Analysis of Two Strategies for Structuring Medicare

Reimbursement to Maximize Profitability in Acute Care General Hospitals

by

James D. Barrington

A dissertation submitted in partial fulfillment
of the requirements for the degree of
Doctor of Philosophy
Department of Health Policy & Management
College of Public Health
University of South Florida

Major Professor: Alan M. Sear, Ph.D.
Barbara Langland-Orban, Ph.D.
Etienne E. Pracht, Ph.D.
Yiliang Zhu, Ph.D.

Date of Approval:
April 16, 2010

Keywords: DRG, investor owned hospital, discretionary procedure, marginal effects,
reciprocal of the debt ratio, gaming

UMI Number: 3425654

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Dedication

It is a wonderful opportunity and great honor for me to dedicate my dissertation to the memory of my father, James Durrel Barrington (1920-2003). During what turned out to be our last lucid conversation I was able to inform my dad that I had been accepted into the PhD program. He was elated! My father had grown up in the depression in abject poverty. Before he was ten years old he was working as a farm-hand to help his mother support their household. Perhaps influenced by his own harsh youth, his primary goal that he worked so hard all his life to create was a better life for his children. He set an example of what patience, tenacity, and a strong work ethic could accomplish. He was stern yet exercised wisdom and a sense of fairness and justice, which often are qualities nurtured in people who have experienced hard work and hard times.

He fought in WWII, graduated from officers' candidate school and finished his tour of duty as a first lieutenant. He incurred a back injury during combat, the effects of which would cause him pain the rest of his life.

He then worked hard and diligently for the next several decades, giving of himself to his children and grandchildren, making sure none of them would ever experience what he had as a boy, that of poverty, hunger, and a demand to grow-up immediately.

He died in January 2003. He would have been 83 the following month. Though his body was greatly weakened, he still left the earth with the same qualities he had lived by; that of a quiet and bold acceptance of the facts and an admirable sense of dignity. It is often said that the WWII generation was the greatest generation. Having the privilege to have known my father I am convinced this is true.

Acknowledgments

Sincere appreciation is expressed to my doctoral committee members, Major Advisor Dr. Alan M. Sear, Dr. Barbara Langland-Orban, Dr. Etienne E. Pracht, and Dr. Yiliang Zhu.

Dr. Sear is a stern, no-nonsense type of professor that is brutally honest. His old-school approach and unbridled candor were not always well received, but in retrospect I realize these qualities helped intensify my focus and bring the dissertation full-circle. Dr. Sear also has an immense background in health outcomes research of which was an invaluable and replete source of information and direction.

Dr. Orban examined the dissertation in great detail and made numerous salient recommendations which resulted in substantial improvement of the document. Dr. Orban also provided invaluable guidance on the determinants of hospital profitability as well as the importance of the case mix index and Medicare mix when examining financial performance in the context of Medicare. Dr. Pracht also helped to improve the document by specifically requiring the inclusion of the technical appendix (Appendix 9), which featured the addition of three important variables. The appendix helped to assure that parsimony in model development had not occurred at the expense of excluding valuable information. Dr. Zhu provided valuable help in understanding and using interacting variables in model development as well as the calculation of marginal effects and standard errors of marginal effects.

I also wish to thank Dissertation Defense Chair Dr. Thomas Mason, who managed the session at an efficient pace without overlooking any relevant detail.

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Analysis of Two Strategies for Structuring Medicare Reimbursement to Maximize Profitability in Acute Care General Hospitals

James Barrington

ABSTRACT

The healthcare literature sometimes cites Medicare as a negative determinant of hospital profitability. However, a review of Florida acute care short-term general hospital data revealed a subset of profitable hospitals with high percentages of their revenue structure comprised of Medicare reimbursements. Some investigators might contend that these hospitals are just better managed; that hospital profitability is not related to patient mix or payer source. Although good management enhances financial health, there are perhaps other reasons why certain hospitals can become profitable with Medicare as their primary revenue source.

Research findings indicate there is wide geographic variability shown for per-capita volumes of discretionary procedures reimbursed by Medicare, and broad variations in Medicare spending per enrollee for general acute care short-term hospitalizations. It was also found that many of the hospitals performing higher rates of discretionary procedures and showing the ability to make a profit with Medicare are investor owned.

The focus of this study, covering years 2000-2005, was to examine two strategies using discretionary procedures under Medicare that Florida investor owned hospitals may employ to increase profitability and maintain long-term financial health.

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Part 1 of the study examined the association between long-term financial viability, measured by the total assets ÷ total liabilities (TATL) ratio (the reciprocal of the debt ratio) and percentages per hospital of two discretionary cardiac and orthopedic procedure variables, reimbursed by conventional Medicare. A positive association was found between the TATL ratio and these variables, as well as significant marginal effects in the association between the TATL ratio and interaction terms for hospital ownership (where investor owned = 1 and not-for-profit = 0) and the discretionary cardiac procedure variable and ownership and the discretionary orthopedic procedure variable.

Part 2 used total charges as the dependent variable for patient discharges reimbursed by Medicare HMO. It was found that investor owned hospitals generally assess significantly higher charges than not-for-profits for discretionary CABG and valve replacement procedures for patients with equivalent levels of medical services and hospitalization. It was also found that charges significantly increase for both investor-owned and not-for-profit hospitals located in the southern region of Florida.

Chapter 1

Introduction / Statement of the Problem

Of the $2.0 trillion spent on health services in the United States in 2005, 16.0% of the Gross Domestic Product (GDP), $611 billion was spent on hospital services (Catlin, Cowan, Heffler et al 2007). Of the amount spent on hospital services, Medicare paid close to $200 billion (CMS 2005).

Since the Medicare Prospective Payment System (PPS) for hospitals was introduced in October 1983, there have been reports in the media (and sometimes found in little-known government publications, trade publications, and newsletters published by professional associations, citizen groups, and law firms) documenting hospital Medicare fraud, e.g., DRG upcoding (ACFE 2005-06, Psaty, Boineau, Kuller et al 1999, Rosenberg, Fryback & Katz 2000), misuse of the PPS DRG outlier methodology (CMS 2003, Darmiento 2002, Becker & Kessler 2005), and the performance of unnecessary coronary artery bypass grafts (CABG), valve replacements, and percutaneous coronary interventions (PCI) (Darmiento 2002, Kesselheim & Brennan 2005).

In the late 1980's some hospitals increased their operating margins by upcoding medical procedures which they performed. Upcoding involves billing for a higher level of service than was actually rendered via code manipulation; altering a diagnostic code to reflect greater patient severity and more intensive levels of medical services performed

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to, in turn, obtain higher reimbursement (ACFE 2005-06). Although this method was effective in generating greater revenue in the short-term, Medicare eventually began to investigate and enforce sanctions against hospitals using the upcoding strategy, causing these hospitals to be more cautious in gaming DRG codes (Middleton 2002). "In practice, upcoding has run the gamut from questionable to outright fraud. Ferreting out the fraudulent cases from the borderline ones is a delicate task" (Middleton 2002).

In the mid and late 1990's some hospitals began aggressively utilizing the Medicare outlier payment system as a source of additional revenue. CMS (2003) cited a number of hospitals that had been "manipulating the outlier formula by aggressively increasing their charges compared to costs, costing taxpayers over $2 billion in 2002 and $1 billion to $2 billion a year in inappropriate overpayments for each of the last four years." Despite these sporadic reports there have been no scientific studies documenting the annual amounts of Medicare funds lost to hospital Medicare fraud.

In 2002 it was discovered that for several years Redding Medical Center, a subsidiary of Tenet Healthcare, Inc. had been submitting false billings to Medicare, abusing the Medicare outlier program, and even performing and charging for invasive surgeries that were medically unnecessary (Darmiento 2002, HHS OIG, December 11, 2003, DOJ May 17, 2004).

Increased Legal & Regulatory Provisions

Increased strength of the Federal False Claims Act [31 USC § 3729, 3730 (1)] beginning in the late 1980's provided Medicare with an imposing weapon to use against any organization engaging in fraudulent activities with federal funds (Zack 2001). The 1996 HIPAA legislation also gave federal investigators increased funding and a mandate

to root out Medicare fraud and abuse. "The resulting crackdown prompted some hospitals to down-code hospital stays for fear of triggering an investigation" (Middleton 2002)

In 2002 the Sarbanes-Oxley (SOX) act was passed into law in response to the corporate scandals of 2001 and 2002 (Bisk 2009). In the context of healthcare, this act was passed in a political environment where rooting out fraud and abuse was paramount. "This law significantly changed the laws of corporate governance and the rules and regulations under which accounting firms and corporations must operate" (ACFE 2005-06). Additionally, certain provisions substantially increased the responsibilities of management and the accounting profession regarding financial reporting, design and operation of the internal control structure, and prevention and detection of fraud (ACFE 2005-06). SOX applied only to publically traded companies, but many of the provisions of SOX have been implemented as best practices by not-for-profit hospitals (Bisk 2009).

Ubiquitous and Recurrent Nature of Gaming

It seems that no matter what laws are enacted or how strictly regulatory actions are enforced, there will always be sectors of the healthcare industry involved in *gaming*. When one game becomes too risky, there is always another game that laws do not yet cover, or that regulators' are not focusing upon.

"Gaming" has always been part and parcel of the Federal Medicare program. At its inception, doctors discovered that by increasing their fees they would receive higher Medicare reimbursements in subsequent years" (Middleton 2002). Historically, a "crackdown" in one area involving the misuse of Medicare funds has only resulted in more sophisticated "gaming" strategies in other areas.

Gaming in this study is defined as a recurrent strategic maneuvering across legal and/or ethical thresholds of conduct for the purpose of acquiring additional unwarranted profit. The recurrent nature of gaming in this context implies *scienter,* which means the gamer (i.e., offending party) has knowledge and willful intent of engaging in wrongful behavior (Convisor Duffy 1996).

Listed below is a brief typology of gaming behaviors that are historically characteristic of the health care industry (ACFE 2005-06, Cleverly & Cameron 2002).

- Kickbacks
  - Payment for referrals of patients
  - Payment for insurance contracts
  - Payment for vendor contracts

- Inflated billings
  - Alterations – of claim forms, amounts charged, and financial ledgers
  - Adding services never rendered to actual services received by a patient
  - Upcoding (defined above)
  - Experimentation with the Medicare outlier methodology

- Unbundling Charges/Fragmentation
  - Submitting charges of a comprehensive code as well as one or more component codes
  - Billing for mutually exclusive procedures
  - Global service period violations – billing for a major procedure (e.g., surgery) as well as related procedures, when the fee for the major procedure already includes fees for related procedures within the global service period (pre-defined period of which all related services are covered following a major procedure) (ACFE 2005-06)

Focus of the Investigation

This study will investigate other types of gaming, ones that are not usually listed in a typology of gaming behaviors. These include hospitals systematically increasing the numbers of certain types of discretionary procedures performed under conventional Medicare, and inflating charges under the Medicare HMO program. The example cited above of fraud at Tenet's Redding Medical Center initially inspired this research.

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The study period for this project covers years 2000-2005 which begins soon after the passage of the Balanced Budget Act (BBA) of 1997. This act was an omnibus legislative package designed to balance the federal budget by 2002, with expectations of savings from Medicare of $112 billion between 1998 through 2002 (Guterman 2000). It introduced major Medicare reforms which included reduced payments to providers (Doherty, Date Unknown), though payments were raised in subsequent legislation under the Balanced Budget Reform Act (BBRA) of 1999, and certain reimbursements were reinstated in 2000 (Doherty, Date Unknown, Guterman 2000).

On the surface this would appear to be an era when Medicare may not be a profitable revenue source for hospitals. Despite this surface appearance there were some Florida short-term general hospitals that maintained unusually high profitability while at the same time deriving high percentages of their annual total revenue from Medicare during the years of this study, 2000-2005. High profitability defined in this study (and attributed to the group of hospitals just mentioned) is based on operating margin as a short-term *(≤ one year)* indicator found on hospitals' income statements and on the total assets ÷ total liabilities (TATL) ratio (the reciprocal of the debt ratio) as a long-term *(> one year)* indicator derived from hospitals' balance sheets.

In the dataset that will be used for part of this analysis (described on page 67) observations are provided for 891 Florida hospitals between 2000 and 2005. The dataset shows amounts of net revenue derived from Medicare for each hospital as well as two important financial indicators, the operating margin and the TATL ratio, just mentioned. Preliminary analyses showed that certain short-term general hospitals with high percentages (≥ 60%) of their revenue derived from Medicare relative to other payers, had

operating margins ≥ 10%, and a few hospitals of this group even had margins ≥ 20%. These hospitals also showed TATL ratios ≥ 10.0, and a few even had ratios ≥ 15.0.

The magnitudes of operating margins and TATL ratios in these hospitals can be better understood by a brief discussion of the scales of these financial indicators in the dataset. The dataset showed that of the 891 hospitals the mean operating margin was 2.25%, and the median is 3.30%. The third quartile is 9.5% while the 95th percentile is 19.5%. The mean average for the TATL ratio is 3.92 with a median of 1.94. The third quartile for the TATL ratio is 4.33 and the 90th percentile is 12.00. Considering the scales of operating margin and the TATL ratio among total hospitals, it is clear that the subset of hospitals just mentioned with ≥ 60% of their revenue base derived from Medicare, are very profitable.

The research question is what is different about certain hospitals, that they could realize inordinately high profitability when their largest revenue source, Medicare, is consistently identified in the healthcare industry and in the literature as unprofitable (Williams & Hadley 1992, Younis & Forgione 2005).

One explanation for higher profitability and better financial health in these hospitals may be due to better management, which would entail prudent cost cutting and highly efficient service delivery. Also because of sound strategic direction these hospitals may have structured their markets to offer a very profitable patient mix of DRG procedures and are extremely competent in delivering these services to maximize both efficiency and quality.

Still another possible explanation, because their operating margins and TATL ratios are so high, would be that these hospitals (the physicians on staff there) are

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performing higher volumes of certain procedures, some of which may be questionable or perhaps marginally necessary. Additionally, these hospitals may be assessing monetary charges for certain procedures that exceed the extent of medical services performed. Because hospital administrators may be more cautious regarding Medicare's continuing investigations for upcoding and excessive use of the outlier methodology, certain hospitals may be using a strategy of boosting profitability by *overusing* or *overcharging* of certain DRG codes.

It was found that hospitals that are profitable and also have high percentages of their revenue base comprised of Medicare payments carry out high rates of surgical procedures described as *"discretionary."* The definition of discretionary procedure will be examined in detail in Chapter 3, Research Methods – Data Structure & Identification of Variables, but in short it refers to a procedure for which there is a lack of full scientific agreement regarding its effectiveness. Discretionary would also mean that the procedure is performed in variable per-capita rates per geographic area or region. It is distinguished from a *nondiscretionary* procedure for which clinical agreement has been established and medical practice is statistically uniform regardless of the hospital or geographic area.

If financial gaming occurs in connection with discretionary procedures, financial incentives and medical practice would differ depending on the type of Medicare payer. Conventional Medicare reimburses procedures on a fixed-rate per DRG code while Medicare HMO compensates hospitals on a charge basis. The incentive for hospitals to make a profit with Medicare HMO would be to assess charges higher than are warranted by the extent of medical services provided. Even if Medicare agrees to pay only a

fraction of patient charges the hospital may still financially benefit if reimbursement turns out being higher than it would have been had charges been at realistic levels.

The incentive under conventional Medicare would be to increase volumes of certain types of procedures for which the costs of care would be, on the average, consistently less than the DRG reimbursement.

Overcharging for medical services or overusing certain DRG codes may be two of the strategies used by certain hospitals that may allow them to be very profitable while depending so heavily on Medicare as their primary revenue base.

As will be shown in the Research Methods sections (chapters 3-6), this study will be presented in two parts, Part 1 and Part 2. Part 1 will test the association between financial performance and discretionary cardiac and orthopedic procedures carried out in investor owned hospitals. The population in Part 1 will be confined to general acute care Florida hospitals, 2000-2005. Explanatory variables will include percentages of certain cardiac and orthopedic procedures performed per hospital, reimbursed by conventional Medicare, 2000-2005. The dependent (outcome) variable will be the TATL ratio, the reciprocal of the debt ratio.

Part 2 will test the association between total patient charges and discretionary cardiac procedures carried out in investor owned hospitals. The population will be confined to valve replacement and CABG procedures reimbursed by Medicare HMO, and the outcome variable will be total charges. The explanatory variable will be hospital ownership.

Chapter 2

Review of the Literature

Introduction

The Review of the Literature is intended to present rationale for carrying out this investigation and to provide a theoretical basis for setting research objectives, deriving hypotheses, and selecting variables.

Brief Summary of the Literature Review

The review begins with an overview of hospital financial performance indicators and a discussion of factors which may favorably or adversely affect these indicators. This will help determine which indicators might be useful as variables in the Research Methods section (Chapter 3) and will establish a foundation for the selection of certain control variables.

One factor often adversely associated with financial performance indicators is a hospital's volume of Medicare patients or percentage of revenue derived from Medicare (Younis & Forgione 2005). A review of previous research will show that Medicare is often negatively associated with profitability, and as explained in the problem statement, it is counter intuitive that a group of Florida hospitals with high percentages of Medicare comprising their revenue structures to simultaneously have high operating margins and other favorable financial performance indicators.

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The literature review then cites investigators that have concluded that a hospital's percentage of Medicare revenue is irrelevant, that good management regardless of payment sources or patient mix is the key to profitability (Clarke 1991, Cleverly 2004). These investigators also conclude that, though there are inherent differences between investor owned and not-for-profit hospitals, ownership per se does not account for strong financial performance. It is the characteristics of many investor owned hospitals that make them more profitable such as reduced labor costs, better long-term capital planning, etc. (Galloro 2004, Smith 2002).   These characteristics are often induced by boards of directors in investor owned hospitals that tend to pay closer attention to the bottom line (Smith 2002, HFMA 2004).

