function can be written as:

$$Q = E\{\cdot\}\, f(B, L), \tag{1}$$

where E{·} represents an exogenous Hicks-neutral efficiency function described below. Expressing equation (1) in relative factor terms gives:

$$Q/B = E\{\cdot\}\, g(L/B). \tag{2}$$

The left hand side of equation (2) can be interpreted as average product per bed. It can also be interpreted as a general indicator of average productivity because it reflects how much output can be generated from a bed with the amount of various inputs, like nurses and physicians per bed, held constant.

Agglomeration economies potentially influence the production of hospital services through the efficiency function. As mentioned in the introduction, urban economists point to two types of agglomeration economies: localization and urbanization economies. Localization and urbanization economies are introduced into equation (2) by supposing that the efficiency function can be specified as a function of the number of community hospitals, H, and population, POP[1], in the market area, or:

$$E\{\cdot\} = e(H, POP, X). \tag{3}$$

If both types of agglomeration economies hold, the efficiency function increases with the number of hospitals and population, *ceteris paribus*.

In addition to the two agglomeration variables, a vector of variables, X, is specified in the efficiency function to control for organizational and market factors potentially affecting productivity. One such organizational variable is the typical size of a hospital because theory suggests that productivity may depend upon the size or scale of the organization. In addition, prior research has suggested that health maintenance organizations (HMOs) may be associated with greater hospital productivity (Miller and Luft, 1994). Most hospitals are organized on a not-for-profit basis and the attenuation of property rights may create an incentive for not-for-profit hospitals to operate with some slack or X-inefficiency. By design, health maintenance organizations (HMOs) are supposed to encourage health care providers to adopt cost-effective practices. If slack exists in production, the pressure from HMOs to adopt cost-effective practices may cause hospitals to raise average productivity. As a result, greater dominance of HMOs in the market area might be found to be associated with greater productivity.

Lastly, income and an indicator of teaching status are specified in the empirical model to control for efficiency differences. Because the quality of medical care is most likely a normal good, and more time per patient reflects higher quality, an inverse relation is anticipated between per capita income and average productivity. That is, employing more resources per patient within a particular time period means fewer patients can be treated. Likewise, teaching hospitals generally operate with higher levels of quality and treat more severely ill patients. Higher levels of quality and more severe case-mixes require additional time per patient and thus results in lower average productivity.

Given that this study examines how the clustering of hospitals affects productivity, defining the relevant market area in which hospitals cluster becomes an important consideration. We assume that the metropolitan area serves as a suitable measure of the relevant geographical market (RGM). While this definition of the RGM partly results from the ready availability of data, researchers such as Baker, Cantor, Long, and Marquis (2000), Pauly, Hillman, Kim, and Brown (2002), and Spang, Bazzoli and Arnould (2001) have recently used the metropolitan area for their empirical studies on the health insurance and hospital services markets. Moreover, agglomeration economies potentially take place in urban areas, providing another important reason to define the metropolitan area as the RGM.

The metropolitan area also serves as the unit of analysis. Because of the aggregated level of the analysis, some bias may be introduced if the individual hospitals in the metropolitan area face different underlying production structures or incentives. For example, larger hospitals may operate with more sophisticated medical technologies than smaller ones. However, the aggregation process may help to reduce another type of bias that results from individual hospitals reacting to anticipated rather than actual demand. That is, the observed output rate deviates from the planned rate due to unforeseen changes in demand. Borts (1960) refers to this dilemma as the 'regression fallacy'. Keeler and Ying (1996) suggest using state data because the "use of group means should dramatically reduce or eliminate the bias resulting from the regression fallacy" (p. 473). Our use of metropolitan level data should serve a similar purpose. Thus, by using metropolitan level data, we have chosen to trade-off one type of econometric problem against the other.

