Modeling an outcome with many zeros: An application of an integrated two-part model in hospital service diversification

Abstract

Traditional methods used to address semi-continuous variable—a combination of many zeros and highly skewed positive values—have been the Heckman selection model or two-part model. However, they are two separate models. In this paper we specified an integrated two-part model to address the growth of hospital subacute care service diversification over time. The integrated model more realistically accommodated the association between the likelihood as well as the amount of subacute care service diversification, by examining both of them simultaneously in the context of time-varying and time-invariant covariates. It accommodated the three well-known problems of the outcome variable: excessive zeros, skewness, and correlated observations. The results of this study indicated that competitive pressures, demographics (percentage of population aged 65 years and older in the market), and organizational characteristics (Not-For-Profit status) had effects on the likelihood as well as on the amount of hospital subacute care service diversification. The effects of HMO penetration on hospital diversification were not observed.

Key words: Hospital service diversification, Integrated two-part model, HMO penetration

Huabin Luo[1*], Richard Shewchuk[2], Jeffrey Burkhardt[2]

1 School of Business, Mount Olive College, Mount Olive, USA

2 School of Health Professions, University of Alabama at Birmingham, USA

* Corresponding author

e-mail addresses:

HL: hluo@moc.edu
RS: shewchuk@uab.edu

JB: jburkhar@uab.edu

1. Introduction

Over the last several decades, there have been many forces that influenced the operational strategies of US hospitals, such as government-mandated cost-containment, managed care plans, and advances in medical technology (Mick 1990; Shortell et al. 1992). Service diversification — provision nonacute care or subacute care — has been one of the strategies attempted by hospitals to address environmental changes (Swayne et al. 2005). Yet, the strategic decision for hospitals to diversify into subacute care services and the degree to which they diversify are highly variable. For instance, within a given time frame, the likelihood of adopting this strategy varies across hospitals; and among those hospitals that decide to diversify, there is likely to be intra- and inter-hospital variability in terms of the amount of diversification undertaken. The measurement of different aspects of diversification — presence or absence, amount of diversification, and the changes over time—presents complex analytical challenges when attempting to examine the trend of hospital diversification overtime. In this paper, an integrated two-part model (Olsen and Schafer 2001) was developed to address these challenges. The approach used in this study represents a methodological advancement from traditional approaches in that it combined the traditional two separate models into one concurrently estimated model, and accommodated the three well-known problems of the outcome variable: excessive zeros, skewness, and correlated observations.

Traditional approaches to analyze variables with severe non-normal distributions include the two-part model (Duan et al. 1983; Manning et al. 1981) and the Heckman selection model (Heckman 1979). The two-part, namely U part and Y part, model was originally used to examine medical expenditures in cross-sectional studies. A logit (probit) model was applied to model the probability of nonzero expenditure and a conditional linear equation was used sequentially to model the log-expenditures given that there were non-zero values (Duan et al. 1983; Manning et al. 1981).

With the Heckman selection model (Heckman 1979), analysis is performed in two stages. In the first stage, presence or absence of the outcome variable is estimated in a probit model and a selection bias parameter—Lambda—is calculated. In the second stage, the nonzero values of the outcome variable are estimated with Generalized Linear Models (GLM), with the same predictors as in the probit model, plus the Lambda parameter. Attempts have been made to extend the Heckman selection model to longitudinal studies. For instance, Wheeler et al. applied Heckman model and accommodated the inter-dependence of observations in a longitudinal study by using Generalized Estimating Equations (GEE) in the second stage (Wheeler et al. 1999).

These traditional models are really two separate models because the two components are not directly integrated (Manning et al. 1987). The two-part approach does not fully address the relationship between the two parts, and as a consequence may introduce bias into the estimated coefficients (Olsen and Schafer 2001).

Olsen and Schafer extended the two-part model to deal with semi-continuous variables in longitudinal settings (Olsen and Schafer 2001) on principles of Structural Equation Modeling (SEM) and latent growth modeling. The new approach introduces random coefficients into both logistic and linear equations. And these two components are linked by allowing the parameters to correlate across the components. In an integrated model: The first component deals with the “occurrence,” and the second deals with the “intensity” or “amount”. In this paper, we demonstrate the application of an integrated two-part model to estimating hospital diversification behavior overtime. We examined this strategic behavior of hospitals in relation to unique environmental and organizational factors. It is hypothesized that health maintenance organization (HMO) penetration rate and other determinant factors would have an impact on hospital subacute service diversification.

Deleted:

2. Application

2.1 Data and sample

The sample used for this study was all non-government, general acute care hospitals that operated during the years 1992 through 1996. Newly established hospitals, and those that merged, consolidated, or closed during that period were not included. The final sample for this study included 2,506 hospitals.

