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How Does Payer Mix and Technical Inefficiency Affect Hospital Net Revenue?

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Abstract

As changes in the US health care system continue to evolve and change, maintaining the financial viability of hospitals is crucial to the system's operation. Two lines of inquiry have been pursued in describing factors affecting financial viability. The first line of inquiry relates to the external payer mix of patients focusing on patients who are unable to compensate hospitals for the care received. The second line of inquiry focuses on internal management and because hospitals do not typically answer to shareholders, managers become lax and X-inefficiency may arise. In this paper, we assess both these lines of research in order to determine if payment source by patients and/or managerial efficiency contributes to higher total net revenue. By using a weighted DEA we measured the inefficiency of inputs to the production process on our sample of 144 hospitals operating in Florida during 2005. We used the derived inefficient use of inputs along with the number of days by payer group (Medicare, Medicaid, private insurance, other public insurance, and uncompensated care) in order to explain their effects on total net revenue. To preview our results, we found that the inefficient use of beds and the provision of care to patients who are considered as uncompensated care reduce significantly total net revenue while private pay patients and patients covered by other public insurance add to total net revenue. These findings add to the literature by showing that it is patient payer mix and managerial inefficiency together affect hospital financial viability. We also demonstrate how our findings contribute to current policy debates both on the federal US and the state of Florida level.

Keywords: Hospital; Net Revenue; Efficiency; Payer; Uncompensated Care.
JEL Classification: I12; I18; D2; L2.

How Does Payer Mix and Technical Inefficiency Affect Hospital Net Revenue?

1. Introduction

Health policy focuses on the issues of access, quality, and cost containment, particularly as it applies to hospitals. Since the 1980's, access to hospital care for the uninsured has been discussed and was the impetus for health care reform proposals in the 1990's under President Clinton and more recently The Patient Protection and Affordable Care Act (PPACA) of 2010 passed and signed by President Obama. As laudable as the proposed expansion of health insurance coverage is, other issues remain. Some raise the issue that a significant number of uninsured will remain. For example, Katz et al. (2010) have estimated that 23 million will remain uninsured even under PPACA and if disproportionate share (DSH) is reduced as proposed under PPACA, hospital viability may be threatened, which could curtail access to hospitals if some, especially serving vulnerable populations have to close. In order to ascertain the potential impact of these possible outcomes, there are two basic lines of inquiry regarding hospital economic viability.

One line of research reports that challenges to hospital economic wellbeing is the proportion of care hospitals provide to the poor and uninsured. Feder, Hadley, and Mullner (1984) argue that hospital financial status and care to the poor are closely connected. Re-organization of hospitals in response to market pressures have been examined and research results have pointed to a reduction of care for the poor as the proportion of for profit hospitals in the US increases (Thorpe and Seiber, 2000). Even before the recent recession, $28.8 billion of uncompensated care was provided in 2006 with this burden falling on some hospitals more than others (Katz, et al. 2010). Because of the social responsibility hospitals face, even uninsured patients can not be turned away when in need as codified in law by the Emergency Medical Treatment and Active Labor Act (EMTALA, 1986). Therefore, the treatment for the poor, uninsured, and underinsured is exogenous to hospital decision makers. The only discretionary choice hospital decision makers do have in reducing the number of uninsured patients is to limit services.

Historically, hospitals were able to cross-subsidize uncompensated care by average cost pricing and receiving higher reimbursements from insured patients. This strategy was greatly reduced with the introduction of the prospective payment system implemented by Medicare, and contracts with private payers to exchange lower fees for increased patient bases. With increasing cost consciousness among third party payers, the burden of uncompensated care was absorbed by hospitals which in turn would threaten financial viability.

Friedman et al. (2004) examined hospital profitability, defined as net revenue and payer groups and found positive relationships among Medicare, Medicaid, and privately insured payers. These authors found that Medicare covered patients added the most to hospital profitability followed by privately insured, Medicaid, and self insured. Mukamel et al. (2002) also tied hospital financial viability to the amount of bad debt and charity care provided. Adding to the literature on payment source and hospital profitability, these authors however did not explicitly focus on internal efficiency.