Although profitability is positively associated with good management practices, there are also other mechanisms that may improve financial performance. For example, certain Florida hospitals could be practicing gaming behaviors especially considering the excessively high operating margins that are characteristic of certain Florida hospitals with Medicare as their greatest revenue source. Gaming has already been defined in the problem statement as recurrent maneuvering across legal and/or ethical thresholds of conduct for the purpose of ostensibly improving financial performance.

Gaming behaviors in previous research have focused on upcoding and gaming the DRG outlier methodology, but no research has addressed performing inordinately high volumes of discretionary procedures, some of which may be unnecessary, as a gaming strategy.

Also, very few previous studies have examined charges assessed by profitable hospitals to determine if these charges are significantly higher than other hospitals that

carry out the same medical treatments and perform the same extent of medical services. A good example of why such a study might be important is Redding Hospital, a subsidiary of Tenet Healthcare, which was found performing unnecessary heart surgeries, submitting false billings, and overcharging for services (Darmiento 2002).

The literature review lays the theoretical groundwork for identifying potential DRG codes which may be subject to gaming behaviors. As the literature review ensues it will be shown that DRG codes vulnerable to gaming tend to represent *discretionary* procedures. The criteria to determine a procedure as discretionary in this study are based on lack of clinical consensus of effectiveness and variability in the performance of these procedures across geographic areas that are not linked to rates of disease (Wennberg 2005, Dartmouth 1999).

The literature review will then discuss an association between the rates of discretionary (and possibly gamed) procedures and geographic variations of medical practice patterns. Numerous investigators are cited who provide evidence that rates of certain procedures and per capita Medicare expenditures vary widely depending on location. Wide fluctuations are observed between states and selected cities in the nation and between cities and hospital referral regions (HRRs) in Florida.

Wennberg's (2005) surgical signature theory will be introduced in the literature review and referenced several times in this study. The surgical signature is identified by wide geographic variability in federal spending and in the performance of discretionary procedures reimbursed by Medicare.

Indicators of Financial Performance

Many studies use operating margin (operating income ÷ total operating revenues), the proportion of profit remaining after subtracting total operating expenditures from operating revenues (Cleverly & Cameron 2002), as a dependent variable because it is an excellent measure of financial performance. Operating margin is a summary measure of an organization's income statement reflecting profitability typically over a one year period. It reflects *ongoing* revenue and expenses *over a short-term (one year) period of time.*

The TATL ratio (total assets ÷ total liabilities) is a reliable summary indicator of the balance sheet reflecting long-term solvency, viability, and the risk of bankruptcy (Gardiner 1995). In the composition of the TATL ratio, total liabilities include current and long-term liabilities and current and fixed assets as well as other assets such as goodwill if relevant.

The TATL ratio is the reciprocal of the debt ratio. The debt ratio may be expressed as (total liabilities ÷ total assets) or (total debt ÷ total assets). It indicates the percentage of an organization's assets that are provided by debt as opposed to equity (i.e., net assets or fund balance in a not-for-profit's balance sheet) (Williams, Haka, Bettner et al 2008). The ratio is an indicator of an organization's overall debt load and its mix of equity and debt. It can help diagnose the overall financial risk confronting an organization, as generally the greater amount of debt held by an organization the greater the financial risk of bankruptcy (Williams, Haka, Bettner et al 2008).

As the inverse to the debt ratio, the TATL ratio also is an indicator of liquidity vs. leverage and is a measure of both cash-flow and balance sheet solvency.   It reflects a *snapshot* of long-term financial condition *at a given point in time* (Plank & Plank 2000).

Other *long-term* measures instead of the TATL ratio were considered, such as the debt to equity (fund balance) ratio and the total liabilities to net equity (fund balance) ratio. But data generated for the TATL ratio was cleaner, had fewer missing values, and was determined to be more reliable for the analysis.

One problem for the literature review was that, though there are many research findings using operating margin as well as total margin that can be cited, there are virtually none that use a TATL ratio. For that matter there are very few studies in the healthcare literature that have used other financial ratios as dependent or independent variables.   Because so many studies use short-term measures of financial strength, such as operating margin or total margin as outcome variables, and this study uses the long-term TATL ratio, it seemed necessary to present findings from the literature regarding other useful (long-term) financial indicators, which are provided in the following subsection. This information may establish further rationale for using a long-term financial indicator such as the TATL ratio.

Multiple Indicators of Financial Performance

Despite the consistent use of operating margin or total margin as outcome variables in studies in the healthcare literature, these margins represent just one dimension of financial health and are just two among many indicators of financial performance. Cleverly (2004) and Lee (1984) stress the importance of examining financial data representing multiple dimensions of the organization. This means that the

assessment of financial performance necessitates a simultaneous understanding of a comprehensive set of indicators including liquidity, profitability, activity, and debt, as well as determining the interrelationships of these indicators (Lee 1984).

Several financial indicators representing long-term dimensions are presented in the next few paragraphs, most of which are derived from items on the balance sheet and can be encapsulated within the TATL ratio.

Langabeer (2008) stated "true economic condition (of hospitals) is based on long-term viability." Threats to viability are best reflected by "poor liquidity, a high degree of debt leverage, and significantly low fund balances (i.e., accumulated retained earnings)." These indicators of long-term risk are derived from the balance sheet, as is the TATL ratio. Operating margin or total margin derived from the income statement are not indicators of long term risk, but only of short-term ($\leq$ one year) profitability.

Schulman (2008) has explained that hospital financial performance must be examined via separate analyses using operating margin, liquidity ratios, debt leverage ratios, LOS/patient discharges, and average payment period ratios. Each tool reflects a different aspect of the organization. These separate assessments should be reviewed, with a comprehension of how they interrelate, over one and five year periods to be assured of gaining both short and long-term perspectives of financial health.

Cleverly (2004) states that, though total margin is an excellent indicator of a hospital's ability to generate income, return on investment (ROI) [(gain on investment – cost of investment) ÷ cost of investment] is the most reliable overall measure of long term profitability because financial performance is measured in terms of invested capital.

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Management's comprehension of the level of fixed asset intensity within a service line is also critical, as the "revenue production associated with that service allows an organization to make informed capital allocation decisions" (Cleverly 2004). Capital planning is dependent upon addressing questions of how capital requirements affect required margins by specialty area, and the level of capital that will be needed for future investment. Healthcare organizations that practice systematic capital planning are better able to judiciously invest in long term assets to modernize plant operations while skillfully negotiating the most favorable terms to finance improvements (HFMA 2004, Cleverly 2004, Shattuck Hammond 1997). This practice generally results in a high TATL ratio that is sustained for many years.

Financial ratios and margins are the best indicators (on paper) of financial performance, but it must be remembered that even they do not always provide a completely clear representation of financial health because they are indicators that must be extracted from financial statements. For example, *off-balance sheet (risks) liabilities* are items not reported in the body of financial statements as a liability, but represent that the organization may be required to incur severe future financial implications. Off-balance sheet liabilities often include litigation, guarantees of future performance, and renegotiations of claims under a government contract (Siegel & Shim 1995, Plank & Plank 2000).

There is no way to reflect off-balance sheet liabilities in ratios or margins and no way to account for them in this study. Fortunately, substantial off-balance sheet liabilities are not frequent, and their presence in connection with certain hospitals should not affect overall findings.

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Medicare is Not a Profitable Revenue Base?

Factors most often cited in connection with poor hospital profitability are aging of plant facilities, hospital location in economically disadvantaged areas (Brown 2001, Younis & Forgione 2005), high debt (Vogel, Langland-Orban & Gapenski 1993), too few or too many beds (Kim, Glover & Stoskopf et al 2002), low patient occupancy (Langland-Orban & Gapenski 1996, Younis & Forgione 2005), high LOS (Younis 2004), and high percentages of uncompensated care and delinquent accounts (Brown 2001).

In addition to the factors mentioned above, a number of studies will be cited in the next few paragraphs that indicate that high volumes of Medicare (and Medicaid) patients are a negative determinant of hospital profitability, hospital administrators and physicians bemoaning declining revenue due to Medicare's prospective payment system (and the Balanced Budget Amendment of 1997).

Younis & Forgione (2005), sampling not-for-profit short term community hospitals and using total profit margin (i.e., margins including non-operating revenue and expenses net of taxes and extraordinary items) as the measure of profitability, found that profitability is adversely affected by low occupancy, hospital location in poor neighborhoods, and high volumes of Medicare and Medicaid patients.

Williams, Hadley & Pettingill (1992) found that hospital profitability was adversely related to rural location as well as a high percentage of Medicare patients, while it was positively associated with larger hospital size, larger community population, and high patient case mix.

Carpenter & McCue (2001) noted that investors lack confidence in hospitals with greater dependencies on either Medicare or Medicaid reimbursement because these

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hospitals are perceived as being vulnerable to political uncertainty and budgetary retrenchment. Investors also perceive high percentages of Medicaid patients to be concomitant with serving a disproportionate share of uncompensated care patients.

Jantzen & Loubeau (2003), using a sample of hospitals in the United States that issued fixed rate bonds in 1995 and 1996, found that LOS was one of the factors of concern by investors because of Medicare's PPS. They were mindful that hospitals had to keep LOS in check to make a profit with Medicare.

Clarke (1991) examined behaviors that diverge between "high performance hospitals," which Clarke defined with ROI in the upper 25 percent of all hospitals and "low-performance hospitals," those with ROI's in the lower 25 percent. High performance hospitals were also identified as having significantly higher operating margins than low-performance hospitals, as well as better liquidity and newer plants and equipment.

As part of his discussion Clarke conceded there are factors beyond management's control which may contribute to poor financial performance. Clarke found that low performance hospitals had higher Medicare and Medicaid caseloads and tended to be located in more highly regulated states, which limits management's flexibility.

Conversely, Silverman, Skinner & Fisher (1999) shed light on Medicare as a potentially profitable revenue source. They studied hospital conversions between 1989 and 1995 and found that not-for-profits recently converted to investor owned status tend to be the most aggressive in seeking profit and cutting costs. The study entailed an examination of total per-capita Medicare spending in areas served by for-profit and not-for-profit hospitals, as well as for-profit hospitals that had recently been converted from

not-for-profit. Medicare expenditures were examined in 208 areas where all hospitals (in these areas) remained under for-profit ownership (i.e., all beds in the area were in for-profit hospitals), 2,860 areas where all hospitals remained under not-for-profit ownership (i.e., all beds in the area were in not-for-profit hospitals), and 33 areas where all hospitals had been converted from not-for-profit to for-profit ownership.

Federal spending was defined as Medicare expenditures per area and included hospital services, physician services, home healthcare, and services at other facilities. Expenditures for each health service category were examined separately. It was found that per-capita Medicare spending was greater among all health services categories in areas containing for-profit hospitals vs. areas containing not-for-profits. It was also found that per-capita Medicare spending grew more rapidly in the 33 areas containing recently converted hospitals relative to the 2,860 areas containing not-for-profits.

This is an important finding because it shows that recently converted hospitals had perhaps identified effective strategies to make a profit with Medicare. Recently converted hospitals would likely need to identify profitable revenue sources, as ownership conversion requires restructuring of the organization to satisfy new shareholders and to begin meeting a new liability, the tax burden.

It may not be Medicare (volumes of Medicare patients or a hospital's percentage of Medicare revenue to total revenue) per se that contributes adversely to financial performance. Instead it may be the types of DRG codes that are emphasized (utilized with greatest frequency) by hospitals under Medicare that contribute to high or low financial performance.   Gapenski, Vogel & Langland-Orban (1993) found that patient mix variables are very useful predictors of profitability. They also found that higher

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hospital profitability is associated to a higher case-mix index (CMI) (i.e., average DRG weight for all hospitals' Medicare volume) (Midwest Healthcare Coding, 2008) and Medicare mix (Langland-Orban, Gapenski & Vogel 1996).

Good Management is the Strongest Determinant of Profitability

Some researchers contend that payer mix is irrelevant, as it is good management and sound strategic direction that results in profitability and long-term financial health for hospitals. These researchers explain that the determinants of hospital profitability include market factors, operational efficiency, patient demographics, patient occupancy, cost-control, structure of the labor mix, LOS, hospital-physician relationships, and recent changes in federal and state legislation.

Determinants of financial health associated with the physical structure of the hospital include geographic location, aging of plant and equipment, and economies of scale (numbers of beds). In the context of plant and equipment, a primary determinant affecting a hospital's long term financial viability and survival is the organization's ability to generate capital to invest in new technologies and upgrade aging facilities.

The ability to simultaneously manage and strategically negotiate these determinants of hospital profitability (and long-term viability) listed above reflect what most researchers identify as good management practices.

Clarke's (1991) study comparing high and low performance hospitals was just mentioned in the discussion on Medicare. Although Clarke conceded that high volumes of Medicare and Medicaid patients and tight regulatory requirements hampered management's effectiveness, there were some hospitals under these constraints that still performed well. Clarke found that high performance hospitals used 15 percent fewer

labor hours per case (adjusted for case mix and outpatient volume) than low performance hospitals. "Because labor-related expenses represent more than 60 percent of all operating expenses for hospitals, labor usage is an important factor in financial performance" (Clarke 1991).

Cleverly (2004) supports Clarke's findings, stating that effective hospital management is the key to successful financial performance regardless of ownership, patient mix, financing sources, etc. He buttresses this position by citing that payment mechanisms do not differ materially between profitable and unprofitable hospitals, but financial performance is related entirely to hospitals' ability to enhance efficiency and control costs.

Explaining how hospitals with high numbers of Medicare patients remain financially healthy, Cleverly (2004) cited findings from a sample of 3,076 hospitals, including 971 teaching hospitals and 2,105 non-teaching hospitals. Cleverly reports. "The high profit group has a cost structure that is 42 percent lower than for the low profit group on a relative weight adjusted basis."

Cleverly's position is that investor owned hospitals are generally more profitable than not-for-profits not due to ownership status per se, but because of more efficient operations and better strategic direction. Investor owned hospitals are generally more aggressive in optimizing their labor force, eliminating unprofitable services, and tailoring their mix of services with the intent of realizing highest reimbursements at lowest treatment costs (Galloro 2004).

Sear (1991) reported findings, consistent with Cleverly's, in examining a sample of 50 investor owned and 60 not-for-profit hospitals in Florida between 1982 and 1988.

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Sear found that wages per adjusted patient day and LOS were the most important factors in explaining why investor owned hospitals are more profitable.

Garrison & Wayne (2008) found that ongoing data examination by management of LOS, especially severity adjusted LOS, and disciplined efforts to reduce LOS are among several characteristics associated with successful hospitals. Schulman (2008) found that hospitals are more likely to have higher operating margins if they have shorter LOS, lower personnel cost percentages, and higher outpatient gross revenue percentages. Schulman described LOS as an "indicator in containing inpatient services costs."

Schulman (2008) also found that investor owned hospitals financially out-performed not-for-profits. Between 2003 & 2007 operating margins ranged from 5.45 to 8.87 for investor owned hospitals while not-for-profit margins ranged from -1.86 to 0.54. The difference in financial performance was attributed in part to investor owned hospitals incurring 20 percent less in personnel costs than not-for-profits. Investor owned hospitals also had lower accounts receivable days and wrote-off delinquent debt more rapidly. Average LOS was also found to be slightly less in investor owned vs. not-for-profit hospitals.

Profitability after Regulatory Changes

Sear (2004) demonstrated that good management can often transcend legal and regulatory changes that affect revenue, such as the BBA's effects on Medicare and Medicaid. Using a sample of 25 acute care hospitals, Sear examined operating margins before and after passage of the BBA, between 1990 and 1997 and between 1998 and 2001. Certain hospitals with negative margins, ostensibly caused by BBA, actually had negative margins for the entire 12 year period, before and after BBA.

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Other hospitals experienced cyclical margins moving higher and lower and not concomitant with BBA. Still other hospitals maintained strong operating margins over the entire 12 year study period regardless of BBA. "These hospitals established management strategies, to adapt to changes in the reimbursement and expense environments." Sear concludes. "In the 25 Florida acute care hospitals, the percentage of operating revenue derived from Medicare does not account for a significant amount of the variance in average operating margins in the post-BBA period" (Sear 2004).

Sear showed that poor operating margins could not be attributed to BBA, but to poor management before and after its passage. Sound management, cost control, and strategic direction may be the most important determinants of profitability and may assure adaptation to changes in federal reimbursement and market structures.

Managing Assets to Raise Capital & Assure Future Profitability

As already mentioned, the outcome variable for Part 1 of this study is the TATL Ratio. A high TATL ratio often reflects sound strategic direction for long term investments and covering of long term liabilities. For long-term viability hospitals should define and estimate their future available capital capacity, prioritize capital spending, and their capital capacity analysis should dovetail with strategic financing issues. This should result in a systematic strategy for deriving capital for long term investments such as upgrading plant and equipment and restructuring debt.

Gapenski Vogel, Langland-Orban (1993), for example, found that aging of plant facilities as well as high debt were both negative determinants of profitability. These negative determinants can be many times mitigated or reversed by methodical long-term capital planning. But for many hospitals long-term planning is not systematic. Shattuck-

Hammond (1997) reported that large sectors of the health care industry plan only for the annual budget, and long-term investments are based on management or board intuition.

As discussed in more detail later in the literature review boards of directors in investor owned hospitals may engender an environment that is more conducive to long-term systematic corporate planning than not-for-profits. It would not be surprising for an organization guided by decisions that have a factual basis and long-tem perspective to be financially stronger than one that is guided by ambiguity and visceral perception.

Management & Strategic Direction in Initial Location Decisions

Geographic location is described in the Research Methods sections (chapters 3-6) as an important control variable. Previous studies have found an association between profitability and geographic location and have found that many hospitals located in more affluent areas are investor owned.