This study focused on the time frame from 1992 to 1996 for two reasons. First, managed care, especially HMOs, grew steadily during that period (Kertesz 1996). Second, the Balanced Budget Act (BBA) of 1997 required the Center for Medicare and Medicaid Services (CMS) to implement prospective payments for skilled nursing facilities. This requirement posed a new challenge to hospital-based subacute care services, particularly those in high Medicare or managed care markets (Rovinsky 1999). Therefore, the time frame for the present study covered a period after Medicare’s Prospective Payment System (PPS) of 1983 and before the implementation of Balanced Budget Act (BBA) of 1997, and provided a special time span to exclusively examine the effect of HMO penetration on hospital diversification behavior, by keeping out the confounding effect of BBA of 1997 on hospital diversification. As such, the period of 1992-96 could potentially capture the growth trajectory of hospital diversification into subacute care services in face of the rapid growth of managed care.

2.2 Measurement of the outcome variable and covariates

The covariates in the model were identified within the theoretical framework of both institutional theory and strategic choice perspectives. In brief, institutional theorists propose that external constraints and pressures influence organizational decision. One institutional factor is the managed care penetration (especially *Health Maintenance Organization penetration*) (i.e., selective contracting). For instance, having a subacute care unit can make an acute hospital more attractive to a managed care plan in that the hospital is viewed as being able to ensure a continuum of care and better quality, and save cost by treating patients in a less intensive care setting. In addition, institutional theory suggests that organizations in uncertain environments often pursue "taken-for-grantedness" and mimic others (DiMaggio and Powell 1983; Suchman and Eyre 1992). Thus they tend to adopt an innovation, not because of the innovation's efficiency or returns, but because of a bandwagon pressure caused by other organizations that have adopted such innovation (Abrahamson and Rosenkopf 1993). Given this, *competitive pressures* from other hospitals with subacute care services would be another institutional factor of hospital diversification into such services.

On the other hand, the strategic perspective suggests that organizations can exercise discretion in decision-making within the environment constrains (Arndt and Bigelow 1992;

Greenwood and Suddaby 2006) . In the case of subacute care service diversification, acute care hospitals decide to provide such services in order to enhance Medicare reimbursement. And subacute care units would allow hospitals to more effectively manage lengths of stay of some Medicare patients (*senior citizens* in the community) by providing an appropriate "step-down" level of care (Kothmann 1995). Other covariates identified according to the theoretical framework include hospital o*wnership status, system affiliation, full- time equivalent employees (FTEs) per bed*.

Table 1 lists the measures of variables. The outcome variable in this study is the total number of subacute care beds in a hospital. From 1992 to1996, there was a change in American Hospital Association (AHA) survey items of subacute care services. In order to ensure that the measurement of subacute care services was consistent, only the five common items that were surveyed by AHA each year from 1992 to 1996 were selected. These items were rehabilitation service, psychiatric care, alcohol/chemical dependency care, skilled nursing care, and intermediate care. As hospitals with more beds would likely have more subacute beds, the dependent variable—number of subacute care beds— was normalized by dividing it by the total number of hospital beds then multiplying the result by 100. This percentage, therefore, reflects the degree of subacute care diversification of a hospital.

(Insert Table 1 about here)

Independent variables*. FTEs per bed ratio is* the total number of FTEs of a hospital divided by the total number of beds in the corresponding year and then multiplied by 100. A higher FTEs per bed ratio would indicate more human resources available to a hospital. *Ownership* (Not-for-profit [NFP] vs For-profit [FP]) *and system affiliation* (system-affiliated vs non-system-affiliated) types are two dummy variables, and were treated as time-invariant. The other three independent variables (*competitive pressure, HMO penetration rate, and senior citizen rate*) were measured at the health service area (HSA) level. There are 802 health service areas (HSAs) in the continental United States (Makuc et al. 1991). *HMO penetration rate* was the total HMO enrollment in a year at the HSA level divided by the total population in the corresponding year for the HSA. *The senior citizen rate* was measured in the similar manner: the total number of people 65 years of age and older each year in an HSA was aggregated and then divided by the total population in the corresponding year in an HSA. *The competitive pressure* was calculated by dividing the total number of hospitals that reported any subacute care beds by the total number of hospitals in an HSA in a year (hospitals with missing values of subacute beds were not counted).

2.3 Analytical approaches

Among the 2,506 hospitals in the study sample, 538 hospitals reported having no subacute beds at any time during the 1992-1996 study period. Preliminary analyses of the outcome variable-subacute care beds, showed that it exhibited extreme skewness, with a preponderance of zeros and large positive values, not amenable to data normalization (see Figure 1).