A second line of inquiry has been on inefficiencies arising in hospitals including ownership organization, regulation, principal-agency, and third party payers (Eakin, 1991; Puig-Junoy, 2000). A unique feature of the US hospital system is multiple ownership forms. A majority of community hospitals operating in the US are not-for-profit (approximately 58% followed by government public hospitals (22%) and for-profit (20%) (American Hospital Association, 2009). Because of these various ownership forms, hospitals pursue different objectives other than profit maximization or cost minimization. Given varying ownership forms and differing objectives, there is a chance of X-inefficiency arising. X-inefficiency as described by Liebenstein (1966) hypothesized that without strict economic objectives, managers may be lax in

ensuring cost minimization or profit maximization is achieved. In the case of hospitals, there is the pursuit of other objectives include optimizing quality and quantity, providing social goods (i.e., teaching), maintaining safety net features (care for the poor, uninsured, and underinsured), offering highly technical and expensive services such as burn units, trauma center, and neo-natal care, and paying shareholders Other factors associated with cost variability among hospitals include, the maintenance of excess capacity in case of emergency (Joskow, 1980); the widely reported non-price competition in terms of duplication of highly technological services (Sloan, 2000); regulations requiring staffing ratios, (Coffman, et al., 2002; Cox, et al., 2005); and case mix of patients (Rosko and Chilingerian, 1999; Vitaliano, 1987). Given the stochastic demand for hospital services and the other private and social objectives hospitals are to meet (for example the provision of charity care), traditional economic models for either of these objectives are complicated. Because of the competing demands on hospitals to provide private as well as social goods, objectives such as cost minimization or profit maximization are not strictly pursued, therefore, theoretical cost (profit) functions are not appropriate. Because of the limits to more traditional economic modeling of hospital economic behavior, literature using alternative modeling techniques has been employed to measure hospital productivity and efficiency.

Data envelopment analysis (DEA) is one such approach. Flexible in its structure, this method has been used to determine the use of inputs to produce outputs and from this, define production frontiers, wherein deviation from these frontiers measures inefficiency. Hollingsworth, (2003, 2008) provides a comprehensive review of this literature. Focusing on the DEA literature, it is argued that minimizing input use to produce a given level of output, the definition of input-based efficiency, is a necessary condition for minimizing costs. Conversely, maximizing the number of outputs (number of patients treated) is necessary for maximizing revenues. Another benefit of the DEA approach is that the resulting efficiency findings are relative rather than absolute in the engineering sense. Therefore no unrealistic objectives are imposed on the hospitals and measuring performance against peer groups permits reasonable assumption regarding improving efficiency.

The two threads of inquiry used here combine how patient payer mix including care for the poor (either via Medicaid or uncompensated care) and how internal hospital inefficiencies may affect economic viability. In other words, both the external environment and the performance of the hospitals within these environments will affect how well hospitals maintain their economic well-being (Cody, Friss, and Hawkinson, 1995). By using the payer mix we include a de facto measure of allocative efficiency and by using the inefficient number of inputs we include a measure of technical efficiency, and therefore we completely describe the economic definition in assessing the differences in net revenue. By using the concept of net revenue rather than accounting measures such as operating margins we maintain consistency with the economic component in measuring efficiency. Using this definition of the economic outcome also can be readily applicable to managerial and policy decision making since the marginal effects of each payer group and use of inputs can be parlayed into a monetary interpretation.
In the next section of the paper, we describe our methodological approaches. We provide the data source and descriptive statistics in section 3. Results are presented in section 4 followed by discussion in section 5.

2. Methods

A. Measuring Technical Efficiency

As Hadley et al. (1994) note, “the heart of the theoretical problem is that the objective function is usually unobservable”. In light of the difficulty of specifying the objective function, it is similarly difficult to specify a functional form since this may lead to specification error. Since we are working with a theoretical premise that hospitals do not cost-minimize, we opt to use the nonparametric DEA frontier

for three main reasons. First, by virtue of the DEA approach, no a priori assumption of cost-minimization (profit maximization) needs to be incorporated into the model. Second, DEA only requires information on input and output quantities. No price information is needed which is a major advantage in the hospital sector. Third, DEA uses a multiple input and multiple output framework, which is relevant to hospitals that produce many different services using many types of labor and capital. Traditional production function relies on a single output or requires price and behavior assumption in order to derive the cost function in a multiple output context.