Some measure of hospital output, Q, is necessary to conduct the empirical analysis. Investigators have used a number of different indicators of hospital output including the number of discharges, admissions, or inpatient days. However, these measures fail to capture the medical care provided in the outpatient facilities of hospitals. If the data available to us assigned various hospital inputs to either inpatient or outpatient care, the neglect of outpatient care would not be too troublesome except for any problems associated with substitutability between these two types of hospital care; but that is not the case with our data set. As a result, we use adjusted inpatient days as our measure of hospital output. Adjusted inpatient days equal the sum of inpatient days and the number of equivalent outpatient visits based on the ratio of outpatient to inpatient expenses. The services and treatments embedded in the measure of adjusted inpatient days are kept as homogeneous as possible by only including community hospitals in the sample. Community hospitals tend to produce a similar cluster of inpatient and outpatient services.

One potential drawback of using adjusted inpatient days as a measure of hospital output concerns the lack of any adjustments for patient case-mix and quality. Some hospitals handle more severe case-mixes and/or offer higher levels of quality than others. Unfortunately, data on patient case-mix and quality of care are not readily available at the metropolitan level for inpatient care and do not appear to be available for outpatient care. However, the absence of any case-mix or quality adjustment may not be cause for serious alarm because the dramatic case-mix and quality differences that normally exist among hospitals within a given urban area may average out across hospitals in different metropolitan areas (Keeler and Ying, 1996). In addition, a first difference of data approach is also used in the analysis so any remaining case-mix and quality differences may be netted out.

Data are collected from various sources for the metropolitan areas in the U.S. for both 1993 and 1999. Four different labor inputs, total nurses, physicians and dentists on staff, other salaried personnel, and admitting physicians, are specified in the multiple regression equation. All but admitting physicians are expressed in full-time equivalent terms. Figures for the actual number of admitting physicians are unavailable so the total number of active, nonfederal physicians less the number of physicians and dentists on staff is used as a proxy. To reduce the likelihood of collinearity between the number of hospitals and population, the number of hospitals is specified on a per capita basis. Statewide enrollment in HMOs as a percent of the population is specified to capture the relative dominance of HMOs in each metropolitan area.[2] In the empirical model, the number of trainees per bed captures the prevalence of teaching hospitals in the metropolitan area. Appendix A lists the mean, standard deviation, minimum and maximum values, and data source of each variable used in the empirical study.

A few metropolitan areas in New England could not be used in the empirical test because data for population and income are reported at the consolidated metropolitan level and therefore are not consistent with the hospital data listed for metropolitan areas. Observations for the two years differ because new metropolitan areas were designated after 1993.

EMPIRICAL RESULTS

Substituting equation (2) into equation (3) yields the following function:

$$Q/B = e\ (H, POP, X) \cdot g\ (L/B), \tag{4}$$

or more simply:

$$Q/B = m\ (H, POP, X, L/B). \tag{5}$$

It is assumed that all of the variables in equation (5) enter the estimation equation in log form so the estimated coefficients can be interpreted as elasticities.[3] Ordinary least square estimates of the parameters are obtained.[4] White's (1980) test finds evidence of heteroskedasticity so his method is used to derive heteroskedasticity-consistent estimates of the standard errors. The multiple regression results are provided in columns 2 and 3 of Table 1 using data for 1993 and 1999, respectively. The estimated coefficient and associated t-statistic are shown opposite each independent variable. Each coefficient identifies how a marginal change in an independent variable affects the number of adjusted inpatient days per bed in the metropolitan area, assuming all other variables remain constant.

Recall that the purpose of this paper is to test for the existence of agglomeration economies in the hospital services industry. Theory suggests that agglomeration economies may arise from a clustering of economic activity as a result of shared knowledge and input suppliers and of labor market pooling. In addition, competition among the firms in the same industry cluster may encourage innovation and productivity. The finding of positive coefficient estimates on the number of hospitals and population provides support for localization and urbanization economies, respectively, in the hospital services industry. In particular, a positive coefficient estimate on the number of hospitals per capita can be interpreted as suggesting that it is possible to deliver increased hospital services from a given amount of resources (nurses, physicians, etc.) when more hospitals group within an area because of localization economies.