Given the characteristics of the outcome variable examined in this study, an integrated model was chosen for statistical analysis. The outcome variable (hospital subacute care beds) was modeled in two integrated components: a U-part (the likelihood of hospital having subacute care beds) and a Y-part (the degree of diversification, given that a hospital has subacute beds). The U-part estimates the growth trajectory of proportion of hospitals having subacute care beds, while the Y-part estimates the growth trajectory of the amount of subacute care beds. In the U-part, if a hospital had no subacute beds in a year, then the outcome variable was coded as 0; if a hospital had a nonzero number of subacute care beds, it was coded as 1; if the value was missing, then it was coded as missing. In the Y-part, if a hospital had a positive number of subacute beds in a year, then the actual number was modeled; if a hospital had no subacute beds or did not report subacute beds (missing), the value was coded as missing (see Appendix 1 for a coding example).

As distinguished from traditional models, the two growth trajectories are modeled simultaneously within an integrated framework (see Figure 2). For each growth trajectory,

(insert Figure 2 about here)

there is an intercept (level) parameter, indicating the averages of diversification at a given point, and a slope (rates of change) parameter, describing the growth trajectories of the likelihood (proportion) of hospital diversification and the amount of diversification (subacute beds). Specifically, (*iu*) represents the average likelihood (proportion) of hospital diversification in this study, and (*iy*) represents the average degree of diversification (percentage of subacute care beds) in 1994; (*su*) represents the rate of change in the likelihood of diversification, and (*sy*) represents the rate of change in the degree of hospital diversification in the study period. The curved arrows indicate that the growth factors are correlated. The between-hospital variability in the level and the rate of change of diversification are reflected by the random effects associated with each growth parameter. In addition to estimating growth parameters' means, variances and correlation of growth parameters are also examined. Detailed specification for the two-part model are described in the following studies: B. Muthén(2001) , B. Muthén and Asparouhov (2002), and Kim and Muthén (2007). An equation of two-part model can be expressed as:

$$Y_{ik}* = \Lambda_{(u)k}\eta_{(u)_{ik}} + \varepsilon_{(u)ik}$$

$$U = \begin{Bmatrix} 1 & if & Y* > 0 \\ 0 & if & Y* = 0 \text{ or missing} \end{Bmatrix}$$

where k = 1, 2, 3, 4, 5, representing Year 1992, 1993, 1994, 1995, 1996.
i denotes the indiviual hospital.
6 covariates, namely HMO rate, Competitive pressures, System affiliation, Ownership type, Senior citizen rate, and FTEs per bed ratio were inluded in the model.
$\Lambda_{(u)k}$ *is a* 1×6 *matix of factor loadings for the dichotomous part (U part), for class k.*
$\eta_{(u)ik}$ *denotes a 6 vector scores and* $\varepsilon_{(u)ik}$ denotes *a vector of residuals, for the U part class k. And* $\varepsilon_{(u)ik}$ *is asumed to have multivariate normal distribution* $N(0,\Psi_{6\times6(k)})$.
The off-diagnol elements of $\Psi_{6\times6(k)}$ *are non-zero for the 6 covariates used in the model.*

2.4 Analysis process

The statistical analysis was conducted using Mplus 3.12 (Muthén and Muthén 2004). First, an unconditional model—with no covariates—was estimated to describe the growth factor parameters, especially whether these parameters had sufficient variability to warrant modeling. Second, a conditional model—with covariates—was estimated to examine the hypothesized effect of each covariate on the outcome variable. These covariates include ownership and system affiliation types, competitive pressures, HMO penetration rate, senior citizen rate, and FTEs per bed ratio. Ownership and system affiliation variables were treated as time invariant covariates, and were assumed to have effects on the growth factor parameters for both the occurrence of diversification part (U-part) and the degree of diversification part (Y-part) of the model. Because of the small variability of these three variables— competitive pressures, HMO penetration rate, and senior citizen rate as revealed in descriptive statistics—and the extreme nonnormality of the outcome variable, it was decided to use the mean values (averaged over the five-year period) in the model in place of the actual values of these variables from each year. Consequently, the dependent variable was centered at the middle of the study period (i.e., the year of 1994). The annual FTEs per bed ratio increased substantially in the study period and was therefore treated as a time-varying covariate. The outcome variable in the degree of diversification part was regressed directly on this variable over the five-year period as it was hypothesized in this study that hospitals with higher FTEs per bed ratio would provide a higher level of subacute care services (see Appendix 2 for input codes for the conditional model).