DEA has been widely used in ascertaining technical efficiency, scale efficiency, and congestion. To review, technical efficiency measures the amount of inputs required to produce a given level of outputs. In order to derive technical efficiency, we follow the methods described by Färe, Grosskopf, and Lovell (1994) and expanded by Färe, and Lovell (1978) which is derived from the original work by Farrell (1957) and Debreu's (1951) definition of productive efficiency. The approach we use in this paper is an extension of traditional DEA as we use the weighted DEA à la Färe and Lovell where the weights are defined as the share of the input cost into total cost. In fact, using the weights as defined here is equivalent to the weights used in a Törnqvist productivity index.

Since DEA is a non-parametric approach, we present the linear programming problems to be solved in order to determine overall technical efficiency. We employ the variable returns to scale technology to permit more peer groupings without having to rely on scalar expansions or contractions as in the case of constant returns to scale. Variable returns to scale relate to a short term horizon which is in line with the operational net revenue we used in the second step of our analysis.
We use the Färe and Lovell (1978) weighted DEA to derive the technical efficiency measures by solving the following linear programming problem:

$$
\begin{aligned}
&\text{Min} \sum_{n-1}^{N} s_n \lambda_n \quad \text{where } s_n = \frac{w_n x_{j,n}}{\sum_n w_n x_{j,n}} \\
&\sum_{k=1}^{K} z_k y_{k,m} \geq y_{j,m} \quad \forall m \\
&\sum_{k-1}^{K} z_k x_{k,n} \leq \lambda_n x_{j,n} \quad \forall n \qquad (1) \\
&\sum_{k=1}^{K} z_k = 1 \\
&z_k \geq 0 \quad \forall k
\end{aligned}
$$

We note that rather than applying the same radial contraction score (λ) to measure the inefficient use of each input, we use different λ for each input and we use the share of each input cost into total cost as their weights in the objective function . In this way we measure the extent to which each input is inefficiently used. These measures we will use in the second step regression are given at the optimal value of (1) by $\lambda_n^* x_{j,n}, \forall n$.

B. Regression Approach
Following the suggestion by Hollingworth (2008), we apply multiple techniques. Whereas it may be relevant for hospital managers and policy makers to be interested in the determination of technical

efficiency for each hospital in our sample, it does not answer the direct question of how both patient payment mix (which may be partially exogenous) and managerial decisions on how best to employ hospital resources can be combined to determine independent effects on each hospital's net revenue. To accomplish this we use the technical inefficient number of beds, physicians, and nurses used for patient care as well as patient inpatient days by payer group as regressors in determining variability among hospitals' net revenue. This is accomplished using ordinary least squares multiple regression. It is important to use multiple regression since we wish to identify independent effects of each variable on net revenue, which can be used in a policy context. Our model is defined as:

$$TNR = \alpha + \sum_{pm}^{PM} \beta_{pm} x_{pm} + \sum_{n}^{N} \beta_n (\lambda_n^* x_n) + \varepsilon \qquad (2)$$

where TNR is the Total Net Revenue (in $), x_{pm} is the number of patients of each type of payers, $\lambda_n^* x_n$ is the inefficiency of each input and ε is a residual term.