Investor owned hospitals tend to comprise about 15 percent of the hospitals in most areas, and they tend to concentrate in the most desirable and potentially lucrative locations, resulting in the exclusion of economically disadvantaged patients (Brown 2001). These areas often include elevated densities of highly reimbursed physician specialties. However, this does not imply there are differences in objectives among ownership types. Not-for-profits do not necessarily locate in economically disadvantaged areas because it is part of their organizational mission. In fact, not-for-profits would more often locate in higher income areas if they could. Investor owned hospitals are generally more likely to possess the ability to shift capital to higher income, new-growth communities with greater celerity than not-for-profit hospitals.

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Investor owned hospitals are not always able to avoid poor neighborhoods, as location is driven by market dynamics. The ability to shift capital and locate hospitals in upper income areas diminishes in the presence of increased spatial competition. When investor-owned hospitals are late entering the market they may find rigid densities of competition already ensconced in wealthier areas, circumventing their ability to shift capital for geographic preference (Brown 2001).

In Nashville, Tennessee, for example, because about half the hospitals are investor-owned, spatial competition forces certain investor owned hospitals to locate in poor areas. In fact, though most maternity patients covered under Medicaid and TennCare, Tennessee's indigent care program, seek care from public hospitals, more of them seek care from investor owned hospitals than not-for-profits (Brown 2001).

Hospital Ownership

As will be discussed in Chapter 3, hospital ownership is one of the most important variables in model development of this study. Ownership is discussed in the context of profitability in several other places in the literature review. But because ownership is an important variable in this study, a separate discussion is devoted to it in this subsection.

In general, investor owned hospitals have higher operating margins and TATL ratios than their not-for-profit counterparts and tend to be represented across the continuum by more favorable financial indicators. Investor owned hospitals also tend to be more capable in raising essential long-term capital which allows them to more effectively modernize facilities, invest in the most current medical technology, and restructure debt. These long-term capital investments, in turn, help investor owned hospitals to maintain favorable financial performance indicators.

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Securing Ongoing Capital

Long term investments, which assures long-term sustained profitability can be financed by investor owned hospitals via contributed capital, often through public stock issuances (Smith 2002). For example, Triad Hospitals, Inc. accumulated $85.4 million shares which yielded $189 million in net proceeds in connection with a stock offering in March 2005. The net proceeds were used for capital expenditures for expansion of Triad's facilities and services, development and potential acquisitions of new facilities, working capital, and repayment of indebtedness (Triad Hospitals, Inc., Supplement to Prospectus March 31, 2005).

Not-for-Profit Hospitals' Tax Exemption

Not-for-profit hospitals cannot issue stock to raise capital, but they do have the benefit of a tax exemption that may at least partly balance their disadvantage of not being able to make stock offerings (Smith 2002). It warrants mentioning that just like investor owned hospitals not-for-profits can raise large amounts of capital via taxable and tax-exempt bond issuances, bank loans, philanthropy, joint ventures, etc.

It should also be pointed out that the tax exemption available to not-for-profit hospitals includes federal income taxes, Florida corporation income taxes, state sales taxes, local property taxes, etc. The federal, state, and local tax exemptions aggregated together represent a very large monetary amount.

Some researchers argue that the benefits accruing to not-for-profits from a tax exemption are depleted because they must absorb higher levels of uncompensated care and Medicaid patients, and they offer needed community services that are not induced by a profit motive. Younis (2004) found that not-for-profit hospitals had longer LOS for

Medicare patients, but concluded that this enhanced the quality of care for these patients, which was consistent with a more benevolent organizational mission of not-for-profit hospitals.

Herzlinger & Krasker (1987) reached a different conclusion regarding community service and charitable care objectives exercised by not-for-profits which presumably serves to drain them of their tax exemption advantage. Herzlinger & Krasker explained that, not-for-profits, though they have the advantage of a tax exemption, do not return greater investments in community service. Therefore, not-for-profits' inability to financially perform as well as investor owned hospitals could not be explained by their expenditure of resources to benefit the community.

Herzlinger & Krasker expressed that a serious question arises when not-for-profits behave like investor owned hospitals in terms of abandoning a community purpose or systematically reducing services to less profitable patients, such as Medicaid and uninsured patients. If a not-for-profit behaves like an investor owned hospital in this context, why should the not-for-profit continue to enjoy the advantages of tax exemption? Wolfson & Hopes (1994) reported. "A survey of financial data for FY 1992 of hospitals in South Central Florida reveals that almost all institutions benefited financially from their tax exempt status and provide relatively little charity care in return."

If these conclusions are accurate, that (some) not-for-profits generally do not provide public service benefits in exchange for their tax exemption, then it could be concluded that not-for-profits have a financial advantage over investor-owned hospitals. The tax exemption may indeed help to balance certain disadvantageous incurred by not-for-profits relative to investor owned hospitals, such as the inability to issue stock.

Perhaps certain factors such as the ability to issue stock does not fully account for why investor owned hospitals tend to outperform not-for-profits. Cleverly (2004) has expressed that it is not ownership status but characteristics that are often associated with investor owned hospitals, greater efficiency and sound strategic direction, that make them more profitable. Streamlined decision making allows investor owned hospitals to quickly shift capital when necessary, subsequently incurring less costs of capital for investments. This gives them the ability to raise sufficient capital to invest in plant and equipment modernizations, restructure debt, organize the case mix to offer procedures that maximize profitability, and to market the most current treatments and procedures made possible through advances in medical research.

The Inurement Principle & Pressures from Governing Boards

A fundamental reason investor owned hospitals generally are more profitable than their not-for-profit counterparts is because of inherent differences in how these organizations relate to their governing boards.

Not-for-profits, though they are allowed to make a profit, are bound by the *"inurement"* doctrine which prohibits them from distributing net earnings for the benefit of private shareholders [(IRC Section 501 (c) (3)]. They are governed by voluntary boards with diverse constituencies, which generally results in protracted decision making and less incentive to aggressively optimize the labor force, eliminate unprofitable services, and tailor their mix of services with the intent of realizing highest reimbursements at lowest treatment costs (Galloro 2004, Smith 2002).

Investor owned hospitals distribute a portion of their profits back to their shareholders which stimulates focus on the bottom line and pressure for management to

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continually adapt to market forces and streamline operations (Smith 2002). The motivations of corporate boards can sometimes place exacting and even unrealistic profit goals upon management which results in very efficient operations but also can lead to financial statement misrepresentation and gaming payment systems (ACFE 2005-06). Pressure to increase earnings may obscure the line in management's perception between aggressively pursuing revenue goals and gaming Medicare.

But not-for-profit hospitals sometime also feel the pressure from governing boards to improve financial and operational performance, and they often respond by emulating behaviors of investor owned hospitals. Galloro (2004) reported that behavioral differences between not-for-profit and investor owned hospitals diminish when tax exempt hospitals are confronted with increasing competition. Not-for-profits in the 1990's affected by increasing investor owned hospital competition began mimicking investor owned behaviors with respect to cost control, labor utilization, service mix, and even the likelihood of upcoding to maximize reimbursement through the use of diagnostic coding.

Findings by Silverman, Skinner & Fisher (1999), discussed in a previous section, showed that hospitals recently converted from not-for-profit to investor owned status were much more aggressive in seeking profit than not-for-profits or even other long-term investor owned hospitals. Needleman, Lamphere & Choilet (1999) found that hospitals, formerly public or not-for-profit, recently converted to investor owned status tend to be the most aggressive in reducing uncompensated care, even more aggressive than hospitals that have been investor owned for a long time.

This shows that inherent behavioral differences between investor owned and not-for-profit hospitals do not originate with ownership status per se but with the objectives of governing boards, rising competition, and how hospital administration is expected to respond to changes in hospital structure, healthcare markets, and the bottom line.

Does Good Management Fully Explain Inordinately High Profitability

There is no doubt that findings reported by researchers in the previous sections of this chapter regarding the association between profitability and good management are accurate. Organizations that can be quickly and decisively aligned to changes in market and regulatory environments will be more profitable than hospitals without these characteristics, and more favorable measures of financial performance for well managed hospitals should be expected. It should be anticipated that the ability to restructure debt and finance facility and equipment modernizations should result in long-term financial health and viability.

The question is does good management alone account for financial indicators such as operating margins and TATL ratios being as inordinately high for certain investor owned hospitals as those described in the problem statement. At what point does efficiency begin to encounter diminishing returns in its contribution to high profitability? Even if a hospital's financial condition is made stronger by reductions in personnel or LOS, for example, there is a floor whereby certain resources cannot be reduced any further. There may also be a ceiling of which financial indicators cannot climb beyond due only to sound management practices and fiscal discipline.

Operating margins and TATL ratios that are higher than what would be explainable by good management may be due to gaming payment systems, either by

artificially increasing codes or charges and/or by driving up volumes of profitable procedures. But how prevalent is gaming in healthcare and how surprising should it be if gaming strategies are partly responsible for financial health in some hospitals? The following two sections address these questions by providing a historical overview of healthcare fraud from academic and trade literature and real-world prosecutions.

Investor-Owned Hospitals' Propensity for Gaming Medicare

Investor-owned hospitals have reportedly carried out gaming behaviors with greater frequency and at more egregious levels than not-for-profits. Investor owned hospitals may be more aggressive or proficient in gaming payment systems than not-for-profits in the hospital industry, and historically they have been particularly bold in gaming Medicare.

This section provides an overview from studies done by Silverman & Skinner (2001) and Dafny (2003) on gaming procedures and payment systems in the context of investor owned hospitals.

Silverman & Skinner found that investor owned hospitals are more profitable than not-for-profits, but the greatest difference between the two was that investor owned hospitals were generally more involved in the shifting of patients' DRG codes to those that yield higher reimbursements from the Medicare system, i.e., upcoding.

Silverman & Skinner also cite a history of lawsuits in connection with upcoding against hospitals and hospital chains, explaining that these gaming behaviors provide a "valuable window for understanding how for-profit and non-profit hospitals make tradeoffs between pecuniary benefits and reputational or penalty costs" (Silverman & Skinner 2001).

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Silverman & Skinner's study focused on hospital admissions involving pneumonia and respiratory infections. These two diagnostic categories are often difficult to distinguish from each other, but a diagnosis for respiratory infection at that time paid about $2,000 more to the hospital. Between 1989 and 1996, the incidence of the most expensive DRG codes for pneumonia and respiratory infection increased by ten percent among stable non-profit hospitals. Conversely, this same diagnosis increased by 23% among stable investor owned hospitals and rose by 37% for hospitals, formerly not-for-profit that had been converted to investor owned status. There was also evidence that not-for-profit hospitals operating in heavily investor owned markets were almost as likely to upcode as were investor owned hospitals.

Silverman & Skinner conclude their discussion by stating that after 1996, the upcoding index had dropped significantly in response to adverse publicity and lawsuits. Nevertheless, other lucrative gaming strategies would likely evolve.

Dafny (2003) examined a 20% sample of all hospitalizations of Medicare enrollees from the 1985-1991 Medicare Provider Analysis and Review data to assess responses by hospitals to relative price changes under Medicare PPS and other public and private insurers.

Studies before Dafny's had been unable to isolate price change responses because changes in reimbursement amounts are typically what Dafny defined as "endogenous: adjusted to reflect changes in hospital costs." Dafny "exploited an exogenous 1988 policy change that generated large price changes for 43 percent of all Medicare admissions." This exogenous policy change involved the recalibration of DRG prices to eliminate age as a criterion as part of certain diagnostic categories.

At the time of Dafny's study, about forty percent of DRG codes were paired for each diagnosis. For example, cardiac arrhythmia would have one code for patients aged 70 and above, or with complications, and a second code was used for patients under 70 without complications. Dafny's findings suggested that costs for patients without complications were similar, regardless of age. Dafny then recalibrated DRG prices to eliminate age as a criterion for data beyond 1988. This resulted in an average 11 percent increase in DRG prices for the top codes in each pair (those with complications) and an average six percent decrease in DRG prices for the bottom codes.

Dafny found that hospitals responded to these price changes by upcoding patients to diagnostic codes associated with larger reimbursements, resulting in an estimated additional reimbursement of $330-$425 million annually. This response to price changes, as reported by Dafny, was sophisticated, with more upcoding in DRG codes where the spread between top and bottom codes had increased the greatest.

Dafny also emphasized that responses to price changes were particularly strong among investor owned hospitals. With the exception of elective diagnoses, Dafny found "little evidence that hospitals increased the intensity of care in diagnoses subject to price increases, where intensity is measured by total costs, length of stay, number of surgical procedures, and number of intensive-care-unit days." Hospitals also did not increase the volume of patients admitted to more remunerative diagnoses, notwithstanding the strong a priori expectation that such a response should prevail in fixed-price settings.

Dafny concluded that hospitals, particularly investor owned, do not alter their treatment or admissions policies based on diagnostic-specific prices. Instead they employ

sophisticated coding strategies in order to maximize total reimbursement. It was concluded from this study that changes in DRG levels were unrelated to changes in costs.

Prevalence of Health Care Fraud

Uncovering gaming behavior in healthcare is not isolated to a few academic studies such as Silverman & Skinner's and Dafny's, as historically these behaviors cover the gamut of the health care industry. According to a 1993 survey by the Health Insurance Association of America (CMS, September 2004) fraudulent activities in health care break down as follows in Table 1.

Table 1
Distribution of Fraudulent Activities in Healthcare, 1993

Fraudulent Activity	Percentage
Fraudulent Diagnosis	43%
Billing for Services Not Rendered	34%
False Reporting of Patient Deductibles and Co-Payments	21%
Other	2%

Source: CMS, 2004

Specifically for Medicare, CMS (September 2004) and Benson (2005) identified the most common forms of fraud which include:

- ❖ Billing for services not furnished (or not furnished as billed – upcoding)
- ❖ Misrepresenting the diagnosis to justify payment
- ❖ Soliciting, offering, or receiving a kickback
- ❖ Unbundling or "exploding" charges
- ❖ Carrying out plans of treatment and falsifying medical records to justify payment
- ❖ Fraudulent cost reports
- ❖ Kickbacks and self referrals
- ❖ Grant or research fraud

The following paragraphs present only a few cases of the numerous prosecutions each year, showing the magnitude of tax dollars lost for healthcare organizations caught gaming Medicare.

The U.S. Department of Health & Human Service's Office of the Inspector General (OIG) reported on February 11, 2004 that under a settlement agreement Greenville, SC based St. Francis Hospital, Inc., agreed to pay almost $9.5 million to resolve Medicare improprieties from 1997-1999 in its home health, hospice, and durable medical equipment programs. This represented one of the largest OIG settlements obtained under the Self-Disclosure Protocol (Compliance Monitor, February 18, 2004).

The OIG and United States Attorney for the District of Maryland (HHS OIG February 14, 2003) reported a settlement agreement with John's Hopkins University to resolve charges of fraudulent Medicare billings. The settlement resolved a federal investigation under the False Claims Act (31 USC § 3729-3733) arising from alleged false and improper billings for services of teaching physicians to Medicare beneficiaries covering calendar year 1994 (HHS OIG February 14, 2003).

In December 2000, HCA (formerly known as Columbia HCA), the largest investor owned hospital chain in the United States, pled guilty to criminal conduct and agreed to pay more than $840 million in criminal fines, civil penalties and damages for unlawful billing practices. Of this amount, $731,400,000 was recovered under the False Claims Act. Under the settlement agreement, HCA's payment was to resolve several allegations regarding the manner in which it billed the federal government and certain states for health care costs (DOJ, December 14, 2000).

The settlement for HCA was designed to resolve allegations for billing for lab tests that were medically unnecessary and not ordered by physicians, upcoding patients' medical problems in order to get higher reimbursements, billing Medicare for advertising

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under the guise of "community education," and billing the federal government for non-reimbursable costs incurred in the purchase of home health agencies around the country (DOJ, December 14, 2000).

Other allegations for HCA were not resolved by the settlement which included HCA unlawfully charging the federal government costs for operating its hospitals and paying kickbacks to physicians to get Medicare and Medicaid business (DOJ, December 14, 2000).

Tenet's Billing and Medical Malfeasance

Cases of billing fraud, financial statement misrepresentation, defalcation, kickbacks, corruption, etc. have been shown to be abundant in the healthcare industry. But far more sinister types of fraud have also occurred which have had negative effects on patients' lives in addition to over-billing payment systems (HHS OIG December 11, 2006, DOJ May 17, 2004).

On Oct. 31, 2002 Tenet Healthcare Corp., then the nation's second largest investor owned hospital chain, disclosed that federal prosecutors were investigating allegations that two doctors at Tenet subsidiary Redding Medical Center in Redding, CA, conducted unnecessary heart procedures and billed falsely for them.   Later it was found that Tenet had been charged with medical malfeasance affecting at least 750 former patients, primarily recipients of CABG surgeries, valve replacements, and catheterizations, who subsequently pursued litigation for medical malpractice and fraud.

Tenet's actions resulted in Tenet divesting itself of most of its hospitals and healthcare entities and encountering legal damages that could amount to settlements in excess of $50 Million (DOJ May 17, 2004). Tenet's stock also went down by $20 (from

$49.31 down to $28.75 per share) on the trading day the information was released, representing a decline in market value greater than $10 billion (Darmiento 2002).

It was also discovered in connection with allegations of unnecessary surgery that Tenet's Medicare outlier payments were at much higher levels than those of its competitors. It was estimated that outlier payments comprised 16.7% or $418 million of Tenet's total Medicare reimbursements for the year ended September 30, 2002.

It was also found that Tenet inflated its prices to be able to claim larger outlier payments from Medicare, similar large "stop-loss" payments from managed care companies, and extra payments from Workers Compensation, DSH, and Medicaid. "Its dramatic financial recovery from a low at the end of 1999, to a market darling in October 2002, was largely due to a massive increase in these outlier, stop loss and related payments. Outlier and stop loss rates were 23%-26% in Tenet hospitals compared with an average of 3%-5% in other hospitals" (Middleton, 2002).