Both regression results provide evidence to support localization economies in the hospital services industry given the statistically significant positive coefficient estimates on the number of hospitals per capita. Also, because of the insignificant coefficient estimates on population, both regression results lend no support for urbanization economies. The estimated coefficient on the number of hospitals per capita in column 3 indicates that in 1999, hospital productivity was 1.6 percent higher in those metropolitan areas with 10 percent more hospitals per capita than the average amount.

The regression findings associated with the other variables are also interesting and worth discussing. The conceptual model anticipates a direct relation between each of the labor inputs and average product per bed. For the most part, this expectation is met given that the coefficient estimates are positive on all of the labor inputs. Moreover, most of the coefficients are also statistically significant and reasonably consistent for both of the years. As an exception, the estimated coefficient on the number of admitting physicians changed considerably from 1993 to 1999 in terms of both magnitude and statistical significance.

TABLE 1
Cross-sectional Regression Results

IndependentVariable	1993 Results	1999 Results
Constant term	5.71*	6.620*
	(10.91)	(10.79)
Hospitals per capita	0.065*	0.163*
	(2.37)	(4.77)
Population	-0.002	0.014
	(0.22)	(1.53)
Staff per bed	0.021*	0.014*
	(3.93)	(2.15)
Other salaried personnel per bed	0.132*	0.128*
	(2.97)	(1.93)
Admitting physicians per bed	0.030	0.181*
	(1.13)	(4.89)
Nurses per bed	0.049**	0.047
	(1.51)	(0.78)
HMO penetration rate	0.022*	0.035*
	(3.25)	(2.72)
Trainees per bed	-0.007*	-0.025*
	(1.82)	(4.26)
Per capita Income	-0.161*	-0.250*
	(3.35)	(4.32)
Average Hospital Size	0.203*	0.280*
	(8.69)	(8.96)
Observations	303	312
Adjusted R^2	.38	.39

Notes for the table:
1. Dependent variable is adjusted inpatient days per bed.
2. All variables expressed in logarithm form.
3. Coefficient estimates with t-statistics in parentheses shown opposite each independent variable.
4. Two asterisks imply statistical significance at the 10 percent level or better. One denotes the 5 percent level
5. Corrected for heteroskedasticity using White's method.

It has been hypothesized that increased dominance of HMOs, as measured by the statewide HMO penetration rate, directly impacts average productivity. The argument is that HMOs should put greater pressure on hospitals to practice cost-effective medicine and the resulting increased efficiency should show up in higher average productivity. According to the empirical findings for both of the years, the coefficient estimates on the statewide HMO penetration rate are positive and statistically different from zero at the 5 percent level of significance or better. The relation is quantitatively small with a 10 percent increase in the statewide penetration rate only improving average productivity by no more than .35 percent in the typical metropolitan area.

Average hospital size is another factor hypothesized to influence productivity. According to the results, average hospital size directly relates to average productivity, most likely reflecting scale economies in production. In particular, a 10 percent increase in average hospital size is associated with an average productivity increase of 2 to 2.8 percent. Lastly, per capita income and number of hospital trainees per bed, as an indicator of the prevalence of teaching hospitals, are expected to exert an inverse impact on average productivity through its effect on quality. In agreement with expectations, the estimated coefficients on per capita income and the number of trainees are negative and statistically significant for both years.

To further investigate the existence of agglomeration economies, the model is reestimated by first differencing the data over the two years. More specifically, the difference between each of the various independent variables in log form is regressed on the difference in the average product of a bed between 1993 and 1999. Like the cross-sectional results, the coefficient estimates on the first differenced independent variables can be interpreted as elasticities. The first difference approach provides several advantages over the cross-sectional method. First, the first difference approach neutralizes any fixed effects associated with the various metropolitan areas such as systemic city, regional, or state variations in practice style. Second, first differencing of the data also helps to negate any structural differences in case-mix and the quality of medical care that may surface across metropolitan areas. Third, the first difference method allows an empirical determination of dynamic agglomeration economies reflecting how average productivity changes over time in response to the clustering of hospitals. The cross-sectional study provides a static determination of agglomeration economies or how the clustering of hospitals affects average productivity at a point in time.