3. Data and Descriptive Statistics

Three separate data sets were merged in order to perform this study. Limiting our sample to general, short term hospitals we use The Florida Agency for Health Care Administration (data on hospital capacity), Hospital Inpatient Discharge Data (patient characteristics) and the Hospital Financial Data for Florida for specific service capabilities. Case mix data for the hospitals comes from Solucient and is based on DRG pairs derived from Medicare data. Reliance on Medicare data should not be a problem even though our discharges cover all payers since it has been found that the Medicare case-mix index is highly correlated with other hospital case mix indices (Jensen and Morrisey, 1985). These specific case mix indices from Solucient have also been used in previous studies including Clement et al. (2008) and Valdmanis, Rosko, and Mutter (2008). Because hospitals treat a variety of patients with varying levels of disease/illness severity it is necessary to adjust hospital efficiency to account for these differences. Otherwise, there may be an upward bias of technical inefficiency without considering that higher case mix patients require more resources to treat them effectively. Since we have limited information, we derived the number of outpatient visits as a measure of inpatient discharges using the formula of adjusted outpatient equals gross outpatient revenue divided by inpatient gross revenue per inpatient day (www.whainfocenter.com, 2010).

The first step in our analysis is the DEA model in order to determine technical efficiency. For inputs we use the number of staffed and licensed beds, the number of full time equivalence (FTE) physicians, the number of FTE nurses, the number of FTE other personnel and the number of inpatient days. We include the number of inpatient days as an input since in order to produce patient discharges we need an input to represent the amount of treatment during a patient stay. We also argue that inpatient days can be seen as substitutes for the other more familiar inputs. For example, with fewer nurses, patients would have an increased length of stay rather than a more intense care that would be possible with more nurses that would result in fewer inpatient days.

For outputs, we used the total number of inpatient discharges, outpatient equivalent days and the case mix index per hospital. We use inpatient discharges as output because we consider hospital activity as exogenous with the objective of minimizing inputs given a level of activity. We argue that the number of inpatient days is under the control of the hospital and endogenous. That is why it is used as an input. We use case mix as a separate output to better categorize hospitals by peer groups based on the severity of patient care provided which is directly tied to resource use. The inputs and outputs used for this analysis are given in Table 1.

Table 1. Descriptive Statistics for Determining Technical Efficiency. N=144.

Variable	Mean	St. Deviation
INPUTS		
Inpatient days	75,480	76,448
Beds	348	306
Physicians in direct patient care	292	305
Nurses in direct patient care	375	442
Other Personnel	850	1,137
OUTPUTS		
Total Inpatient Discharges	18,017	15,454
Case-Mix	1.40	0.23
Outpatient in estimated days	34,821	31,510
FINDING FROM DEA ANALYSIS		
Technical Efficiency Measure for Physicians in direct patient care	0.75	0.27
Technical Efficiency Measure for Nurses in direct patient care	0.85	0.15
Technical Efficiency Measure for Other Personnel	0.83	0.20
Technical Efficiency Measure for Inpatient days	0.86	0.15
Technical Efficiency Measure for Beds	0.82	0.21

Our sample consists of 144 hospitals operating in Florida during 2005 which represents 60% of all hospitals in Florida (238). There is a wide variability in the outputs and inputs in our sample but we find relatively similar inefficiency scores ranging from 0.75 to 0.86. For example, this finding is interpreted as (1-0.75) equaling 25% is the amount hospitals could reduce physicians (MDs) and maintain the production of outputs. Further, since technical efficiency is a necessary condition for cost reduction, hospitals in turn could reduce costs which should improve financial viability.

As stated above, we are also interested in ascertaining the payer mix of patients' affect of variation in net revenues. Patients are characterized by payment group as reported on the data set. Uncompensated care equals charity care plus bad debt since it is often difficult to differentiate between the two. Other public insurance includes CHAMPUS (the military health group payment) plus other public insurance from the State of Florida. These descriptive statistics are given in Table 2.

Table 2. Descriptive Statistics for Regression Model Variables. N=144.

Variable	Mean	St. Deviation
Net Revenues ($)	3,884,841	28,023,716
Medicare Days	45,795	40,453
Medicaid Days	4,094	10,179
Private Insurance	18,350	23,328
Other Public Insurance	1,898	2,983
Uncompensated Care	5,344	14,662
Inefficient number of Inpatient days	10,445	13,956
Inefficient number of Beds	62	88
Inefficient number of Physicians in direct patient care	78	119
Inefficient number of Nurses in direct patient care	53	76
Inefficient number of Other Personnel	148	243

Again, we find a wide variation in terms of net revenues, as well as the number of inpatient days by payer groups and differences in the inefficient number of inputs.