The behavior of the managers and physicians at Redding may have been an example of possible inducements to carry out unnecessary invasive surgeries in order to adhere to exacting and unrealistic revenue projections, which are sometimes characteristic of investor owned hospitals. Aggressive earnings goals motivate streamlined efficiency and sound financial policy which strengthen the hospital's financial health without endangering patients. But goals that are so high they are unrealistic can induce management to cross the line from an emphasis on productivity to behaviors that are unethical, even illegal, and dangerous to patients.

Tenet's problems were not just confined to California. In 2005 the Florida Attorney General sued Tenet claiming it had repeatedly gamed and overcharged Medicare, inflated

its hospitals prices, and seriously abused the Medicare outlier program. It was reported that Tenet's actions violated Florida's Racketeer Influenced Corrupt Organizations (RICO) Act (Davis 2005).

Discretionary Versus Nondiscretionary Procedures

Why did Tenet use CABG, valve replacements, and catheterizations as the most frequent procedures for gaming Medicare's payment system? Why not use another type of procedure to game such as organ transplantation, tracheotomies, craniotomies, or treatments for burn patients? The rationale for gaming patient volumes and payment systems using CABG, valve replacements, and catheterizations was their *discretionary* nature. Perhaps gaming activities that include the performance of unnecessary medical procedures are carried out more easily when these procedures are discretionary.

A discretionary procedure is subject to physician judgment and is not uniformly prescribed for all patients with the same condition. "The more scientific uncertainly there is about the usefulness of a procedure, the more likely it is that there will be substantial professional disagreement about its use. Some physicians will be strongly in favor of using the procedure and others will be far less enthusiastic in their endorsement of surgery as a treatment choice" (Dartmouth 1999).

Rates of performance for nondiscretionary procedures tend to be fairly uniform per 1,000 Medicare enrollees across geographic boundaries, mirroring rates of disease rather than medical practice style. But the rates of performance for discretionary procedures show wide geographic variability with less or sometimes little association to disease rates. Sometimes whether or not a patient has a particular procedure may depend on where treatment is sought for a given set of symptoms. A male diagnosed with early

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stage prostate cancer in one part of Florida could likely wind up having a radical prostatectomy, but if this same patient had sought treatment in another part of Florida other remedies, including "watchful waiting," may have been prescribed with far less likelihood of radical surgery (Dartmouth 1999, Luther & Studnicki 2003).

Perhaps it is unfair and unfounded to conclude that discretionary procedures are unnecessary because they occur in geographic areas where rates of these procedures are high. But it does invoke questions, for example, when per capita rates for certain discretionary procedures are much higher in certain Florida cities, counties, or hospital referral regions (HRR) relative to the state average (Weinstein, Bronner, Morgan et al 2004, Weinstein, Lurie, Olson, et al 2006, Dartmouth 2005).

A discussion of discretionary versus nondiscretionary procedures follows in the next few paragraphs. Distinctions between these two types of procedures are very important, as they lay down the theoretical basis to determine the DRG codes that are susceptible to gaming and will be chosen as potential variables in the Research Methods section (Chapter 3).

Nondiscretionary Procedures

If discretionary procedures are subject to physician discretion and carried out with per-capita geographic *variability* (Dartmouth 1999), then it is reasonable to assume that a nondiscretionary procedure would be less subject to physician discretion. Less physician discretion should then be reflected in per-capita rates with much more geographic uniformity (Dartmouth 1999). For example, a patient with colon cancer in Phoenix, AR is likely to receive the same surgical approach as a patient with the same condition in Tampa, FL given the type and level of progression of the disease is the same.

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Later in the Review of the Literature a number of medical procedures are discussed that are cited often in the literature as discretionary. Listed below are just a few procedures that are never defined as discretionary in the literature. These procedures were selected by the author based on their nondiscretionary nature to demonstrate a contrast between discretionary and non-discretionary procedures. A brief discussion of each of these nondiscretionary procedures may give insights as to why they may be less profitable and why they would be less subject to gaming.

Heart transplantation (DRG 103), along with many other types of transplantation (e.g., lung, pancreas, bone marrow, etc.), usually follows a long adverse medical history accompanied by the patient waiting for a donor. Although heart and other transplantations are highly reimbursed Medicare procedures (CMS 2004), they are often associated with factors such as costly post-operative complications that make them less profitable.

"Full Thickness Burn with Skin Graft (DRG 506)" is a procedure of which there is absolute scientific agreement on its application, and the procedure is used for patients uniformly who have suffered burns of similar severity. But hospitals do not routinely profit from burn procedures, as patient care and general operation of a burn facility are very cost intensive.

"Tracheostomy (tracheotomy) with Mechanical Ventilation 96+Hours for Face, Mouth & Neck Diagnosis" (DRG 483) is a highly reimbursed DRG, but this procedure is carried out with little margin for miscalculation or medical opinion, is done usually in connection with end-of-life care, and is associated with high treatment costs.

Discretionary Procedures & Efficacy of Alternative Treatments

Several discretionary procedures are described in the next few paragraphs with discussions regarding perceptions by some physicians that alternative treatments, often less invasive, may sometimes be preferable.

Life Expectancy for CABG Patients vs. Those Who Do Not Elect CABG

After more than 20 years of clinical trials and health outcomes research, it has been found that there is no difference in life expectancy for patients *electing* as opposed to not electing CABG surgery. CABG does not provide greater life expectancy, though that may be the perception of many CABG patients as well as the public. For many patients CABG is recommended to improve angina symptoms, better breathing capacity, and generally better quality of life, and the decision for surgery is presumably based on physician opinion and patient preference. But the variation in rates of CABG across geographic regions suggests that physicians may have different symptom thresholds for recommending surgery and may not interpret patient preferences in a uniform manner (Luther & Studnicky 2003).

Mastectomy vs. Lumpectomy

As of early 2000 despite evidence that the survival rate is identical for breast sparing surgery (lumpectomy) and for mastectomy, there continued to be wide variation in surgical rates indicating that perhaps surgery was based more on practice patterns and physician preference instead of disease incidence and preferences of patients.

In some cases, patients may choose traditional mastectomy over breast conserving therapy (BCT) due to fears of radiation therapy, especially when radiation oncology counseling is not offered in connection with treatment options. It has also been found

that BCT rates have been highest in hospitals with radiation oncology facilities on the hospital grounds (Elward, Penberthy, Bear et al 1998). The use of BCT decreases when the patient must be sent to an outside facility for radiation treatment. In other words, certain patients may have been advised to forego BCT for more radical surgery because of medical logistics as opposed to disease status.

Benign Prostatic Hyperplasia (BPH) & Radical Prostatectomy

Although prostatectomy has been shown to improve urinary symptoms, slightly more effective than pharmaceutical regimens, the surgery is accompanied by significant risk of side effects including retrograde ejaculation and a small risk of incontinence. There are striking geographic variations in rates for this procedure which indicate differing medical opinions among physicians concerning the necessity and benefits of surgery.

Widespread accessibility of prostate cancer screening has disclosed many early stage cancers especially among older males. Efficacy of different treatment regimens has not been established, but side effects, incontinence and impotence have been well established for surgery and radiation. Many patients, when informed of the alternatives, may elect to avoid the harmful side effects and forego the possibility that active treatment may be more effective.

Joint Replacement & Revision

The prevalence of joint replacement and revision (i.e., surgical replacement of an artificial worn-out joint) for degeneration of the knee joint has shown high degrees of variation even among neighboring regions. Elderly people experience joint stiffness and pain due to osteoarthritis (i.e., chronic deterioration of joint surfaces). Most physicians

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agree that joint replacement or revision is effective for improving patients' ability to function, though clinical trial findings are still limited to support this, and the risks and side effects associated with this type of surgery have been well established and include post-operative infection and mortality, prosthesis related complications, and long periods of rehabilitation and recovery. Also, joint revisions are more complex than replacements with less predictable results.

It is likely that differences in joint replacement rates are driven by physicians' assessments of the risks and potential benefits of this type of surgery. These assessments are likely driven by the level of pain and difficulty in functioning communicated to the physician by the patient.

Back Surgery

Many patients experience back pain due to spinal stenosis or herniated discs, though the precise cause for some patients is never fully established. There is evidence that back surgery results in immediate improvement, but there is much disagreement among researchers about the long term benefits of back surgery, chiefly because there is little research on the natural history of these conditions treated without surgery. As with knee replacement, back surgery may be driven by physician preference as well as perception of the patient's level of pain and ability to function.

Geographic Variability of Discretionary Procedures

Dartmouth (2003) identified wide geographic variability in connection with the discretionary procedures just discussed. Table 2 below shows minimum and maximum rates for each procedure between states in the nation and cities in Florida.

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Table 2
Range of Rates of Discretionary Procedures Per 1,000 Medicare Enrollees, Highest
& Lowest State Rates in US and Highest & Lowest City Rates in Florida, 1999

Procedures	Minimum & Maximum Rates of Procedure per 1,000 Medicare Enrollees	
	States in US	Cities in Florida
Coronary Artery Bypass Grafting	3.1 – 11.3	5.4 - 9.5
Mastectomy for Breast Cancer	0.8 – 3.3	0.9 - 2.7
Surgery for Benign Prostatic Hyperplasia	2.6 – 14.6	2.9 - 10.1
Joint Replacement for Degeneration of the Knee Joint	1.6 – 10.0	3.7 - 7.1
Surgery for Back Pain (including spinal fusion)	1.3 – 9.0	2.7 - 7.1
Radical Prostatectomy for Prostate Cancer	0.5 – 5.0	0.8 - 3.9

Source: Dartmouth, www.dartmouthatlas.org

Table 2 shows CABG, BPH, knee joint replacement, and back pain surgery each

with a large range between the lowest and highest rates, both for Florida and the United

States. BPH shows a very wide range of seven points (10.1-2.9) for Florida with a range

of 12 points (14.6-2.6) for the nation. CABG and back pain surgery for Florida show

ranges > 4 points, respectively 9.5-5.4 and 7.1-2.7 and > 3, respectively, 7.1-3.7 & 3.9-

0.8, for joint replacement and radical prostatectomy. The national ranges for these

procedures are even much broader.

Medicare Rates for Certain Short-Term Inpatient Hospital Stays in Florida, 2005

Table 2 provided examples of geographic variability for procedures carried out

per 1,000 Medicare enrollees in Florida and the United States in 1999. Figures 1-3

provide 2005 data per 1,000 Medicare enrollees for percutaneous coronary intervention

(PCI), knee replacement, and back surgery. Each of these figures depicts the broad

variation between HRRs in Florida in carrying out these procedures.

Figure 1 showing PCI procedures per 1,000 Medicare enrollees per HRR is shown below.
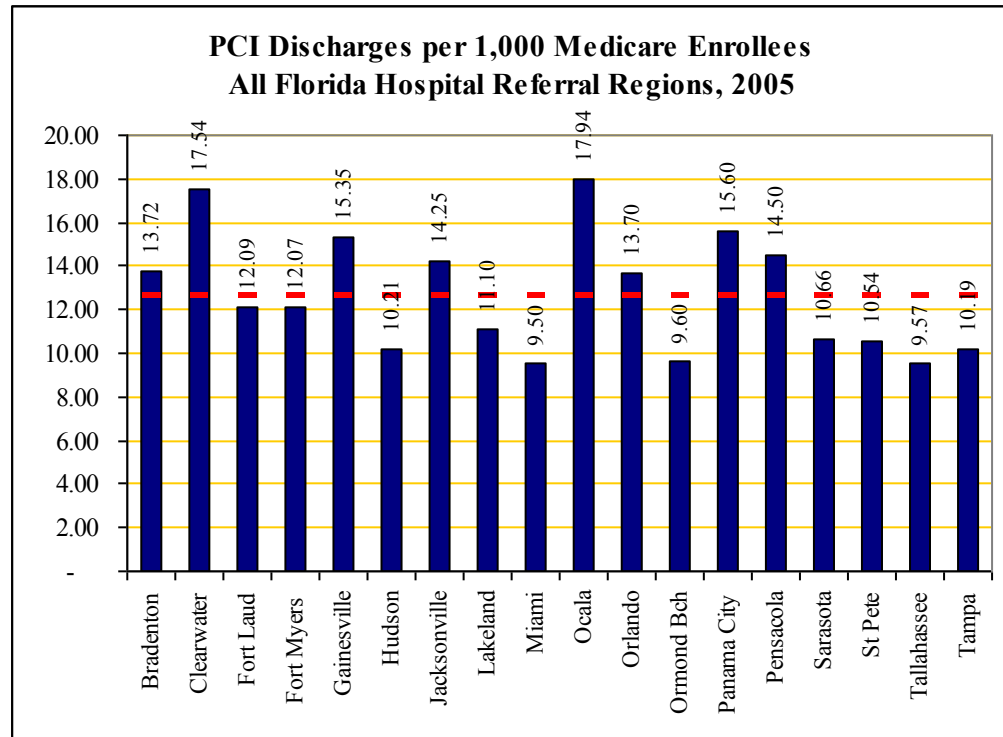
Figure 1
Source: 2005 Dartmouth Surgical Discharges, www.dartmouthatlas.org

The horizontal dashed line on the chart represents the mean average rate of 12.67 of PCI procedures for all 18 Florida HRRs. The figure shows much variation around the mean with a standard deviation of 2.75 and range of 8.44 (17.94 – 9.50).

According to Figure 1 Miami has the lowest number of PCI procedures per 1,000 Medicare enrollees. This low rate in Miami is not exclusive to PCI, but is also shown for back surgery and knee replacements shown in figures 2 & 3. Close to Miami in low rates of PCI, also shown in Figure 1, are Ormond Beach and Tallahassee with rates at 9.60 and 9.57 per 1,000 Medicare enrollees.

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As will be seen in Table 4 shown in a subsequent section, Miami has the highest dollar figure in Florida for Medicare reimbursements per Medicare enrollee for short-term inpatient discharges as well as for total Medicare spending. Yet it has the lowest number of overall surgical discharges per 1,000 Medicare enrollees in Florida, 2005 (Dartmouth Surgical Discharges, 2005).

Ocala and Clearwater show the highest numbers of PCI in Figure 1 with more than 17 per 1,000 Medicare enrollees. Gainesville and Panama City show over 15.

Figure 2 shows discharges for knee replacements by HRR per 1,000 Medicare enrollees, 2005.
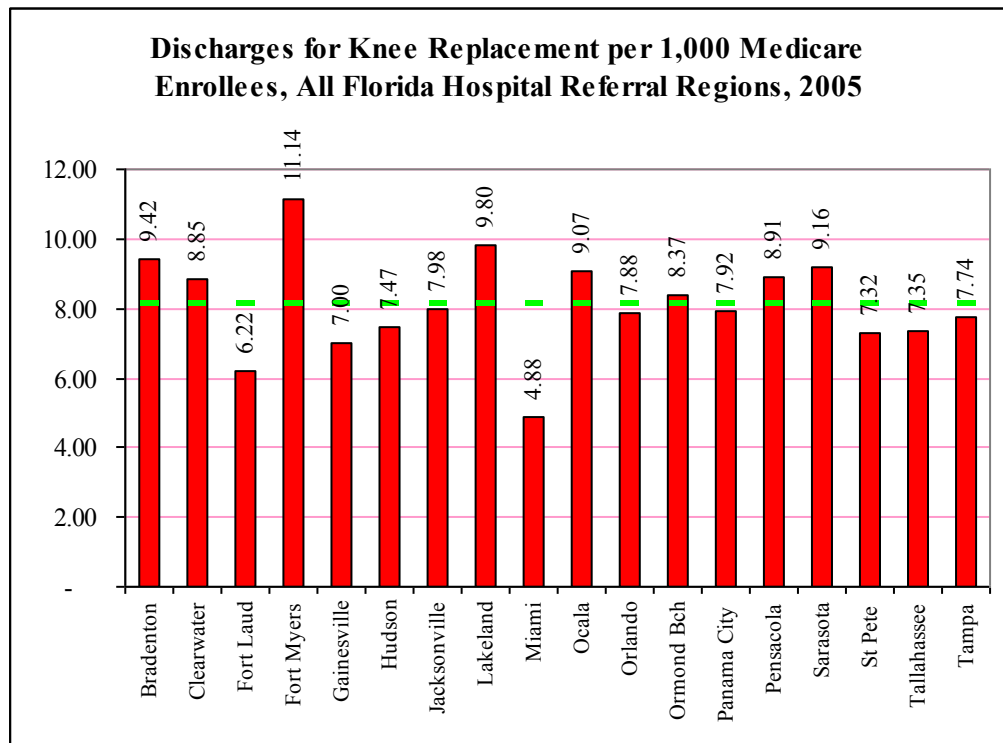
Figure 2
Source: 2005 Dartmouth Surgical Discharges, www.dartmouthatlas.org

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The horizontal dashed line shown in Figure 2 represents mean average knee procedures of 8.14 for all 18 Florida HRRs per 1,000 Medicare enrollees. With a mean of 8.14 there is a broad range of 6.26 (11.14 – 4.88).

As depicted in Figure 2, Miami again shows the lowest rate at 4.88 for knee replacements with the highest rate at 11.14 in Fort Myers. The assorted heights of the histogram show the broad variation around the mean in the performance of knee replacements between HRRs in Florida.

A similar scenario is shown in Figure 3 which shows back surgery per 1,000 Medicare enrollees for each Florida HRR, 2005. Again there is a broad range of rates reflecting dissimilar practice patterns for back surgery between HRRs.