3. Results

3.1 Unconditional model results

At the first step, the functional form of growth in subacute care beds was modeled, excluding all covariates. The variances of growth factor parameters (see Table 2) indicated significant variation in the intercepts for both components of the model (variances = 92.91 and 337.18, *p*s < .001, respectively). This statistically significant variation suggests that individual hospitals differed in the mean level of the likelihood of having subacute care beds as well as the percentage of subacute care beds (if they had any subacute care beds) in1994. Results show that the slope or rate parameters (variances = 2.46 and 4.14, *p*s < .001) also had

(Insert Table 2 about here)

statistically significant variation around the mean of growth rates in the proportion of hospitals having subacute care beds and percentage of subacute care beds. Significant positive correlation (.38, $p < .01$) was shown between the intercept growth factor parameters for the U-part and Y-part, that is, hospitals with a higher likelihood of providing subacute care had correspondingly more subacute care beds in 1994. The correlation (-.24, $p < .01$) between the intercept growth factor parameter of the Y-part and the slope growth factor parameter of the U-part was negative. Other correlations among growth factor parameters, both within and between the two parts, were non-significant. However, these growth factor parameters were required to be correlated to ensure model convergence.

3.2 Conditional model estimates

A conditional model with all time-varying and time invariant covariates was estimated. Model results are presented in Table 3. In the U-part, the intercept growth factor parameter (*iu*) mean was fixed at zero by default because the outcome variable was categorical. However, the slope growth factor parameter (*su*) mean (1.87, $p < .05$) was significant, indicating that the proportion of hospitals having subacute care beds increased by a factor of 6.5 standard deviations annually during the study period. In the Y-part, the intercept growth factor parameter (*iy*) (20.38, $p < .001$) was significant; that is, the average proportion of subacute beds for hospitals was 20 percent in 1994, while the slope growth factor (*iy*, annual rate of change) (0.08, $p > .05$) was not significant, which suggests that there was no significant increase in the degree of diversification (amount of subacute care beds) on average during the period 1992-96.

(Insert Table 3 about here)

Model results showed that *HMO penetration rate* did not have a statistically significant impact on hospitals' diversification into subacute care. *Competitive pressures* (.47, $p < .001$) had a significant impact on the occurrence (U-part) of hospitals' diversification into subacute care in 1994, suggesting that hospitals imitated other hospitals in the same HSA in the adoption of diversification strategy. *Senior citizen rate* (.34, $p < .01$) had a statistically significant effect on the degree of diversification (Y-part) in 1994. Hospitals located in HSAs that had a higher senior citizen rate provided a higher percentage of subacute care beds (i.e., a higher level of subacute care services in a hospital). A 1 percent increase in senior citizen rate was associated with a .34 percent increase in the percentage of subacute beds in 1994 when controlling for other variables.

The coefficient (3.54, $p < .01$) associated with effect of *ownership* types on the intercept of occurrence of diversification (U-part) suggests that NFP hospitals were more likely to diversify into subacute care in 1994; that is, the odds that a NFP hospital would have subacute care beds were 34 times higher than the odds that a FP hospital would do so. However, the estimate (-1.49, $p < .01$) of the effect associated with NFP hospitals on the annual growth rate shows a significant, negative effect, which implies that the growth rate of providing subacute care services in NFP hospitals was declining. In addition, the estimated effect (4.68, $p < .001$) of the ownership variable on the intercept of degree of diversification (Y-part) suggests that NFP hospitals had a higher percentage of subacute beds than FP hospitals did in 1994. Specifically, NFP hospitals were more likely to diversify into subacute care services and that NFP hospitals had higher level of subacute care services in 1994, but the annual rate at which NFP hospitals set up subacute care services declined during the study period. Results also show that system-affiliated hospitals had a lower percentage of subacute care beds than non-system hospitals.

The coefficients (-.02, -.02, and -.01; $p < .001$, $p < .001$, and $< .01$, respectively) associated with *FTEs per bed ratio* in 1992, 1993, and 1994, as well as the coefficient (-.01, $p < .1$) in 1995 and the coefficient (-.01, $p > .05$) in 1996, suggests that, in general, the number of FTEs per bed ratio had a significant negative effect on the degree of diversification (Y-part). When other covariates were controlled, a 1 percent increase in FTEs per bed ratio was associated with about a 1 to 2 percent reduction in the percentage of subacute beds in a hospital.

Model fit. As the unconditional and conditional models are not nested, model fit was judged on Akaike's Information Criterion values (AIC) (Akaike 1985). According to AIC criterion, the model with lowest value of AIC is considered to fit the data best. The conditional model had an AIC of 62,042.46, which was smaller than that of 62,928.14 from the unconditional mode (data not shown), indicating that the conditional model was a better fit for the data.