4. Results

Positive net revenue is integral for hospitals maintaining financial viability in the continuance of providing hospital care access to their communities. We use multiple regression techniques in order to ascertain the independent effect of each of the explanatory variables on the variation of net revenue. We chose the multiple regression ordinary least squares approach for a straightforward interpretation of the independent variables affect on variations on net revenue. The findings from our regression results are presented in Table 3.

Table 3. Regression Results

Dependent Variable Net revenue= Total Revenues-Total Expenses. N=144.

Variable	Coefficient	t-test	Pr <
Intercept	648,074	0.35	0.73
Number of Medicare Inpatient Days	7	0.21	0.91
Number of Medicaid Inpatient Days	331	-0.95	0.35
Number of Private Insurance Inpatient Days	525	5.19	0.0001
Number of Other Public Insurance Inpatient Days	1,007	2.07	0.04
Number of Uncompensated Care Inpatient Days	-1,616	-6.90	0.0001
Inefficient number of Inpatient days	281	0.83	0.41
Inefficient number of Beds	-47,206	-2.48	0.01
Inefficient number of Physicians in direct patient care	3,171	0.31	0.76
Inefficient number of Nurses in direct patient care	69,487	0.88	0.38
Inefficient number of Other Personnel	-17,453	-1.61	0.11
F~64.38 PR <0.0001			
Adjusted R^2 =0.82			

The results we provide in Table 3 demonstrate that hospitals can increase net revenue by increasing the share of patients covered by private insurance and by other public insurance. There is no statistically significant effect of increasing Medicare or Medicaid, patients share towards increasing net revenue. We also find that treating uncompensated care reduces hospitals' net revenue by $ 1,616 per day. The inefficient use of hospital beds results in the loss of $47,206 per bed annually. There is no statistically significant effect of the inefficient use of the number of nurses on hospital net revenues. From these findings, there is no evidence that payer mix as defined for this sample of Florida hospitals is detrimental for earning net revenue except in the case of providing hospital care to individuals who are considered as uncompensated care per day and it appears from the regression results that it is difficult to cover these costs per day by private or other public payment. In the case of organizational effects, hospital managers, could however, increase financial performance by reducing the number of excess beds, ceteris paribus.

5. Discussion

The objective of this paper is to assess both hospital patient payer mix and technical efficiency in order to ascertain variations in net revenue which is crucial in maintaining economic/financial viability. Using the weighted DEA approach, we find that on average, hospitals could reduce excess costs by 18% (the average of the individual inputs' score) by increasing technical efficiency of the inputs used. From the

regression results this decrease in costs and subsequent increase in net revenue would be realized by reducing the number of inefficiently used beds. This finding is consistent with Joskow's (1980) theory of reservation quality. If hospitals wish to pursue this objective in terms of employing inefficient beds, they will have to incur higher costs and lower net revenue. It should also be noted that using this Florida data set, Leleu et al., (2011) also found that hospitals had an excess number of beds leading to economic inefficiencies. Since the best practice frontier derived from the DEA is based on the observations in the sample and is relative rather than absolute, hospitals can in essence learn from their peers how best to reduce the number of inefficient beds while maintaining patient care.

From the payer variables, hospitals could increase net revenue by providing care to private pay patients and other publicly insured patients. There is no impact on net revenue for hospitals providing inpatient day care to Medicare, or Medicaid indicating there is no over financial profiting for hospitals via the public sector. We did find a statistically significant impact on net revenue in the treatment of uncompensated care patients which corroborates earlier studies such as Friedman et al. (2004). From our findings, the increased pressure on Medicare (via prospective payment) and more cost control on the part of private insurers, the past practice of cross-subsidization is not even a possibility for hospitals which primarily serve this population.