Discharges for Back Surgery per 1,000 Medicare Enrollees, All Florida Hospital Referral Regions, 2005
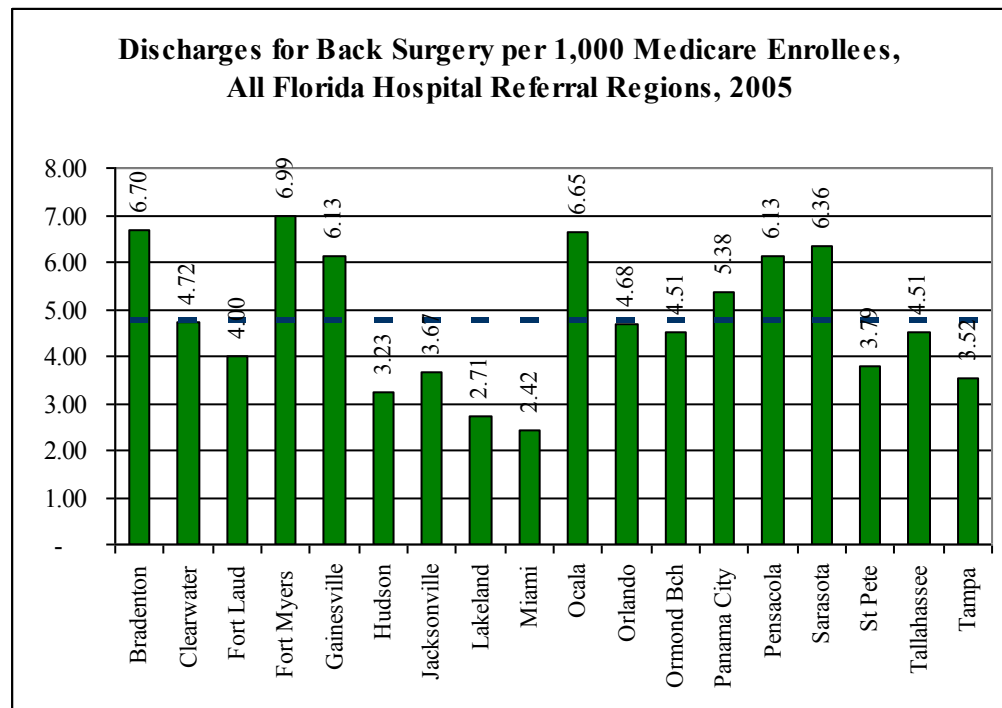
Figure 3
Source: 2005 Dartmouth Surgical Discharges, www.dartmouthatlas.org

As with figures 1&2, the horizontal dashed line on Figure 3 represents the mean average of 4.78 for back surgery discharges for all Florida HRRs per 1,000 Medicare enrollees. There is also a broad range for back surgery discharges of 4.57 (6.99 – 2.42).

Miami shows the lowest rate of back surgeries per 1,000 Medicare enrollees with 2.42. Lakeland is slightly higher with 2.71. At the other end of the spectrum are Fort Myers, Bradenton, Ocala, and Sarasota respectively with 6.99, 6.70, 6.65, and 6.36.

Broad differences in practice patterns are observed in figures 1-3 for PCI, knee replacement, and back surgery. The final section in the literature review's (Chapter 2) discussion on geographic variation of discretionary procedures features Wennberg's (2005) surgical signature theory. The signature theory is introduced as a potential explanation of geographic disparities in medical practice patterns in the performance of certain types of discretionary procedures.

Further Literature Findings of Geographic Variation of Discretionary Procedures

In 1999, a Dartmouth report (Dartmouth Atlas Quick Report for Florida – Discretionary Surgery, 1999) identified several procedures as *discretionary* based on criteria of scientific uncertainty and geographic variability. These procedures include CABG, mastectomy, BPH, joint replacement for degeneration of the knee joint, surgery for back pain, endarterectomy for carotid artery disease, lower extremety bypass surgery, and radical prostatectomy for prostate cancer. These procedures and a few others are shown in Appendix 1, and they will be used in subsequent phases of the analysis.

A subsequent Dartmouth report (Studies of Surgical Variation: Cardiac Surgery Report 2005) defined certain cardiac procedures as discretionary, again based on grounds

of clinical uncertainty and geographic disparity. These procedures included CABG, aortic and mitral valve replacements, and PCI.

Wennberg, Brownlee, Fisher et al (2008) identified "ten common conditions with widely varying use of discretionary surgery." These include early stage cancer of the prostate, enlarged prostate, early stage cancer of the breast, osteoarthritis of the knee, osteoarthritis of the hip, osteoarthritis of the spine, chest pain due to coronary artery disease, stroke threat from carotid artery disease, ischemia due to peripheral artery disease, and gall stones.

Birkmeyer, Sharp, Finlayson, et al (1998) partially support Dartmouth's findings in Florida using 1995 hospital patient discharge data for Medicare patients, aged 65-99 years, to test variability of surgical rates across national HRRs. It was found that rates of "hip fracture repair, resection for colorectal cancer, and cholecystectomy" showed low variability, only 1.9-2.9-fold across HRRs. CABG, transurethral prostatectomy, mastectomy, and total hip replacement had "intermediate variation profiles, varying 3.5-4.7-fold across regions." Lower extremity revascularization, carotid endarterectomy, back surgery, and radical prostatectomy had the "highest variation profiles, varying 6.5-10.1-fold across HRRs."

The American College of Physicians (2001) also found low regional variation with treatments for hip fractures and colectomies. In contrast, regional rates of CABG, back surgery, radical prostatectomy, and peripheral angioplasty showed high variability.

Fisher, Goodman, Skinner et al (2009) reported that Medicare spending in 2006 varied more than threefold across national HRRs. "Research has shown that some of the variation is due to differences in the prices paid for similar services, and some is due to

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differences in illness; but even after accounting for these factors, twofold differences remain. In other words, the differences in spending are almost entirely explained by differences in the volume of health care services received by similar patients."

Tenet's Choice of Discretionary Procedures

Tenet's choice of procedures for gaming is consistent with the types of discretionary surgeries described earlier by Wennberg (2008) and Dartmouth (2005) which have included CABG, valve replacements and catheterizations. Catheterizations include coronary angiography, coronary arteriography, and PCI (American Heart Association 2009).

Weinstein, Lurie, Olson et al (2006) identified hip replacement, lumbar discectomy/laminectomy and lumbar fusion as discretionary based on a lack of scientific consensus and unwarranted geographic variations. But they stated the "rates of spine surgery are among the most variable of all surgeries. The underlying causes of international and regional variations found in rates of spine surgery include lack of scientific evidence, financial incentives and disincentives to surgical intervention, and differences in clinical training and professional opinion."

Burns, Moskowitz, Ash et al (1997) studied geographic variations in the performance of hip procedures in Houston, Pittsburg, and Minneapolis. They found "despite an absence of evidence supporting its appropriateness and a much higher cost, hip replacement is used to treat non-displaced fractures much more frequently in Houston and Pittsburgh than in Minneapolis."

Among heart procedures discussed in this study pacemaker implants and implantable cardioverter defibrillators (ICD) appear to have the greatest medical

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consensus regarding efficacy. But geographic variations were still found with these procedures the determinants of which were economic and demographic factors (Ovsyshcher & Furman 2003). Essentially, pacemaker implants were less likely to occur among patients residing in economically disadvantaged communities.

Carlisle, Valdez, Shapiro et al (1995) examined geographic variations in Los Angeles, CA for CABG, carotid endarterectomy, hysterectomy, artery angioplasty, permanent pacemaker insertion, mastectomy, and transurethral prostate resection (TURP). Large geographic variation was found for all cardiac procedures with the exception of pacemaker implants. In fact, out of all procedures studied, pacemaker implants and hysterectomies had the smallest geographic variation, though even these procedures showed variation with respect to race and ethnicity and socioeconomic status.

Spencer, Fung, Wang et al (2004) investigated a sample of 16,352 cases from Veteran's Affairs Central Cancer Registry that were diagnosed between 1997 and 1999 with stage I or II prostate cancer. They found that patients (veterans) in the western part of the U.S. had a higher likelihood of undergoing surgery than radiation compared to the northeast, south, or Midwest. They also found that African American men with lower grade and higher stage tumors as well as unmarried men of all races were more likely to undergo radiation rather than curative treatment or surgery.

The discussion in the Research Methods section (Chapter 3) will show that many of the discretionary procedures discussed above are a good theoretical starting point for selecting DRG codes as variables that contribute to hospital profitability and may be subject to gaming.

The Effects of Geographic Disparities in Medicare Spending

It is plausible that Medicare spending would be roughly similar per capita between regions accounting for differences with respect to health status, age, etc. But Medicare spending is as geographically variable as volumes of discretionary procedures.

After adjusting for clinical, demographic, hospital, and regional characteristics Cowper, DeLong, Peterson et al (1997) found wide variability among states in patient-level cost and LOS for CABG surgery. They suggest there is no association between higher medical costs and lower rates of readmission or mortality.

Fisher, Wennberg, Stukel et al (2003) have noted that Medicare spending increases in areas with high rates of discretionary procedures. But they conclude. "Medicare enrollees in higher-spending regions receive more care than those in lower-spending regions but do not have better health outcomes or satisfaction with care."

Dartmouth (1999) concluded that differences in Medicare spending cannot be explained by "local differences in population age, sex, race, illness or prices. In fact, adjustment for these factors has almost no effect on the range of variation in Medicare spending" (Dartmouth 1999).

Higher Medicare spending in certain areas, and more specifically for certain hospitals, induced by profitable DRG codes results in higher total revenue for a hospital. If these DRG codes represent highly reimbursed discretionary procedures then the direct effect is inordinate Medicare spending when perhaps more affordable alternatives are available, as well as subjecting patients to procedures, often more invasive, that may not be in their best interest. But the effect for the hospital, whether intentional or inadvertent,

is greater operating revenue, which will, in turn, increase profitability, all other things being equal.

Baicker & Chandra (2004) found that geographic disparities for Medicare spending are correlated with the number of practicing physicians in different areas of the country. A similar scenario may exist between hospitals with high operating margins and those with modest to poor margins. Operating margins may be affected by the mix of physician specialties found in certain hospitals. A higher concentration of specialists may result in the performance of higher Medicare reimbursement procedures which would increase spending in certain geographic areas while also improving the bottom line in the hospitals where an excessive number of highly reimbursed procedures are performed.

Areas populated with a substantial number of general practitioners experience lower Medicare spending levels than areas with concentrations of certain types of specialists. According to Baicker & Chandra, this explains wide disparities between Medicare reimbursements per capita between geographic areas.

Baiker & Chandra concluded that additional spending for Medicare does not result in more effective care for the geographic areas with the highest spending rates. "States that spend more per Medicare beneficiary are not states that provide higher quality care." Medicare dollars are "spent on expensive health care that has not been shown to have a positive effect on patient satisfaction or health outcomes" (Baicker & Chandra 2004).

Higher & Lower Levels of Medicare Spending Between States

Table 3 shows Medicare reimbursements per enrollee for short-term inpatient hospital stays for several different HRRs across the nation. Regions shown at the top of Table 3 represent the top ten highest Medicare per enrollee reimbursements for short-term stays. The bottom of the table represents the top ten lowest levels of per enrollee Medicare reimbursement for short-term stays.

Table-3
Medicare Spending by City, State & Hospital Referral Region, Higher & Lower Levels of Medicare Reimbursements Per Medicare Enrollee, 2003

City Name	State	Hospital Referral Region	Per Enrollee Reimbursements*
Top 10 Cities with Highest Levels of Medicare Reimbursements Per Medicare Enrollee for Short-Term Inpatient Stays, 2003			
Baltimore	MD	223	3,776
Miami	FL	127	3,792
Philadelphia	PA	356	3,871
Los Angeles	CA	56	3,991
Chalmette	LA	19014	4,072
East Long Island	NY	301	4,176
McAllen	TX	402	4,211
Covington	LA	19018	4,361
Manhattan	NY	303	5,386
Bronx	NY	297	6,395
Top 10 Cities with Lowest Levels of Medicare Reimbursements Per Medicare Enrollee for Short-Term Inpatient Stays, 2003			
Mason City	IA	195	1,603
Appleton	WI	446	1,607
Neenah	WI	452	1,685
South Bend	IN	187	1,738
Sioux City	IA	196	1,746
Cedar Rapids	IA	190	1,783
La Crosse	WI	448	1,792
Dubuque	IA	193	1,795
Fort Collins	CO	104	1,807
Salt Lake City	UT	423	1,842

*   Reimbursements are not adjusted for inflation
*   Reimbursements are sorted in ascending order both top-10 lowest & highest level Medicare reimbursement groups
     Source: Dartmouth Atlas of Healthcare, dartmouthatlas.org

The Bronx and Manhattan, NY, represent the highest per Medicare enrollee reimbursements in the nation for short-term hospitals stays at $6,395 and $5,386 respectively. Three other cities in the northeast in the top 10 highest per enrollee Medicare spending group are also in the northeast and include Baltimore, Philadelphia, and East Long Island. Two cities from Louisiana, Covington & Chalmette, have reimbursement levels $4,361 & $4,072. McAllen, Texas, has the forth highest Medicare reimbursement level at $4,211. Miami is shown to have the ninth highest Medicare reimbursement level in the nation with $3,792. Subsequent review will show that Miami has the highest levels of Medicare spending in Florida.

At the other end of the continuum listed in Table 3 are ten top cities with the lowest levels of per enrollee Medicare reimbursements for short-term hospitals stays. Four cities in Iowa are listed in this group including Mason City, Sioux City, Cedar Rapids, and Dubuque which show per enrollee spending of $1,603, $1,746 $1,783 and $1,795. Three cities in Wisconsin, Appleton, Neenah, and La Crosse, are also shown at $1,607, 1,685, and $1,792.

What is the difference between short-term inpatient treatments in Mason City, Iowa per Medicare enrollee and spending in The Bronx or Manhattan, New York? Why are spending levels higher in the Northeast and certain cities in Louisiana and Texas, but so much lower in Iowa and Wisconsin?

The most probable reasons for these differences in spending are unionized labor in the northeast and high concentrations of investor owned hospitals in southern states such as Louisiana and Texas. High ratios of specialist physicians per 1,000 Medicare enrollees may also help explain higher Medicare spending in certain areas.

With a few exceptions it was found that mean Medicare reimbursements for inpatient hospital care were generally lower in western and mountain states and higher in southern and eastern states. It was also not uncommon for substantially different levels of Medicare per capita spending even among contiguous states.

It has been suggested that geographic differences in volumes of procedures and Medicare spending can be partially explained by patients' culture, upbringing, and psycho-social factors which would result in varying preferences with regard to the number of visits to physicians, the perception of personal medical need, and the willingness to undergo surgery. However, there is "no evidence that illness or informed patient preferences vary as sharply according to boundaries of health care markets as does surgery" (Wennberg, 2005).

Although patients are consumers they do not have the same objectivity and latitude in their decision making as they would in the purchase of other commodities. Patients tend to follow the recommendations of their physicians because they trust the expertise of the medical profession and tend to question much less the competency or motivation of their physician as they would the providers of other types of services.

Fisher, Bynum & Skinner (2009) found that between 1992 and 2006 per capita inflation-adjusted spending in Miami, Florida grew at an annual rate of 5.0%, relative to 2.3% in Salem, Oregon, and 2.4% in San Francisco. Per capita growth in Medicare expenditures between 1992 and 2006 in Miami was $8,085 per Medicare enrollee. It was also found that 26 HRRs across the nation had more rapid spending than Miami and 18 regions had slower growth in Medicare expenditures than Salem.

As already mentioned, what may account for differences in surgical volumes and Medicare spending is what Wennberg (2005) has labeled the *"surgical signature."* Wennberg's signature theory is explained in this chapter beginning on page 60, after the discussion on "Geographic Differences in per Capita Medicare Spending in Florida." Wennberg argues that geographic variability in Medicare spending between national regions as well as cities in Florida can be explained by the surgical signature.

Geographic Differences in Per Capita Medicare Spending in Florida

Florida is a very important state for the Medicare program. In 2001 Florida had 1,803,422 Medicare enrollees which exceeded the number of enrollees in New York and was second only to California, which had the highest number of Medicare enrollees in the nation. By 2005 the number of Medicare enrollees in Florida had grown to 2,115,397, an increase of 17.3% (Dartmouth Surgical Discharges 2005).

Medicare spending in Florida occurs with similar variability between cities as was shown between states in the previous section. Considering Florida's large Medicare enrollment, if variability indicates that more spending occurs in certain areas than is warranted, then there is a sizeable misplacement of federal tax dollars.

Medicare Reimbursements for Short-Term Inpatient Hospital Stays

Table 4 shows 2005 Medicare reimbursements for short-term inpatient hospital stays per Medicare enrollee for 18 different HRRs in Florida. The second column of this table converts reimbursements to z-scores to ascertain how many standard deviations a reimbursement level may be away from the mean.

Table 4
Medicare Reimbursements for Short-Term Inpatient Hospital Stays Per 1,000
Medicare Enrollees, 2005

City Name	HRR	2005 Reimbursements	Z-Score 2005 Reimbursements
Bradenton	115	2,110	(1.19)
Clearwater	116	2,824	0.37
Fort Lauderdale	118	2,687	0.07
Fort Myers	119	2,328	(0.71)
Gainesville	120	2,989	0.73
Hudson	122	2,431	(0.49)
Jacksonville	123	2,956	0.66
Lakeland	124	2,758	0.23
Miami	127	3,905	2.74
Ocala	129	2,411	(0.53)
Orlando	130	2,900	0.54
Ormond Beach	131	2,428	(0.49)
Panama City	133	3,007	0.77
Pensacola	134	2,491	(0.35)
Sarasota	137	1,720	(2.04)
St. Petersburg	139	2,707	0.12
Tallahassee	140	2,351	(0.66)
Tampa	141	2,756	0.22
National Average		2,955	
Adjusted State Average		2,743	
Unadjusted State Mean Average		2,653	
Standard Deviation		458	
Coefficient of Variation		0.17	

HRR: Hospital Referral Region
Z = (Observation – Mean) / Standard Deviation = (Observation – 2,653) / 458
Source: The Dartmouth Atlas of Healthcare, http://www.dartmouthatlas.org

Table 4 above shows that Miami is an outlier compared to the other cities in the
table. Z-scores were calculated for each of the cities to determine how many standard
deviations each city is from the unadjusted mean of $2,653 for Florida. Miami is almost
three standard deviations above the mean for the state and is significantly above the
national average of $2,955 shown also in Table 4. Keep in mind that in figures 1-3
Miami showed the lowest rates of PCI, back surgery, and knee replacement per 1,000
Medicare enrollees.