4. Discussion

The results of this study show that hospital diversification into subacute care service was influenced by competitive pressures. That is, hospitals imitated what others were doing. This result is consistent with Fennell's argument that hospitals increase their range of services, not because there is an actual need for a particular service or facility within the patient population but because they will be considered as viable only if they can offer the same services other hospitals in the area offer (Fennell 1980). Second, not surprisingly, the results show that hospitals in markets with a higher senior citizen rate tended to diversify into subacute care services to a greater extent than hospitals in markets with a lower senior citizen rate. As Medicare payment accounts for a large part of a hospital's revenue, it is rational that hospitals strategically diversified their services to meet senior citizens' needs in their service areas. However, the non-significant effect of this senior citizen rate on the rate of change of subacute care service diversification might be attributed to the fact that senior citizen rate almost remained constant statistically during the study period when data were collected. As a consequence, hospitals did not provide more subacute care services during the period. Third, the results show that NFP hospitals on average provided more subacute care services than FP hospitals did. This finding is consistent with results observed by Wheeler and colleagues (Wheeler et al. 1999), who found that NFP hospitals were significantly more likely to offer subacute care services than investor-owned hospitals during 1985-91. Of note however, the results also showed that the growth rate in the proportion of NFP hospitals strategically diversifying subacute care was negative. Two explanations could account for this phenomenon. One possible explanation might be that the absolute number of NFP hospitals providing subacute care service declined during the study period. The other explanation is that the proportion of NFP hospitals providing this type of subacute care services was greater than 60 percent in the study period (data not shown), consequently it provided little incremental opportunity for them to diversify into subacute care services.

The results did not support the hypothesized relationship between HMO penetration and the likelihood of hospital of subacute care service diversification. Previous research suggests that the growth of managed care has been a driving force for health service integration (Lin and Wan 1999; Shortell 1988; Wang et al. 2001), hospitals and physician partnerships in management (Burns et al. 2000; Morrisey et al. 1999), and a shift from acute to subacute inpatient care (Robinson 1991). As noted above, this study was based specifically on a period when managed care experienced considerable growth (Kertesz 1996). Given the fact that hospitals viewed subacute care as an opportunity to market to managed care and managed care plans would like patients to be treated in a less costly setting when possible, the insignificant effect of HMO penetration rate on hospital-based subacute services seems paradoxical. This is possible that subacute care services were offered by other providers, such as freestanding skilled nursing facilities and home health care facilities. It is speculated that HMO presence promoted the growth of subacute service in other providers in the market.

Our results did not show that system membership was associated with strategic implementation of subacute care service diversification strategy. System affiliated hospitals did not provide more subacute care services than non-system affiliated hospitals. In the context of a system, member hospitals may not have the opportunity to make a localized decision whether to implement the diversification strategy or not. A freestanding subacute care hospital could be established for the entire system, therefore, subacute care patients could be transferred to a central location for treatment.

The significant negative estimates of FTEs per bed ratio seem to run counter to the argument that a higher FTEs per bed ratio would predict more subacute care services.

However, this finding may reflect an operational reality within a hospital: Acute care patients require more intensive care (i.e., more services from nurses and doctors), and thus “consume” more FTEs; whereas subacute care patients require less services, and therefore they would “consume” fewer FTEs. Consequently, a hospital that made strategic choice to diversify would require fewer FTEs per bed, while those that had did not diversify into subacute care would require more FTEs per bed.

This study applied an integrated two-part model that is capable of accommodating complex characteristics of a longitudinally measured outcome. However, a number of limitations should be noted, which may limit the generalizability of findings from this study. Although this study attempted to model environmental and organizational forces that influenced hospital subacute care service diversification behavior, data such as state level Certificate of Need (CON) regulation (McDowell 1995), Medicaid eligibility level (Kirkman-Liff 1985), and swing beds conversion (Wheeler et al. 1999), which could play a role in hospital strategic decision-making, were not included in the model given the wide range of variability across states and further complexities they could introduce in the model. The hypothesized effect of HMO penetration on hospital diversification into subacute care services was not observed in this study. As discussed above, in addition to hospital-based subacute care units, subacute care can be provided in the form of hospital swing beds, long-term care hospitals, rehabilitation hospitals, and freestanding skilled nursing facilities. A future study might look at the effect of managed care penetration on the growth of subacute care provided in other setting, especially freestanding skilled nursing facilities given that their lower level of cost that is attractive to managed care plans.

5. Conclusion

The analytical approach applied in this study was based in an integrated two-part model that simultaneously estimated both discrete and continuous outcomes. In general, the integrated two-part model could reflect the likelihood of organizations' adopting a strategy (e.g., to provide a new service), the intensity (e.g., the amount of the service) of the strategy pursued, and variability across organizations over time. Specifically, the first component of the integrated two-part model addresses the "occurrence"(likelihood) and the rate of change in the likelihood over time. The second component reflects the "intensity" (amount) and the rate of change in the amount over time. The results of this study suggest that there was both inter- and intra- hospital variability in the likelihood of hospital subacute care service diversification, the rate of change in the likelihood, as well as the amount of diversification and the rate of change in the amount during the study period. The outcome of many strategic decisions examined within health services could conceivably have this pattern (presence or absence). Moreover this pattern is likely to reflect intra-organization as well inter-organization variability especially examined over time. Consequently, the model described in this article can be utilized to examine an array of organizational decision making over time. Within the integrated model, each component should be conceptualized in terms of the appropriate set of time-varying and time invariant covariates. The utility of this modeling approaching is likely to be enhanced when attention is given to relevant theoretical constructs.