Because the provision of uncompensated care may be considered a social good that relies on public intervention, government budget allocations and subsidies such as disproportionate share hospital (DSH) payments mitigate the financial hardship on these hospitals as these subsidies increase income margins for hospitals providing uncompensated care by 2.4% (Agency of Health Care Research and Quality, 2003). In terms of policy, the number of insured Americans as proposed by the Patient Protection and Affordable Care Act is projected to increase; therefore, DSH payments will be cut under the theory that an increased private pay patient load would negate its need.

As a consequence of proposed reductions to DSH, access to hospitals by the poor may still be difficult since Katz et al. (2010) predicts that 23 million individuals will still be uninsured which would still challenge financial viability especially for safety net hospitals. Eliminating DSH payments to our sample hospitals could also result in a greater negative impact threatening financial viability. Officials at the Florida Hospital Association are also concerned that if disproportionate share hospital payments are reduced to Florida hospitals as they may be more prone to financial distress than hospitals operating in other states due to the high uninsured and illegal immigrant populations (Florida Hospital Association, 2009).

More recently, the Governor (Richard Scott, R) submitted a budget drastically cutting Medicaid payments (Kennedy, 2011) because he attributed inefficient and costly use of inputs were attributed to Medicaid payments made to Florida hospitals. Given that in our net revenue equation Medicaid patients did not have a statistically significant effect on net revenue and it does not appear that Medicaid payments leads to higher technically inefficient inputs. Therefore, our research does not support the Governor's contention that Medicaid payments to hospitals lead to non-optimal behavior on the part of managers. Nurses in California are also threatening to strike due to budget cuts (Bernstein, 2011).

On a related policy note, we did not find any statistically significant effect of nurses on net revenue which suggests that they are possibly not being used to increase net revenue. However, we did find a positive relationship between inefficient nurses and net revenue. Since our finding on inefficient number of nurses does not negatively effect net revenue we contend that these results do not contradict earlier research indicating that employing more nurses leads to higher quality of care (Valdmanis, et al., 2008;

Aiken, et al. 2002). The role of registered nurses could increase net revenue as hospitals compete for more paying patients on the basis of quality. Other research has reported that the more nurses hired by hospitals lead to less rehospitalizations which is directly tied to the policy of pay for performance in which reimbursements are directly tied to patient outcomes. New regulations from Center for Medicare and Medicaid Services will not reimburse hospitals for rehospitalization of patients within 30 days of discharge. Jencks et al., (2009) reported of a high number of rehospitalizations, indicates that more rather than fewer nurses should be pursued. Our findings strongly suggest that utilizing nurses efficiently may also enhance the hospital's financial viability. Further, focusing budget cuts in state funding and the consequence of reducing the number of nurses does not appear to be a wise policy to pursue.

The findings we present here rely on data provided by the various data sources. As such, the usual caveats apply. First, hospitals may not be consistent in the reporting in FTE nurses. The number reported are given as an annual figure which may include nurses hired for peak time periods (which is possible given the transient population in Florida particularly in the winter) and some FTE nurses may be hired in other capacities such as administration. Better accounting and specific data collection should be forthcoming given the increased reliance on data for the new health care reform policy. Second, the entire of population of hospitals were not included in this study due to missing values, therefore, the findings are based on 60% of hospitals operating in Florida during 2005. Again, more patient-based data or revenue per payment group would better elucidate the exact relationship between payer group and hospital net revenue. Despite these data shortcomings, the approach we introduce here will be of increased value as hospital and health care costs continue to garner policy importance and better and more generalizable data will become available.

This research is preliminary and should be updated to account for the recent economic recession that may have serious consequences as more individuals become uninsured and postpone necessary management of illnesses that leads to more hospitalizations with reduced reimbursements. State budget cuts, as it affects Medicaid coverage will also impact hospitals particularly those already caring for vulnerable populations.

Our work expands on previous works on hospital financial viability since we also incorporate measures of the technically inefficient use of inputs that hospital managers could address to maintain positive net revenue. Therefore, we posit that this two pronged approach – reimbursements from patients and hospital management – should also be evaluated as health reform changes are implemented to address access to, cost containment for, and financial viability of hospitals.

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