Panama City and Gainesville are each about ¾ of one standard deviation above the mean at 0.77 & 0.73. Jacksonville is not far behind at 0.66.

The question arises as to why there is so much regional fluctuation for Medicare spending. Why is Miami's spending per enrollee for short-term inpatient stays so much higher than other HRRs? What are the differences between areas with high reimbursements per enrollee and those with lower levels? As already mentioned one explanation is the surgical signature theory which is discussed in the next section.

Appendix 2 provides a more thorough review of Medicare reimbursements for short-term inpatient stays per Medicare enrollee. The appendix also presents comparisons between 2000 & 2005 including growth in spending in the five year period.

Total Medicare Spending in Florida

Medicare reimbursements shown in Table 4 referred exclusively to short-term inpatient hospital stays. Table 5 shows inflation adjusted total Medicare spending per enrollee by Florida HRR for 1992 & 2006. Some but not all HRRs follow similar patterns in total Medicare spending across Florida HRRs as they did in spending for short-term inpatient care. The point is that what might be expected would be comparable levels of spending per Medicare enrollee, but instead the table shows geographic variation between HRRs.

Table 5
Inflation Adjusted Total Medicare Spending Per Enrollee by Hospital Referral
Region(HRR) in Florida, 1992 & 2006, Actual & Percentage Growth

HRR Place	#HRR	*Medicare Spending Per Enrollee, 1992	*Medicare Spending Per Enrollee, 2006	Growth in spending 1992-2006	Annual growth rate 1992-2006
Bradenton	115	4,442	7,640	3,197	3.95%
Clearwater	116	5,432	8,697	3,266	3.42%
Fort Lauderdale	118	6,321	9,816	3,495	3.19%
Fort Myers	119	5,401	8,243	2,842	3.07%
Gainesville	120	5,235	8,357	3,122	3.40%
Hudson	122	5,356	9,058	3,701	3.82%
Jacksonville	123	5,610	8,733	3,123	3.21%
Lakeland	124	4,487	8,799	4,313	4.93%
Miami	127	8,266	16,351	8,085	4.99%
Ocala	129	4,614	8,097	3,483	4.10%
Orlando	130	5,408	8,588	3,179	3.36%
Ormond Beach	131	5,010	8,298	3,288	3.67%
Panama City	133	5,413	9,678	4,265	4.24%
Pensacola	134	5,477	7,946	2,468	2.69%
Sarasota	137	4,983	7,466	2,484	2.93%
St. Petersburg	139	5,801	9,103	3,301	3.27%
Tallahassee	140	5,140	7,257	2,117	2.49%
Tampa	141	5,368	8,991	3,624	3.75%
Florida Mean (all 18 HRRs)		5,431	8,951	3,520	3.58%
Florida Std. Dev. (all 18 HRRs)		842	1,973	1,269	0.68%
Florida CV (all 18 HRRs)		0.155	0.220	0.361	19.02%

*Inflation adjusted Medicare spending
Source: The Dartmouth Atlas of Healthcare, http://www.dartmouthatlas.org

The most noticeable HRR in Table 5 is HRR 127, Miami which shows $16,351 of

2006 inflation adjusted total Medicare spending per enrollee. Miami also showed the

highest level of short term inpatient spending in Table 4. As already mentioned under

Table 4 and in figures 1-3, Miami had shown the lowest rate of PCI, back surgery, and

knee replacements of all Florida HRRs. Miami also shows the lowest overall surgical

rate for all HRRs in Florida.

Fort Lauderdale, Panama City, St Petersburg, and Hudson show 2006

reimbursements per enrollee of over $9,000. In fact, Fort Lauderdale shows over $9,800

and Panama City close to $9,700. Bradenton, Pensacola, and Sarasota each show reimbursements per enrollee under $8,000.

The 2006 rate of growth, inflation adjusted between 1992 & 2006, is $3,520 with a large standard deviation of $1,269 with a comparably large coefficient of variation of 0.361. There is also a high coefficient of variation at 19% for the annual percentage growth rate.

The "Surgical Signature" as a Theory to Account for Differences in Prevalence of Procedures and Levels of Medicare Expenditures

Broad variations in certain types of surgical rates per 1,000 Medicare enrollees and in Medicare per capita spending may be explained by what Wennberg (2005) refers to as the "*surgical signature*" theory. Wennberg describes the surgical signature in the context of orthopedic surgery as the "propensity of local surgeons to specialize in a particular subset of the orthopedic surgical workload and in the workforce's ability to find candidates that meet clinical appropriateness criteria. Surgical specialists tend to become expert in a subset of the procedures that their specialty performs and to orient their workload toward patients eligible for the procedure" (Wennberg 2005). Wennberg tested this theory by reviewing rates of several orthopedic procedures among cities in Florida.

Particularly in cases of hip and knee replacements decisions regarding surgery tend to be made by small groups of surgeons. This evolves practice patterns that result in steady increases in these types of surgeries until available surgeons can no longer accommodate further increases. Numbers of surgeries for the community then stabilize at a high level and remain there for long periods of time.

Wennberg reported that the number of per-capita orthopedic surgeons show variations of four-to-seven fold among regions with no correlation between the numbers of surgeons and the performance of surgeries. Wennberg explains the surgical signature by showing comparisons between Manhattan, New York with four cities in Florida including Miami, Fort Lauderdale, Fort Myers, and Sarasota, discussed below. Wennberg concludes that the surgical signature accounts for differences in surgical rates, discharges, and medical expenditures more than any other factor.

Surgical Signature in Several Florida Cities

Between 2000 and 2001, Medicare per capita rates for knee surgery in Fort Myers were three times higher than the rate in Manhattan. The rate in Sarasota was 2.5 times higher, and the rate in Fort Lauderdale was 1.8 times higher. The rate of hip replacement in these three cities was twice the rate for Manhattan. Back surgeries were more than three times higher for Fort Myers and Sarasota compared to Manhattan, and Fort Lauderdale showed a back surgery rate that was five times higher. Oddly, hip replacements were lower in Miami than Manhattan.

Within a decade surgeons in Fort Myers performed 7,250 more back operations, 7,000 more knee replacements, and 2,600 more hip replacements than would have been done had the Manhattan rate per 1,000 Medicare enrollees prevailed in those communities. Miami surgeons carried out 870 more back surgeries, 1,400 more knee surgeries, but 56 fewer hip replacements if the Manhattan rate had been applied to Miami over the same ten-year period.

In 2005, surgical discharges for back surgery in Manhattan were 1.94 per 1,000 Medicare enrollees. Fort Myers and Sarasota, on the other hand, had, respectively, 6.99

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and 6.36 back surgery discharges per 1,000 Medicare enrollees. Recall from Figure 3 that Miami had the lowest per capita rate of back surgeries with 2.42 per 1,000 Medicare enrollees. But even Miami, with the lowest per capita back surgery rate among all HRRs in Florida showed a higher rate than Manhattan which was 1.94 (Dartmouth 2005).

This is also found for knee replacements in 2005. Although the Miami HRR has the lowest per capita knee replacement rate in Florida with a rate of 4.88 per 1,000 Medicare enrollees (see Figure 2), Manhattan has a per capita rate of 3.72. Fort Myers, Sarasota, and Bradenton have per capita rates of 11.14, 9.16, and 9.42 (see Figure 2) (Dartmouth 2005).

Per capita discharges for CABG surgeries in 2005 were 3.48 in Manhattan relative to 5.51 in Sarasota. Per capita rates were also 4.27 and 4.28 for Fort Lauderdale and Fort Myers, respectively (Dartmouth 2005).

Per capita PCI discharges in Manhattan were 12.99 in 2005. Contrast this rate to those of Ocala and Clearwater which showed rates of 17.94 and 17.54 (Dartmouth 2005)

Commonly cited reasons for these geographic variations in Medicare expenditures related to back surgeries include the incidence of osteoarthritis and herniated discs, but considering such wide disparities between communities it is doubtful that these differences in expenditures were completely dictated by medical need.

Dartmouth (Date Unknown) found a positive correlation between physician visits and density of cardiologists per capita 100,000 residents. For example, patient visits to cardiologists were five times higher in areas with 12 cardiologists per 100,000 residents relative to two per capita 100,000.

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Dartmouth also found that rates of procedures, which are lower in central and Midwestern states, are concomitant with lower density of specialists per 100,000 residents relative to east and west coast states. In 1995-1996 Dartmouth also found positive correlations between the density of hospital beds and discharges for all medical conditions per 1,000 Medicare enrollees.

Geographic location

Findings from the literature regarding geographic variations in medical practice patterns, particularly those in Florida, provided the impetus to create two variables for geographic location. In Part 1 of the study, geographic location is based on median income levels for 67 counties in Florida and is dichotomized according to high vs. low income levels. In Part 2 of the study geographic location is based on north, central, and south geographic regions in Florida. This variable is a dichotomy with the combined northern and central regions as the base level.

Research Summary

The Literature Review up to this point has examined several financial performance indicators and how they may be influenced by a hospital's percentage of Medicare revenue or amount of Medicare patients, good management and prudent strategic direction, possible gaming of payment systems, and overuse or overcharging of certain discretionary medical procedures. The Literature Review has also assessed what constitutes a discretionary procedure based on scientific uncertainty and geographic variability and cited several studies that reached similar conclusions on what type of procedures should be considered discretionary.

The investigation will now proceed to first define and operationalize the term *discretionary procedure* for purposes of this study (Chapter 3). The investigation will then go on to test the association between the *TATL ratio* and certain types of *discretionary heart and orthopedic procedures* reimbursed by conventional Medicare (chapters 5 & 7).

The analysis will also focus on the interaction between these two discretionary procedure variables and hospital ownership. This will help to address the question if the performance of higher rates of certain types of discretionary procedures relates to stronger balance sheets (i.e., higher TATL ratios) in investor owned vs. not-for-profit hospitals. It may also help to shed light on fluctuating rates in performing these discretionary procedures with respect to hospital ownership and geographic location.

The analysis will then switch from an investigation of rates of discretionary procedures under conventional Medicare to an analysis of total patient charges under Medicare HMO (chapters 6 & 8). This will address large disparities in patient charges, unrelated to patient disease severity or the extent of medical services provided, with respect to hospital ownership and Florida geographic region.

This summary is expressed in more detail under Research Goals & Objectives, shown in Chapter 3, Research Methods - Data Structure & Identification of Variables, which is next.

Chapter 3

Research Methods – Data Structure & Identification of Variables

Research Goals & Objectives

The intent of this research is to determine which DRG codes are associated with investor owned hospitals with high TATL ratios, if these codes represent discretionary procedures, how these DRG codes differ from codes associated with TATL ratios of less profitable hospitals, if these DRG codes are being used with inordinate frequency considering the medical needs of the patient population, and to determine if charges are commensurate with other hospitals that perform the same procedures.

Two broad goals and several objectives for parts 1 & 2 have been formulated to address the research questions. The two goals are listed as follows in connection with parts 1 & 2 of this study.

Goal for Part 1

Determine if investor owned hospitals with high TATL ratios are using conventional Medicare to perform discretionary procedures at significantly higher *rates* than their not-for-profit counterparts.

It is important to distinguish that the context is a positive association between the TATL ratio and percentages of discretionary procedures, not higher volumes. It was shown in the preliminary analyses that not-for-profits performed higher overall volumes of discretionary procedures during the study period, 2000-2005 (See Table 9). However, preliminary analyses also indicated that percentages per hospital of certain discretionary procedures, reimbursed by conventional Medicare, increased concomitantly with rising TATL ratios in investor owned hospitals.

Objectives for Part 1

1) To operationalize a definition for *"discretionary procedure,"*
2) To identify DRG codes which represent discretionary procedures
3) To determine if hospitals' TATL ratios increase corresponding to increases in percentages per hospital of certain discretionary procedures reimbursed by conventional Medicare
4) To determine if the association between the TATL ratio and percentages of certain discretionary procedures, reimbursed by conventional Medicare, differ according to hospital ownership
5) To determine if the association between the TATL ratio and percentages of certain discretionary procedures, reimbursed by conventional Medicare, differ according to geographic location

Goal for Part 2

Determine if investor owned hospitals are charging significantly higher amounts for the same extent of medical services than their not-for-profit counterparts using Medicare HMO to perform certain discretionary procedures.

Objectives for Part 2

1) To operationalize a definition for *"discretionary procedure,"*
2) To identify DRG codes which represent discretionary procedures
3) To determine if mean charges for these discretionary procedures reimbursed by Medicare HMO are significantly greater for investor owned hospitals than mean charges for not-for-profit Florida general short term acute care hospitals.
4) To determine if mean charges for these discretionary procedures reimbursed by Medicare HMO differ according to geographic region

The goals differ for parts 1 & 2 because incentives under conventional Medicare and Medicare HMO also differ. As already mentioned, since conventional Medicare is based on a fixed rate per DRG code there is no incentive for hospitals to artificially increase charges. Their incentive would be to increase volumes of certain procedures that make them profitable, while attempting to minimize other types of procedures. Inflating charges would be an incentive for hospitals reimbursed by Medicare HMO, since it is similar to an insurance charge-based payment system.

It should also be observed that references to geographic location in Part 1 and geographic region (or sector) in Part 2 are consistent with Wennberg's theory of the *surgical signature,* as discussed in the literature review in Chapter 2.

Data Sources

Hypotheses will be addressed using four datasets that provide clinical, demographic, operational, and financial data. These datasets include the Florida Agency for Health Care Administration (AHCA) Discharge Data for all patients treated in Florida hospitals over a six year period, 2000-2005, AHCA Financial data *(hardcopy)*, 2000-2005, AHCA Financial data *(electronic file)* for the same time period, and median income data for each county in Florida for each year, 2000-2005, available from the U.S. Department of Housing & Urban Development (www.hud.gov).

AHCA hardcopy and electronic financial data are considered two different datasets because though they overlap in some areas they report on different financial items in others. For example the hardcopy dataset provides some income statement data including operating margins, as well as operating revenues and expenses that comprise these margins for all Florida hospitals, but it does not report balance sheet data. The electronic data does not provide income statement data with the exception of total margins, but it does provide data on hospital balance sheets, including items that comprise total assets and total liabilities, of which the TATL was constructed.

Structure of the Datasets

Datasets for parts 1 & 2 will be composites of respectively four and three of the datasets listed above.

Selection of Hospitals

The selection of hospitals to be used in the analysis were derived from the AHCA Financial data and included only acute care general investor owned (C-corporation) hospitals, religious and other not-for-profit [501(c)(3)] hospitals, and governmental hospital district facilities. Excluded from the data-set were rehabilitation and psychiatric facilities, certain government owned hospitals (e.g., state and county hospitals, etc.), teaching hospitals, specialty hospitals, limited liability companies (LLCs), and partnerships.

A total of 891 hospital observations were comprised of roughly 150 hospitals from each year, 2000-2005. For example, of the 281 health facilities listed in the 2005 AHCA Financial Data, 151 facilities were used and were comprised of 69 investor owned hospitals, 20 religious not-for-profit hospitals, 46 other not-for-profit hospitals, and 16 hospital district facilities. Discharge and financial data were segmented to include only patients discharged from these general acute care short-term hospitals.

Data Structure for Part 1

Total observations for Part 1 included the entire 891 observations representing repeated measures of approximately 150 acute care general hospitals for each year, 2000-2005.

For Part 1 this means that a large AHCA dataset of 4 million conventional Medicare patient observations must be merged with a much smaller AHCA hospital financial data set comprised of 891 observations.

The structure of the models must be driven by the dependent variable which for Part 1 is the TATL ratio. This means that because the TATL ratio is specific to each

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hospital, each observation must represent an individual hospital in a given year. This allows each observation of the dependent variable to be unique.

Individual patient data used in the analysis for Part 1 were downloaded from the AHCA Discharge Data and aggregated into data specific to each hospital. For example, conventional Medicare CABG patient observations are aggregated into specific hospitals in which they occurred. These aggregated totals then become total CABG procedures performed within each specific hospital in a given year. Procedures are then converted to percentages per hospital by dividing total CABG procedures reimbursed by conventional Medicare by total discharges performed by each hospital.

Part 1 of the study uses geographic location as a covariate. HUD promulgated median household income data is used as a proxy for geographic location to distinguish hospitals located in higher vs. lower income counties. HUD assigns annual median household income levels for each of the 67 counties in Florida.

Data Structure for Part 2

Part 2 of the study features total Medicare HMO charges for valve replacements and CABG procedures as the dependent variable. The dependent variable, total charges, is the driver in structuring the model. AHCA Discharge data reports a unique observation for total charges for each patient. This allows population parameters to be defined as patients treated with CABG or valve replacement procedures (DRG codes 104, 105, 106, 107,109, 547, 548, 549, 550) financed by Medicare HMO, 2000-2005. This resulted in 12,972 patient observations.

The variable hospital ownership was then coded for each patient observation to represent whether the hospital of which the CABG or valve replacement procedure occurred was either investor owned or not-for-profit.

Not all hospitals within the 891 hospital selection perform CABG or valve replacement procedures reimbursed by Medicare HMO. Only 360 hospitals (approximately 60 hospitals per year, 2000-2005) perform these types of procedures and are the hospitals used in the analysis for Part 2.

Length of stay (LOS) and geographic region are covariates in the models for Part 2. With LOS as a covariate, the objective was to examine increasing charges corresponding to increases in days of hospitalization. The association between charges and the number of days of hospitalization may differ for patients who are discharged due to death as opposed to patients discharged under other conditions. Therefore, it was determined that observations representing patients whose discharge status was due to death should be eliminated from the dataset. This resulted in 12,420 total observations used for the analysis.