The multiple regression results associated with the first difference approach are shown in column 2 of Table 2. Notice that the first difference model explains nearly two-thirds of the change in average productivity over time. In general, the signs of the coefficients on the various independent variables are consistent with the cross-sectional findings. More importantly, the first difference results provide support for dynamic localization economies in the hospital services industry given that the estimated coefficient on hospitals per capita is positive and highly significant. According to its coefficient estimate, a ten percent increase in the number of hospitals per capita over time is associated with a 4.6 percent increase in average hospital productivity.

The first difference regression findings associated with the HMO penetration rate are also worth highlighting. Recall that the cross-sectional results provide evidence that greater penetration by HMOs may result in higher hospital productivity at a point in time. However, the dynamic analysis provided by the first difference method shows that greater HMO penetration has no relation with hospital productivity over time. Thus, the results may provide support for the claim by Schwartz and Mendelson (1992) that the reported cost-savings of HMOs represent only a short-term phenomenon because HMOs appear to be incapable of influencing the rate at which new cost-enhancing medical technologies are introduced and adopted over time. Schwartz and Mendelson argue that once all of the slack is eliminated in the health care system, future attempts by HMOs to raise productivity and lower costs may be impossible unless rationing of medical services takes place.

SUMMARY AND CONCLUDING REMARKS

As far as we know, this is the first study to examine whether agglomeration economies hold in the more modern hospital services sector and to find evidence to

TABLE 2
First Difference Regression Results

Independent Variable	
Hospitals per capita	0.455*
	(11.37)
Population	0.163*
	(2.71)
Staff per bed	0.003
	(0.65)
Other salaried personnel per bed	0.205*
	(5.62)
Admitting physicians per bed	0.311*
	(8.10)
Nurses per bed	0.125*
	(4.50)
HMO penetration rate	0.0003
	(0.57)
Trainees per nurse	-0.005**
	(1.32)
Per capita Income	-0.123*
	(2.17)
Average Hospital Size	0.555*
	(15.39)
Observations	302
Adjusted R^2	.66

Notes for the table:
1. Dependent variable is the difference in adjusted inpatient days per bed.
2. All variables are first differences in logs between 1993 and 1999.
3. Coefficient estimates with t-statistics in parentheses shown opposite each indpendent variable.
4. Two asterisks imply statistical significance at the 10 percent level or better. One denotes the 5 percent level.
5. Corrected for heteroskedasticity using White's method.

support both static and dynamic localization economies. Localization economies result from the efficiency of labor market pooling, incentives to innovate, and from shared input suppliers and knowledge as more hospitals cluster in an area. The observed productivity improvements resulting from the clustering of hospitals provides yet another justification for encouraging a larger number of hospitals in metropolitan areas. The previous justification was that more hospitals in a market area results in lower prices and better health outcomes (Kessler and McClellan, 2000). It follows that antitrust authorities may want to consider also the possibility of any lost localization economies when evaluating the relative merits of a hospital merger. Of course, the analysis must also bear in mind the potential for any scale economies resulting from the merger.

Given the evidence in favor of localization economies, some states may want to seriously reassess the overall value of their certificate of need (CON) programs. CON laws were initially designed to prevent the duplication of medical resources by requiring that health care providers seek regulatory approval before purchasing expensive capital items such as medical facilities and equipment. However, some analysts point out that CON laws create entry barriers into the hospital services industry. For example, Santerre and Pepper (2000) find empirically that CON laws prevent the stock of small hospitals from being naturally replenished. It follows that some localization economies may never be realized if CON laws prevent new hospitals from entering markets especially those providing new ideas and medical technologies.

Another advantage of hospital clustering is that knowledge spillovers resulting from the clustering of hospitals may yield better health outcomes. For example, the increased adoption and dispersion of new medical technologies resulting from the clustering of hospitals may lead to reductions in post surgical mortality without necessarily changing the quantitative relationship between medical inputs and output. Our measure of output, adjusted inpatient days, only takes on a quantity dimension; thus better health outcomes are overlooked. When measures of health outcomes become available on a metropolitan wide basis, researchers may want to revisit this topic.