Acknowledgements

The authors appreciate comments from Drs. Robert Hernandez, Philip Musa, and Bryce Sutton at University of Alabama at Birmingham for their help and suggestion. The authors also want to thank Dr Bengt Muthén and others at Mplus technical support center for suggestions on the statistical model of this study.

Reference List

Abrahamson, E., Rosenkopf, L., "Institutional and competitive bandwagons: Using mathematical modeling as a tool to explore innovation diffusion ", The Academy of Management Review, 18, 487-517, 1993.

Akaike, H. Prediction and enropy. In: Atkinson, A. K., Feinberg, S. E., editors A celebration of statistics. New York: Springer-Verlag, 1-24, 1985.

Arndt, M., Bigelow, B., "Vertical integration in hospitals: A framework for analysis", Medical Care Research & Review, 49, 93, 1992.

Burns, L. R., Bazzoli, G. J., Dynan, L., Wholey, D. R., "Impact of HMO market structure on physician-hospital strategic alliances", Health Serv Res, 35, 101-32, 2000.

DiMaggio, P. J., Powell, W. W., "The Iron Cage Revisited: Institutional Isomorphism and Collective Rationality in Organizational Fields", American Sociological Review, 48, 147-60, 1983.

Duan, N., WG, M., Morris, C., JP, N., "A comparison on alternative models for the demand for medical care", Journal of Business and Economic Statistics, 1, 115-26, 1983.

Fennell, M., "The effects of environmental characteristics on the structure of hospital clusters", Administrative Science Quarterly, 25, 485-510, 1980.

Greenwood, R., Suddaby, R., "Institutional entrepreneurship in mature fields: The big five accounting firms", Academy of Management Journal, 49, 27-48, 2006.

Heckman, J. J., "Sample selection bias as a specification error", Econometrica, 47, 153-61, 1979.

Kertesz, L., "Insurance cost slowdown not likely to continue", Mod Healthc, 26, 26, 1996.

Kim, Y. K. M., B., "Two-part factor mixture modeling: Application to an aggressive behavior measurement instrument. " Retrieved May 3, 2008, from http://wwwstatmodelcom/papersshtml, 2007.

Kirkman-Liff, B. L., "Refusal of care: evidence from Arizona", Health Aff (Millwood), 4, 15-24, 1985.

Kothmann, W. L., "Is subacute care feasible?" Healthc Financ Manage, 49, 60-3, 1995.

Lin, B. Y., Wan, T. T., "Analysis of integrated healthcare networks' performance: a contingency-strategic management perspective", J Med Syst, 23, 467-85, 1999.

Makuc, D. M., Haglund, B., Ingram, D. D., Kleinman, J. C., Feldman, J. J., "Health service areas for the United States", Vital Health Stat 2, 1-102, 1991.

Manning, W., Duan, N., Rogers, W., "Monte Carlo evidence on the choice between sample selection and two-part models", Journal of Econometrics, 35, 59-82, 1987.

Manning, W., Morris, C., Newhouse, J., Orr, L., Duan, N., Keeler, E., Leibowitz, M., Marquis, M., Phelps, C. A two-part model of the demand for medical care: Preliminary results from the health insurance experiment. In: J. van der Gaag, Perlman, M., editors Health, economics, and health economics. Amsterdam: North-Holland, 103-23, 1981.