Deriving an Operational Definition of Discretionary Procedures

Recall that the first two objectives listed under Research Goals & Objectives in this chapter pertain to operationalizing the concept of *discretionary procedure* in the context of this investigation. This concept of discretionary procedure is a critical feature in both parts 1 & 2. Part 1 contains two variables representing discretionary procedures, and Part 2's population parameters are defined, in part, by two discretionary procedures. Before moving forward with a discussion of the variables used in this analysis, it would be useful to define and operationalize the concept of discretionary procedure.

As already discussed in the literature review in Chapter 2, a discretionary procedure is defined as a medical procedure which lacks scientific consensus regarding efficacy and per-capita geographic uniformity in practice patterns.

Criteria for Identifying Discretionary Procedures

Wennberg (2005) and Dartmouth (1999) defined discretionary procedures as those used to treat chronic as opposed to acute illnesses, medical uncertainty regarding efficacy, and geographic variability in how these procedures are prescribed. Of these three criteria the most useful for efficiently identifying discretionary procedures is geographic variability. In fact, geographic variability is an indicator for medical uncertainty because it is the lack of scientific consensus that results in regionally non-uniform rates of procedures that are inconsistent with disease patterns. By contrast, because medical consensus exists for nondiscretionary procedures they tend to mirror disease patterns and occur with more predictable uniformity per 1,000 Medicare enrollees across geographic regions (Fisher, Bynum & Skinner 2009).

Using a Nondiscretionary Procedure as a Benchmark

Wennberg (2005) used geographic variability to identify discretionary procedures by using the geographic uniformity of a nondiscretionary procedure as a benchmark. Hip fracture was used as a benchmark reference because it is acute, painful, and motivates the patient to seek care immediately. It is "almost always correctly diagnosed, and all physicians, irrespective of their specialty or geographic location, agree uniformly on the need for hospitalization, so the rate of hospitalizations mirrors the pattern of disease."

Wennberg calculated rates for hip fracture and several other types of procedures, for all national HRRs, 2002-2003, using the incidence of procedures for prescribed

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geographic areas as the numerator and the resident population as the denominator. These rates were then expressed as ratios to the national average for each procedure. Wennberg then averaged these ratios to derive a "*systematic component of variation, a measure that allows comparisons of variation among procedures with different mean rates*" to measure geographic variability (Vitale, Krant, Gelijns et al 1999, Weinstein, Goodman & Wennberg 1998, Keller, Soule, Wennberg et al 1990).

Hip fracture showed ratios of 0.9 and 1.3 depending on location, 10% below and 30% above the national average with rates stable over time and consistently the highest in the southwest and Texas regions. The systematic component of variation for hip fracture was 13.8, which was used as the benchmark to make comparisons with other procedures.

The hip fracture benchmark was compared with many procedures, three of which were knee surgery, back surgery, and hip replacement. The component of variation for knee surgery was 55.0, more than four times that of the hip fracture benchmark of 13.8. Hip replacement and back surgery had components of variation of 67.2 and 93.6, five and seven times greater, respectively, than that of hip fracture.

Using the Coefficient of Variation as an Indicator of Geographic Variability

Wennberg's approach will be followed to measure geographic variability for surgical procedures in Florida, but a different technique will be used. Wennberg's method showed variability by examining differences in mean ratios for certain procedures between geographic areas. But Wennberg's mean of ratios method can be skewed due to a few very high or very low ratios. This is not as much of a problem in Wennberg's research because of a large sample of HRRs. To derive a measure of variability for procedures in Florida, which has only 18 HRRs, a more conservative test,

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the coefficient of variation (CV) is needed. The CV, also known as *unitized risk,* is expressed as the relationship between the standard deviation and the mean for the data distribution (Garson 2006, Rajaram 2004).

Appendix 1, which was referenced in Chapter 1, shows rates per 1,000 Medicare enrollees of surgical procedures for each of the 18 Florida HRRs, 2003. Below the tables containing these rates in the appendix are descriptive statistics including the CV. The CV for all Florida surgical discharges is 0.07 which is consistent with two nondiscretionary procedures which are used as benchmarks, hip fracture repair and resection for colon cancer, which have CVs of 0.09 and 0.08 respectively.

The CV indicates wide geographic variation, based on the association of the standard deviation to the mean for each rate, for each of these procedures in comparison to the benchmarks. CABG and coronary angiography show CVs of 0.17 and 0.18 respectively. Back surgery has a CV of 0.28 and mastectomy 0.24. Hip and knee replacements show 0.19 and 0.18, and benign prostatic hyperplasia (BPH) shows a CV of 0.37.

Based on the broad distance between the CVs of each procedure and the benchmarks, as shown in Appendix 1, several procedures are determined to qualify under the geographic variability criterion as discretionary and are eligible to be used as variables in the study. Table 6 shows these procedures with their respective DRG codes.

Table 6
Procedures Defined as Discretionary Based on Clinical & Geographic
Variability Criteria

Procedure	DRG Codes
Valve Replacement	104, 105
Coronary Artery Bypass	106, 107, 109, 547, 548, 549, 550
Percutaneous Cardiovascular Intervention (PCI) *(with & without stents)*	112, 516, 517, 518, 526, 527, 555, 556, 557, 558
Major Joint & Limb Reattachment	209
Hip & Femur Procedures	210, 211
Back Surgery - Spinal Fusion	496, 497, 498, 519, 520, 546
Knee Procedures	501, 502, 503, 544, 545
Prostatectomy	306, 307, 336, 337
Mastectomy	257 258 259 260

Discretionary procedures were identified under four major diagnostic categories (MDC). Cardiac procedures are represented under MDC 5, *Diseases and Disorders of the Circulatory System,* and orthopedic procedures are under MDC 8, *Diseases and Disorders of the Musculoskeletal System and Connective Tissue.* Mastectomy is classified under MDC 9, *Diseases and Disorders of the Skin, Subcutaneous Tissue and Breast,* and BPH and radical prostatectomy fall under MDC 11, *Diseases and Disorders of the Kidney and Urinary Tract* (Ingenix 2003, Utah DOH 2008).

The procedures identified in Table 6 will now be explored for potential statistical usefulness in model development.

Selecting Discretionary Procedures for Further Investigation

To begin a selection process, the procedures listed in Table 6 were initially tested using a Pearson and Spearman correlation matrix shown in Appendix 3. Variables used in the matrices included the TATL ratio and percentages of discretionary procedures including CABG, PCI, valve replacement, spinal fusion, hip & femur procedures, joint &

limb procedures, knee, mastectomy, and prostate procedures. Using CABG as an example of how percentages of procedures are calculated, the percentage of CABG procedures equals the number of CABG procedures performed in a particular hospital and reimbursed by conventional Medicare divided by the total number of procedures from all payers in that hospital in a given year.

In the correlation matrix in Appendix 3, associations are observed between the TATL and each medical procedure tested in the matrix. With the exception of mastectomies, coefficients between the TATL ratio and each procedure (e.g., CABG, PCI, etc.) are in excess of 0.20 ($p < 0.0001$). This means that a significantly positive association exists between the TATL ratio and each procedure.

What is also noticed are significant and high correlations between different types of heart procedures. There is a Pearson correlation of 0.93 between valve replacements and CABG procedures. There is also a Pearson correlation of 0.65 between PCI and valve procedures and 0.68 between PCI and CABG. There is a Spearman correlation of 0.87 between valve replacements and PCI and 0.88 between PCI and CABG.

Similar associations, though not as high, are also observed between certain orthopedic procedures. There is a Pearson correlation of 0.75 ($p < 0.0001$) and Spearman correlation of 0.81 ($p < 0.0001$) between hip & femur procedures and joint & limb procedures. There were also Pearson and Spearman coefficients of 0.50 ($p < 0.0001$) and 0.62 ($p < 0.0001$), respectively, between joint & limb procedures and knee procedures.

These high correlations between certain types of medical procedures indicate problems of multicollinearity if each procedure was to be used as an individual variable. After a review of the matrices it was determined that several medical procedures could be

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efficiently and coherently packaged into two independent variables. Although

prostatectomy showed significant and high associations with the TATL ratio it was

dropped from further consideration because the remaining procedures fall into either

MDC 5 or MDC 8. It was determined that they could be grouped together to form two

variables representing *cardiac group procedures* and *orthopedic group procedures*.

Grouping these procedures into two variables will reduce the number of terms used in

model development which will add statistical power and help assure validity and will also

allow several DRG codes to be tested at one time.

The two newly created groups, cardiac group procedures and orthopedic group

procedures, and the patient populations that comprise them are shown in tables 7 and 8.

Table 7
Cardiac Group Procedures Variable, Florida Short-Term Acute Care General Hospitals, 2000-2005

Procedures (Reimbursed by Conventional Medicare)	Total Procedure Volumes
Valve Replacement	20,551
Coronary Artery Bypass	50,158
Percutaneous Cardiovascular Procedures	114,894
Total	185,603

Table 8
Orthopedic Group Procedures Variable, Florida Short-Term Acute Care General Hospitals, 2000-2005

Procedures (Reimbursed by Conventional Medicare)	Total Procedures Volumes
Major Joint & Limb Reattachment	136,121
Back Surgery - Spinal Fusion	25,432
Knee Procedures	9,583
Hip & Femur Procedures	51,389
Total	222,525

The cardiac and orthopedic group procedure variables will be discussed further under the next subsection. It will explain how these groups of procedures will be structured and used as variables.

Listed below in Table 9 is a breakdown of volumes of procedures stratified by ownership for the time period 2000-2005. This table reports volume data for the newly created variables, cardiac group procedures and orthopedic group procedures and for total procedures reimbursed by conventional Medicare and total procedures performed in Florida hospitals. Also listed are percentages of cardiac and orthopedic group procedures relative to total procedures and procedures reimbursed by conventional Medicare.

Table 9
Raw Data & Percentage Breakdown of Cardiac & Orthopedic Group Procedures by Ownership, 2000-2005

Procedures	Investor Owned	Not-for-Profit
Total Procedures	3,492,321	6,788,961
Conventional Medicare Procedures	1,475,156	2,507,551
Cardiac Group Procedures	63,064	122,539
Orthopedic Group Procedures	76,471	146,054
(Cardiac Group ÷ Total Procedures) x 100	1.81%	1.80%
(Orthopedic Group ÷ Total Procedures) x 100	2.19%	2.15%
(Cardiac Group ÷ Convention Medicare) x 100	4.28%	4.89%
(Orthopedic Group ÷ Conventional Medicare) x 100	5.18%	5.82%

* *Totals for cardiac group procedures and orthopedic group procedures in Table 9 represent procedures reimbursed by Conventional Medicare. Total procedures represent procedures reimbursed by conventional Medicare and all other payers.*

The dataset shows, as depicted in Table 9, that investor owned hospitals performed a total of 63,064 cardiac group procedures and 76,471 orthopedic group procedures reimbursed by conventional Medicare between 2000 and 2005. Not-for-profits performed about twice the volume of investor owned hospitals, carrying out

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122,539 cardiac group procedures and 146,054 orthopedic procedures during the same time period.

Between 2000 and 2005, investor owned hospitals performed 3,492,321 total procedures (total payers) and 1,475,156 procedures reimbursed by conventional Medicare. Not-for-profits performed 6,788,961 total procedures (total payers) with 2,507,551 reimbursed by conventional Medicare.

Investor owned hospitals do not exceed that of not-for-profits in terms of volumes or percentages. In fact, percentages of cardiac and orthopedic group procedures relative to total conventional Medicare procedures are slightly higher in not-for-profit hospitals with 4.89% and 5.82% respectively, compared to 4.28% and 5.18% in investor owned hospitals. Percentages of cardiac group procedures and orthopedic group procedures relative to total procedures (total payers) are almost even between not-for-profit and investor owned hospitals showing respectively 1.80% and 1.81% for cardiac group procedures and 2.15% and 2.19% for orthopedic group procedures.

As will be discussed more fully in Chapter 5, Research Methods - Model Development for Part 1, the difference between investor owned hospitals and not-for-profits in this context is that there is a positive association between the TATL ratio and the cardiac group procedure and orthopedic group procedure variables in investor owned hospitals; that the TATL ratio increases corresponding to percentage increases in the cardiac group procedure and orthopedic group procedure variables. This association was not observed among not-for-profits.

Dependent & Independent Variables for Part 1

Following is a discussion of dependent and independent variables used in Part 1 and Part 2 of this study. Specific variables under Part 1 are discussed in the following paragraphs. This will be followed by a discussion of dependent and independent variables used in Part 2. These variables will be used in model development and will be discussed again in chapters 5 & 7 for Part 1 and chapters 6 & 8 for Part 2.

Selection of Variables for Part 1

TATL Ratio: The literature is rife with researchers using operating margin as the outcome variable to operationalize hospital profitability. Operating margin is an income statement item and is a measure of short-term (one year) hospital profitability. The focus of this study was a trend of long term (multi-year) financial health and solvency which was better reflected by the TATL ratio.

The TATL ratio is defined as the ratio of (current + long-term assets) / (current + long term liabilities). The TATL ratio is a comprehensive long-term indicator of financial solvency and viability, and is derived from the balance sheet. The TATL ratio reflects an organization's ability to manage debt, as the greatest portion of liabilities is usually comprised of long term debt. It also reflects investments in plant improvements and equipment, as the greatest portion of assets is usually derived from long term assets including property, plant, and equipment. Based on the objectives of this study the TATL ratio as the outcome variable was selected as an appropriate measure of long term financial strength and solvency for Part 1.

The TATL ratio was used in the modeling phase of the study as a continuous variable. But in some of the preliminary, especially nonparametric analyses the TATL

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ratio was examined as a categorical variable. Several descriptive statistical techniques were used to summarize the TATL distribution and to determine a breakpoint needed to convert the TATL ratio to a dichotomy. After examining the TATL ratio's quartile distribution it was determined that the breakpoint for a high vs. low TATL ratio would be ≥ 5/8 quartile (5/8 Q) (half the distance between the median and third quartile).

The 5/8 TATL quartile was selected because it could be used as a demarcation between hospitals with high levels of financial strength and solvency vs. hospitals with low levels. The third quartile, as well as the sixth and seventh quintiles, were also examined as potential breakpoints and generated results similar to those when the 5/8 quartile was used. It was determined that results of nonparametric tests used in this analysis would be reported using the 5/8 quartile of the TATL distribution, though any of the other quartile breakpoints would have been acceptable.

Ownership: Represented as a dichotomous variable where investor owned hospitals equal 1.0 and all other hospitals equal zero. All other hospitals in this case include religious not-for-profit hospitals, other not-for-profit hospitals, and hospital district hospitals.

Geographic location – County Median Income: As cited in the literature review hospital profitability is associated with geographic location. Preliminary analyses showed that hospitals located in higher income areas tend to have higher TATL ratios than hospitals in economically disadvantaged areas.

It often reflects sound strategic direction for management, if it has the flexibility, to seek out and locate hospitals in more affluent areas. It is also investor owned hospitals that tend to be able to exercise greater flexibility in geographic location. The association

between geographic location, as a strategy for sound management, and the TATL ratio makes geographic location a very good control variable.

The rationale for selecting geographic location as an independent variable is consistent with discussions in the literature review regarding Wennberg's (2005) surgical signature theory. As already discussed, this theory posits that the geographic variability of per capita rates and Medicare spending for discretionary procedures are more related to geographic location than disease status of populations.

The best indicator for geographic location, for which data was available, was a proxy measure of HUD promulgated median income levels for each of 67 Florida counties, 2000-2005 (www.hud.gov). High income geographic locations were defined as hospitals located in Florida counties with high median income levels.

This variable worked well as a continuous, but even better as a categorical variable. The high vs. low median income breakpoint is based on quartiles using annualized distributions for county median income. It was determined that the optimum breakpoint to distinguish a high income vs. low income county was 5/8Q (half the distance between the third and fourth quartile). A list of breakpoints for each year at 5/8Q as well as all quartiles is found in Appendix 4.

Discretionary cardiac group procedures: This variable was identified previously in Table 7 and was developed in conjunction with the definition and operationalization of *discretionary procedure.*

It was impractical to make a variable out of every DRG code or even out of every procedure. Instead, a number of DRG codes were grouped together to comprise a composite variable titled discretionary *cardiac group procedures.* This variable is

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comprised of procedures reimbursed by conventional Medicare under MDC 5 (heart procedures) and include valve replacements (DRG codes 104 & 105) CABG procedures (DRG codes 106, 107, 109, 547, 548, 549 & 550), and PCI (DRG codes 112, 516, 517, 518 526, 527, 555, 556, 557 & 558).

Observations for the cardiac group procedures variable were expressed as percentages for each hospital. Percentages of discretionary cardiac procedures were calculated via the frequency of discretionary cardiac group procedures reimbursed by conventional Medicare for a given hospital divided by total discharges carried out by that hospital. Percentages for each hospital are also calculated each year, 2000-2005.

Of the hospitals that perform cardiac group procedures reimbursed by conventional Medicare, 2000-2005, percentages per hospital range from 0.0% to 15.408%. The mean percentage per hospital is 1.127% and standard deviation is 2.208%.

Discretionary orthopedic group procedures: This variable was identified in Table 8 and was developed in connection with the definition and operationalization of the concept of *discretionary procedure.*

Just as with discretionary cardiac group procedures, this variable includes several orthopedic group procedures reimbursed by conventional Medicare under MDC 8 (orthopedic procedures) and include major hip and femur procedures (DRG code 209), back surgery (spinal fusion) (DRG codes 496, 497, 519, 520 & 546), and knee procedures (DRG codes 501, 502, 503, 544 & 545).

Frequencies of the above listed DRG codes were downloaded from the ACHA discharge data for each hospital and year. Percentages were then calculated by dividing

the frequencies of these procedures by total procedures for each hospital for each year, 2000-2005.