Nevertheless, this study offers valuable insights into agglomeration economies as applied to the hospital services industry. To date, health care researchers have generally overlooked agglomeration economies as another possible source of efficiency in health care markets. At the very least, this paper serves as a vehicle to introduce health services researchers to the concept of agglomeration economies and thereby provides another wide-open avenue for research into various health care industries.

APPENDIX A.

LIST OF DESCRIPTIVE STATISTICS AND DATA SOURCES

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value	Data Source
Average Product per Bed (1993)	322.78	48.15	205.85	509.01	AHA (1994)
Average Product per Bed (1999)	359.32	57.79	221.94	582.81	Health Forum (2001)
Hospitals (1993)	9.52	13.58	1	119	AHA (1994)
Hospitals (1999)	8.66	12.25	1	102	Health Forum (2001)
Population (1993)	649,508	1,079,771	56,626	9,118,939	County and City Extra1994
Population (1999)	680,161	1,122,137	56,954	9,329,989	County and City Extra2000

Appendix A — Continued

LIST OF DESCRIPTIVE STATISTICS AND DATA SOURCES

Variable	Mean	Standard Deviation	Minimum Value	Maximum Value	Data Source
Staff per Bed (1993)	0.030	0.048	0	0.484	AHA (1994)
Staff per Bed (1999)	0.068	0.072	0	0.563	Health Forum (2001)
Trainees per Bed (1993)	0.054	0.085	0	0.634	AHA (1994)
Trainees per Bed (1999)	0.070	0.011	0	0.850	Health Forum (2001)
Other salaried per Bed (1993)	2.91	0.49	1.49	4.41	AHA (1994)
Other salaried per Bed (1999)	3.39	0.69	1.16	6.36	Health Forum (2001)
Admitting Physicians per Bed (1993)	0.65	0.19	0.19	2.73	AHA (1994), County and City Extra (1994)
Admitting Physicians per Bed (1998)	0.76	0.40	0.23	3.34	Health Forum (2001), County and City Extra (2000)
Nurses per Bed (1993)	1.21	0.30	0.63	4.58	AHA (1994)
Nurses per Bed (1999)	1.38	0.29	0.66	3.04	Health Forum (2001)
HMO Penetration (1993)	15.69	9.63	0	38.6	HIAA (1994)
HMO Penetration (1999)	33.6	14.73	0	65.3	Managed Care Digest Series[i]
Population (1993)	649,508	1,079,771	56,626	9,118,939	County and City Extra1994
Per capita income (1993)	19,399	3,307	10,085	32,927	County and City Extra (1994)
Per capita income (1999)	25,357	4,697	12,759	45,199	County and City Databook (2000)
Average hospital size (1993)	76,498	31,227	17,433	216,202	AHA (1994)
Average hospital size (1999)	85,046	38,786	23,215	414,365	Health Forum (2001)

[i]http://www.managedcaredigest.com/edigests/hm2000/hm2000c01s07g01.html

NOTES

1. Researchers generally use population in the metropolitan area to capture urbanization economies.
2. Because HMOs may be drawn to metropolitan areas where hospitals demonstrate high productivity, statewide HMO data are used to avoid any endogeneity bias. The number of HMOs in each state was specified in an earlier model but proved to be highly correlated with the HMO penetration rate.
3. Before taking logs, a very small number was added to the independent variables that sometimes take on zero values including the number of staff physicians and dentists, trainees, and the HMO penetration rate.
4. Another potential econometric problem pertains to the endogeneity of the number of hospitals. That is, more hospitals may be drawn to metropolitan areas with higher productivity. Using the 1999 data set,

the Hausman (1978) method was used to test for the endogeneity of the number of hospitals. Instruments for the test included the growth of population and per capita income from 1993 to 1999. The Hausman test failed to reject the null hypothesis of exogeneity.

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