McDowell, T. N. Federal and state policy initiatives and the subacute industry. In: Griffin, K. M., editor Handbook of Subacute Health care. Gaitherburg, MD: Aspen, 15-28, 1995.
Mick, S. S. Themes, Issues, and Research Avenues. In S S Mick and Associates (eds), Innovations in Health Care Delivery: Insights for Organization Theory. San Francisco: Jossey-Bass, 1-19, 1990.
Morrisey, M. A., Alexander, J., Burns, L. R., Johnson, V., "The effects of managed care on physician and clinical integration in hospitals", Med Care, 37, 350-61, 1999.
Muthén, B., "Two-part growth mixture modeling. " Unpublished manuscript 2001.
Muthén, B., Asparouhov, T. (2002). Latent Variable Analysis With Categorical Outcomes: Multiple-Group And Growth Modeling In Mplus (No 4, Version 5),Retrieved December 12, 2005 from: http://www.statmodel.com/download/webnotes [WWW document].
Muthén, L. K., Muthén, B. O. Mplus user's guide (3rd ed.). : Los Angeles: Muthén & Muthén., 2004.
Olsen, M. K., Schafer, J. L., "A two-part random effects model for semicontinuous longitudinal data", Journal of the American Statistical Association, 96, 730-45, 2001.
Robinson, J. C., "HMO market penetration and hospital cost inflation in California", JAMA, 266, 2719-23, 1991.
Rovinsky, M., "Provisions of the Balanced Budget Act challenge IDS care coordination patterns", Healthc Financ Manage, 53, 31-4, 1999.
Shortell, S. M., "The evolution of hospital systems: unfulfilled promises and self-fulfilling prophesies", Med Care Rev, 45, 177-214, 1988.
Shortell, S. M., Morrison, E. M., Friedman, B. Strategic Choices for America's Hospitals: Managing Change in Turbulent Times: San Francisco: Jossey-Bass, 1992.
Suchman, M. C., Eyre, D. P., "Military Procurement as Rational Myth: Notes on the Social Construction of Weapons Proliferation", Sociological Forum, 7, 137, 1992.
Swayne, L. M., Ginter, P. M., Duncan, W. J. Strategic management of health care organizations. 5th ed: Malden, MA: Blackwell, 2005.
Wang, B. B., Wan, T. T., Clement, J., Begun, J., "Managed care, vertical integration strategies and hospital performance", Health Care Manag Sci, 4, 181-91, 2001.
Wheeler, J. R., Burkhardt, J., Alexander, J. A., Magnus, S. A., "Financial and organizational determinants of hospital diversification into subacute care", Health Serv Res, 34, 61-81, 1999.

Table 1: Variables, measurements, and data source

Variables	Measurements	Data Source
Percentage of subacute beds	(Subacute beds/Total beds) × 100	AHA Annual Survey
FTEs per bed ratio	(Total FTEs/Total beds) × 100	AHA Annual Survey
Ownership	0 = FP, 1 = NFP	AHA Annual Survey
System affiliation	0 = Non-hospital-system member 1 = Hospital system member	AHA Annual Survey
HMO penetration rate	Total HMO enrollees/Total population in an HSA	Interstudy Survey and ARF
Senior citizen rate	Total number of people of 65 and older/Total population in an HSA	ARF
Competitive pressure	Number of hospitals having subacute beds/Total number of hospitals in an HAS	AHA Annual Survey and ARF

Table 2: Variances and correlation of growth factors [a]

Growth Factors	iu	su	iy	sy
iu	92.91***			
su	-.0007	2.46***		
iy	.38**	-.24**	337.18***	
sy	-.059	.19	.017	4.14***

a. The variances are on the diagonal and the correlation coefficients are off-diagonal.

** $p < .01$. *** $p < .001$.

Table 3: Parameter estimates of growth factors and covariates

Variable	Diversification Status in 1994		Annual Rate of Change	
	Estimate	*t*	Estimate	*t*
U-part				
Growth factor mean	0[a]		1.868	2.09*
System affiliation	1.73	1.83	-.110	-0.54
Ownership	3.54	3.47**	-1.485	-3.92**
HMO penetration rate	.01	0.49	.002	0.60
Competitive pressure	.47	5.01***	-.001	-0.07
Y-part				
Growth factor mean	20.38	7.97***	.075	0.13
System affiliation	-.76	-0.89	-.010	-0.72
Ownership	4.68	4.37***	-.310	-1.31
Senior citizen rate	.34	2.58**	.002	0.07
FTEs per bed ratio 1992			-.020	-4.37***
FTEs per bed ratio 1993			-.020	-4.02***
FTEs per bed ratio 1994			-.010	-2.92**
FTEs per bed ratio 1995			-.010	-1.85
FTEs per bed ratio 1996			-.010	-1.38

[a] The mean of the intercept growth factor is fixed at zero by default when the outcome variable is categorical.

U-part = occurrence versus nonoccurrence of diversification.

Y-part = degree of diversification.

* $p < .05$. ** $p < .01$. *** $p < .001$.

Figure 1: Histograms of hospital subacute beds, 1992-96

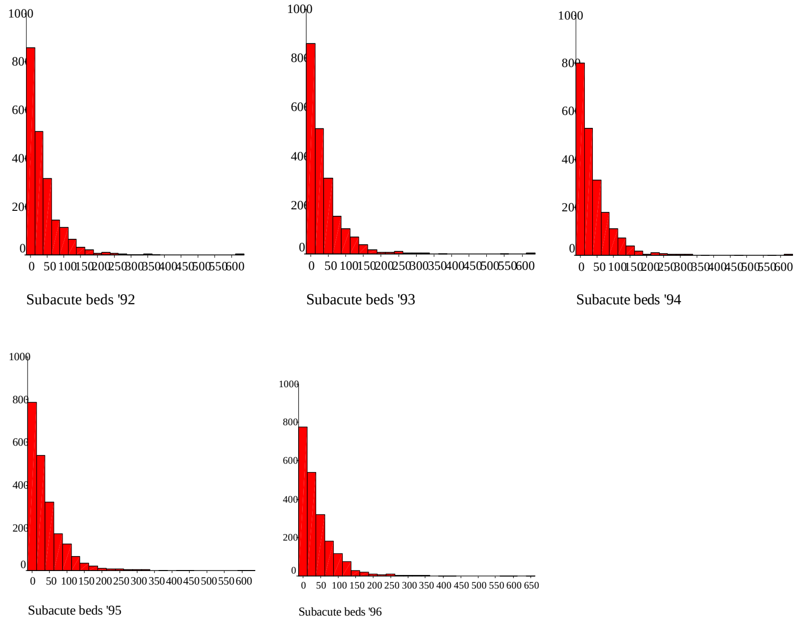
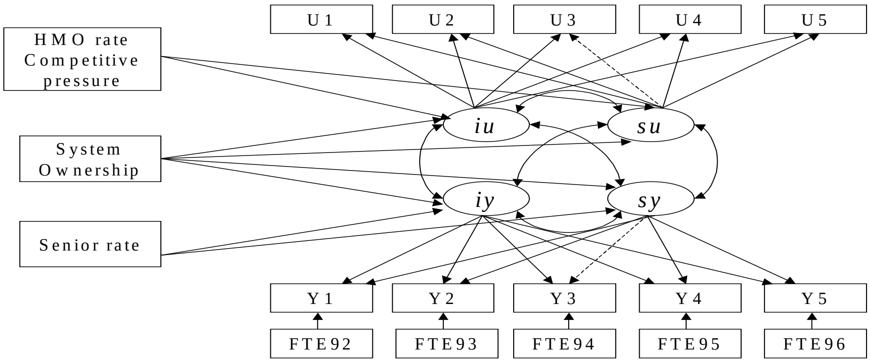


Figure 2: Path Diagram of Two-Part Model[a]



[a] Error terms are not shown in the figure.
iu and iy are the intercept growth factors.
su and sy are the slope growth factors.
U1-U5 are the outcome variables for the U-part.
Y1-Y5 are the outcome variables for the Y-part.
HMO rate is the mean of HMO penetration rates from 1992 to 1996.
Competitive pressure is the mean of competitive pressures from 1992 to 1996.
Senior rate is the mean of senior citizen rates from 1992 to 1996.
System is system affiliation type.
Ownership is the ownership type.
FTE is the FTEs per bed ratio from 1992 to 1996.
The double-arrowed lines indicate the growth factors are correlated.
The single-arrowed lines indicate the direction of influence.

Appendix 1: **A Coding Example of Subacute Bed Variable** [a]

Raw data

I	Sub92	Sub93	Sub94	Sub95	Sub96
6743570	0	0	10	17	17
6749530	0	0	0	0	0
6933735	0	0	15	15	•

Coding into U-part

I	Sub92	Sub93	Sub94	Sub95	Sub96
6743570	0	0	1	1	1
6749530	0	0	0	0	0
6933735	0	0	1	1	-99

Coding into Y-part

I	Sub92	Sub93	Sub94	Sub95	Sub96
6743570	-99	-99	10	17	17
6749530	-99	-99	-99	-99	-99
6933735	-99	-99	15	15	-99

[a] I is hospital ID. Sub92-Sub96 are the subacute beds from 1992 to 1996, respectively. "•"and "-99" represent missing values.

Appendix 2

Mplus version 3.12
Input codes*:

```
variable:
Names are hsa hmo92-hmo96 senior92-senior96
system owner competition 92- competition 96 u1-u5 fteh92-fteh96
y1-y5 Avghmo Avgcompetition Avgsenior;
categorical = u1-u5;
usev = u1-u5 y1-y5;
missing = all(-99);

analysis: type = missing;
estimator = mlr;
algorithm = integration;
coverage = .09;
Cholesky = on;

model:
iu su | u1@-2 u2@-1 u3@0 u4@1 u5@2;

iy sy | y1@-2 y2@-1 y3@0 y4@1 y5@2;
```

* hsa:health service areas
hmo92-hmo96: HMO penetration rates for 1992 to 1996
senior92-senior96: Senior citizen rates for 1992 to 1996
system: system affiliation type
owner: ownership type
competition 92- competition 96: competitive pressures for 1992 to 1996
fteh92-fteh96: FTEs per bed ratio for 1992 to 1996
Avghmo: mean of HMO penetration rates for 1992 to 1996
Avgcompetition: mean of competitive pressures for 1992 to 1996
Avgsenior: mean of senior citizen rates for 1992 to 1996