Of the hospitals that perform orthopedic group procedures reimbursed by conventional Medicare, 2000-2005, the percentages per hospital range between 0.0% and 11.75%. The mean percentage is 2.126% with a standard deviation of 1.772%.

In the final models of this study, rates of cardiac group procedures and orthopedic group procedures were transformed to z-scores. This was done to manage problems of multicollinearity and is discussed further in the discussion on model development in Chapter 5.

Measuring 1Z in Model Development

As just mentioned, standard deviations for cardiac group procedures and orthopedic group procedures, respectively, are 2.208% and 1.772%. Later in the development of regression models and results (chapters 5 & 7), cardiac and orthopedic group procedures will be described as increasing by 1Z. An increase by 1Z for cardiac group procedures will mean that the percentage per hospital increases by 2.208%. An increase of 1Z for orthopedic group procedures will mean that the percentage per hospital will increase by 1.772%.

Selection Criteria for DRG Codes to be used in Model Development

Observations derived from a DRG code that was discontinued by Medicare during the study period, but was replaced by a code(s) representing the same procedure were allowed to remain eligible as observations in either the cardiac group procedures or orthopedic group procedures variable.

For example, a code in the cardiac group procedures variable, DRG 112, was discontinued in October 2001, but was replaced at the same time by DRG codes 516, 517 & 518, and these codes remained active through 2005 (Utah DOH 2008).

DRG 112 represented PCI (i.e., angioplasty) while code 516 also represents a PCI, but includes myocardial infarction (MI). DRG code 517 represents PCI without MI but with an artery stent implant. DRG code 518 represents PCI without MI and without a stent implant (Utah DOH 2008).

DRG codes 516, 517 & 518 were discontinued and replaced in October 2005 with codes 555 (PCI with MCV diagnosis), 556 (PCI with non-drug-eluting stent without MCV diagnosis), 557 (PCI with non drug-eluting stent with MCV diagnosis) & 558 (PCI with non drug eluting stent without MCV diagnosis) (Utah DOH 2008).

The newer codes are expanded to provide greater detail on the surgical procedure. But all of these codes still represent roughly the same procedure for purposes of this investigation.

Selection of Variables for Part 2

Total Patient Charges: The identification of an outcome variable for Part 2 was not difficult. Since the research question is whether charges are significantly different with respect to ownership *(i.e., do investor owned hospitals charge significantly more for providing the same procedures and extent of medical services),* a sound and evident choice for an outcome variable was total patient charges.

Total patient charges are defined as the aggregate amount of charges for all procedures performed for each specific patient prior to discounts. Total charges in the AHCA discharge database include each revenue code including room charges, intensive

care, coronary care, cardiology, anesthesia, emergency room, anesthesia, intensive care, etc. (AHCA 2005). As already mentioned, total charges in Part 2 of this study apply only to Medicare HMO patients, as there is no impetus for hospitals to increase charges under the fixed rate per DRG code conventional Medicare program.

Total charges are used in this study as a continuous variable in model development and as a dichotomous (high vs. low charges) variable in preliminary categorical analyses. As a dichotomy the breakpoint for high vs. low charges is at 5/8Q (half the distance between the median and third quartile). A special provision is made for this variable because total charges increase each year. To adjust for these increases the 5/8Q breakpoint had to be annualized, where the 5/8Q breakpoint equals a different amount specific to each year. For example, $\geq$ 5/8Q for total charges in 2000 was $\geq$ 75,369; $\geq$ 5/8Q for total charges in 2001 was $\geq$ 86,006; etc. A table is provided in Appendix 5 with a breakdown of total charges by year and quartile.

Ownership: Hospital ownership is the only independent variable that will be used in both parts 1 and 2 of the analysis. This variable is critical to both parts since the focus of the study is about investor owned vs. not-for-profit hospitals.

Just as in Part 1, hospital ownership is represented as a dichotomous variable where investor owed hospitals equal 1.0 and all other hospitals equal zero. All other hospitals in this case include religious not-for-profit hospitals, other not-for-profit hospitals, and hospital district hospitals.

Geographic Region (Florida Inspection Area): Geographic location was used in Part 2 of the analysis, but was not based on median income as it was in Part 1. As a state regulatory agency, AHCA oversees 11 inspection regions that are divided into north,

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central, and south Florida geographic sectors. These inspection regions are not relevant to general, acute care hospitals. Instead the inspection regions are used to aid the state of Florida in conducting regulatory compliance inspections of nursing homes that accept Medicare and Medicaid payments. But as it turned out these regions were found to be suitable proxies for geographic location, as Medicare HMO total patient charges differed considerably by geographic region. A listing of Florida counties within each inspection region by north, central, and south geographic sectors is shown in Appendix 6.

It should also be observed that disproportionately fewer CABG or valve replacement procedures occurred in the north Florida region by investor owned hospitals. One of the reasons for this was that there are fewer investor owned hospitals that perform CABG and valve replacement procedures in the northern sector. As a result, the north and central regions were collapsed into one level, and the variable geographic region was reduced from a three level categorical variable to a dichotomy where south = 1 and north & central = 0.

Disease Severity: The preferred variable to adjust for disease severity was APR-DRG codes, but this was unavailable in the AHCA dataset. Other variables included LOS and multiple diagnoses.

LOS is defined as the number of days elapsed from a patient's admission date to discharge date (AHCA 2005). Higher LOS indicates patients being treated are very ill and require greater numbers of days for recovery (Chen 1994). Increasing patient days subsequently generates rising treatment costs (Rivers, Tsai & Munchus 2005) which will drive up hospital charges. This makes LOS a sound control variable in its relationship to charges in Part 2.

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Multiple diagnoses are derived from nine secondary clinical diagnostic categories, recorded for all Florida patients. Each additional secondary diagnosis may indicate a higher level of severity, and in turn, a higher level of costs and charges. The number of secondary procedures was added for each patient to form a continuous variable, which ranged from zero, reflecting least severity, to nine, reflecting greatest severity.

Although multiple diagnoses provided valuable information in preliminary analyses, LOS was determined to be a better variable in model development.

Valve Procedure: Since patient charges in Part 2 are derived from both CABG and valve replacement procedures, and because the data shows that charges for valve replacements tend to be higher than CABG procedures, a dichotomous variable was needed to differentiate between the two. This variable uses CABG as the base level. Therefore, coding for this variable is valve replacements = 1, CABG procedures = 0.

Chapter 4

Research Methods - Plan of Analysis for Parts 1 & 2

As described in the problem statement in Chapter 1, the literature repeatedly provides evidence that hospitals cannot make a profit with Medicare. Yet as this research unfolded it became apparent that many financially strong hospitals had Medicare as a majority portion of their revenue base. It was also noticeable that many of these hospitals were investor owned and performed higher percentages of discretionary procedures covered by Medicare.

The intent of this research is to understand two strategies certain investor owned hospitals may use to remain financially strong with Medicare as an appreciable portion of their revenue base.

Part 1 in chapters 5 & 7 will examine utilizations of certain DRG codes, representing discretionary procedures that are reimbursed by conventional Medicare to investor owned hospitals. The purpose of Part 1 is to determine if selected discretionary procedures reimbursed by conventional Medicare are being utilized at significantly higher rates by investor owned hospitals with high TATL ratios.

As discussed in previous sections the TATL ratio was selected to be the outcome variable for Part 1. The population includes 891 investor owned, religious not-for-profit, other not-for-profit and hospital district acute care general hospitals, 2000-2005.

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As discussed in model development and model results for Part 2 in chapters 6 & 8, the outcome variable for Part 2 is total charges, and the population includes all CABG and valve replacement patient discharges reimbursed by Medicare HMO that occurred in acute care general hospitals, 2000-2005. The purpose of Part 2 is to determine if investor owned hospitals are charging significantly higher amounts than not-for-profit hospitals under the same DRG codes reimbursed by Medicare HMO.

Rules for Interaction Models, Model 1-B in Part 1 & Model 2-B in Part 2

Part 1 and Part 2 of this study present both main effects and interaction models. A few ground rules must be established for the interaction models entailing the use of constitutive terms and methods of managing multicollinearity due to the inclusion of interacting variables.

Constitutive Terms

It must be expressed that interaction models in this study include all constitutive terms. Constitutive terms are "the elements that constitute the interaction term" (Brambor, Clark & Golder 2006). This means that in a model $\hat{Y} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_1 X_2$, if interaction is found for $\beta_3 X_1 X_2$ then both $\beta_1 X_1$ and $\beta_2 X_2$ must remain in the model even if these constitutive terms are not statistically significant (Cortina 1993, Sincich 2004, Jaccard & Turrisi 2003, Brambor, Clark & Golder 2006).

Managing Multicollinearity in Interaction Models

Numerous studies have been done where multicollinearity was incorrectly managed by excluding certain constitutive terms in interaction models. Brambor, Clark & Golder (2006) have admonished researchers that constitutive terms must always be included in regression models except in very rare circumstances.

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As will be shown under model results for Part 1 (Chapter 7), multicollinearity, though not a problem in the main effects models in this study, had to be managed in the interaction model in Part 1, Model 1-B. Multicollinearity often accompanies interacting variables even when it is not problematic in the main effects model (Cortina 1993). "The product term $(X_1 X_2)$ is an exact nonlinear function of the constituent variables (X_1 and X_2), thus correlations of the constituent variables with the product term are usually high" (Cortina 1993).

As just mentioned it is unsound to manage multicollinearity by eliminating constitutive terms or by avoiding interaction altogether (Brambor, Clark & Golder 2006). "High multicollinearity simply means that there is not enough information in the data to estimate the model parameters accurately, and the standard errors accurately reflect this" (Brambor, Clark & Golder 2006). In a multiplicative interaction model what is of direct interest is not the significance of the model parameters per se, but the *marginal effect* of X on Y. So the standard error of interest corresponds to the marginal effect also, not the standard error of the parameter estimate (Brambor, Clark & Golder 2006, Jaccard & Turrisi 2003).

For interaction models affected by multicollinearity, Brambor, Clark & Golder (2006) have recommended certain data transformations that may be helpful in model interpretation. For the models in this study several transformations were used, such as natural logs and centering variables, but z-scores were found to be the most useful. The use of z-scores helped to deflate variance inflation and provided better comprehension of interacting variables and marginal effects. The use of z-score transformations for certain continuous variables in Part 1 are discussed in chapters 5 & 7.

Variance inflation factors (VIF) are an effective and convenient method for assessing multicollinearity and is reported with each model in this study. Other methods were also used in evaluating multicollinearity and are presented in parts 1 & 2 in the discussion on regression diagnostics in chapters 7 & 8.

Chapter 5

Research Methods - Model Development for Part 1

Descriptive Statistics for Continuous Variables Used in Part 1

The preliminary analysis begins with a review of descriptive statistics of the continuous variables to be used in model development for Part 1. Listed in Table 10 are the dependent variable, the TATL ratio, and independent variables, orthopedic and cardiac group procedure percentages per hospital.

Table 10
Descriptive Statistics for Continuous Variables used in Part 1, Models 1-A & 1-B

Variable	Mean	Standard Deviation	Minimum	Maximum
TATL Ratio	4.000	4.530	0.263	31.569
Cardiac Group Procedures	1.127%	2.208%	0.00%	15.408%
Orthopedic Group Procedures	2.126%	1.772%	0.00%	11.750%

According to Table 10, the TATL ratio has a mean of 4.000 with a standard deviation of 4.530. The TATL ratio has a minimum value of 0.263 and a maximum value of 31.569.   The percentage of cardiac group procedures shows a mean average of 1.127% with a standard deviation of 2.208%. The percentages of cardiac group procedures performed in Florida hospitals range from zero percent (no cardiac group procedures performed in the hospital) to 15.408%.   Orthopedic group procedures show a

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mean of 2.126% and standard deviation of 1.772% and range from zero percent (no orthopedic group procedures performed in the hospital) to 11.750%.

Preliminary Analysis for Part 1

A major criticism of many studies levied by Bagley White & Golomb (2001) was the lack of preliminary analyses preceding model development such as nonparametric and bivariate tests to determine the directions and magnitudes of variables. The problem with insufficient preliminary analyses is that variables may be employed in models based on the visceral *intuition* of the researcher rather than a factual comprehension of the data.

In an effort to avoid this type of criticism, several preliminary tests were used as precursors to the development of a regression model. These tests were used to establish a secure foundation for selecting independent variables, assuring model validity, and generating more confidence in the findings from the models. The preliminary analysis began with a review of contingency tables.

Before contingency tables could be created certain continuous variables had to be converted to dichotomies. This required the assignment of breakpoints to identify high vs. low levels. As already discussed, the breakpoint for the TATL ratio was set at 5/8Q. Breakpoints for both cardiac and orthopedic group procedures were determined to be at 0.75Z (three quarters of one standard deviation above the mean of z = 0). Recall that earlier it was discussed that these variables had been converted to percentages per hospital which had then been transformed to z-scores.

Table 11 shows results of contingency tables testing the association between the TATL ratio and the two chief explanatory variables, cardiac group procedures and orthopedic group procedures.

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Table 11
2x2 Contingency Tables for TATL Ratio & Discretionary Procedures Reimbursed by Conventional Medicare, 2000-2005

Variables	Odds Ratio & CI	Chi-Square (p-value)
Cardiac Procedures Group (0.75Z) x TATL (5/8Q)	$1.41 \leq 2.03 \leq 2.92$	15.09 (0.0001)
Orthopedic Procedures Group (0.75Z) x TATL (5/8Q)	$1.08 \leq 1.51 \leq 2.12$	5.72 (0.017)

- TATL (5/8Q): TATL breakpoint $\geq$ 5/8Q for the TATL distribution for all hospitals.
- Orthopedic Procedures Group (0.75Z): Orthopedic Procedures Group Z-Score $\geq$ 0.75 = 1; else = 0
- Cardiac Procedures Group (0.75Z): Cardiac Procedures Group Z-Score $\geq$ 0.75 = 1; else = 0

The association between the TATL ratio and cardiac group procedures is indicated via an odds ratio of 2.03 (p < 0.0001). The odds ratio for orthopedic group procedures is 1.51 (p < 0.0017) with the lower end of the confidence limit down to 1.08, indicating fairly weak association.   Although the magnitude of association between the TATL ratio and orthopedic group procedures is shown to be low in Table 11, association was later shown to be higher between the TATL ratio and the interacting variable of ownership and orthopedic group procedures.

Examinations of Potential Control Variables for Part 1

Other factors aside from cardiac & orthopedic group procedures may help explain rises or declines in the TATL ratio. The literature review cites several authors who argue that profitability and long term financial strength represented by high TATL ratios should be credited to good management more than any other factor. Two factors that are associated with both good management and long term financial health are hospital ownership and geographic location (defined as $\geq$ 5/8Q median-county income in the distribution of 67 Florida counties).

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Contingency table analysis was used to test each control variable and its association to the TATL ratio.   Results of the analyses are shown in Table 12.

Table 12
2x2 Contingency Tables for TATL Ratio & Hospital Ownership, Geographic Location, 2000-2005

Variables	Odds Ratio & CI	Chi-Square (p-value)
Ownership x TATL (5/8Q)	$5.42 \leq 7.50 \leq 10.40$	165.96 (0.0001)
Geographic location (county median income $\geq$ 5/8Q) x TATL (5/8Q)	$1.06 \leq 1.42 \leq 1.90$	5.55 (0.0194)

- TATL (5/8Q): TATL breakpoint $\geq$ 5/8 Q for the TATL distribution for all hospitals.
- Ownership: Investor Owned Hospital = 1; else = 0
- Geographic location (5/8Q): County Median Income Breakpoint $\geq$ 5/8Q for the median income distribution for 67 Florida counties; County Median Income $\geq$ 5/8Q = 1; else = 0.

Ownership shows the greatest association with the TATL ratio demonstrated by an odds ratio = 7.50 (p < 0.0001). The odds ratio for geographic location, represented by high ($\geq$ 5/8Q) vs. low Florida county median income levels, shows a lower odds ratio of 1.42 with the lower bounds of the CI at 1.06. Geographic location is not as strong of a variable as ownership, but later the analysis will show it to be more useful as an interacting variable.

Pretesting for Interaction Using the Breslow-Day Test

In this study potential interaction was assessed in preliminary analyses and then incorporated into hypotheses preceding model development. This practice adhered partly to criticisms imposed by Bagley White & Golomb (2001) and warnings by Louis (2008).

Bagley White & Golomb have been critical of researchers who do not test for interaction in their models, even when such testing is warranted. Louis warned against the cavalier addition of interaction terms to final models and strongly recommends that

interacting variables should be represented in hypotheses after being detected in preliminary analyses.

Louis' (2008) rationale to include interacting variables judiciously and based on careful preliminary examination is because interacting variables have less power than main effects variables, and as already mentioned often result in problems with multicollinearity. Interactions are also vulnerable to outlier effects, and the higher-order the interaction the more distorting the outlier can be.

To circumvent possible criticisms that could be levied against the methods employed in this investigation, the potential presence of interaction was explored thoroughly before incorporating interacting variables in hypotheses and placing them in regression models.

Breslow Day tests were examined for stratified tables to test the potential presence of interaction between variables in their association with the TATL ratio.   The Breslow-Day test is used to assess homogeneity between the odds ratios in stratified contingency tests (Agresti 1999, Stokes, Davis & Kock 2003). Interacting variables identified by the Breslow Day test may be used to generate hypotheses for interaction occurring in model development (Schwartz 2004).

Results of the Breslow-Day tests and Cochran Mantell Henzell (CMH) odds ratios are shown in Table 13. Bear in mind that the most useful information on the table is the results of the Breslow Day tests. The CMH odds ratio is not so useful because it is usually recommended to calculate odds ratios for separate tables when the Breslow Day test indicates that interaction is present.

Table 13

Breslow Day Tests to Assess Interaction using 2x2 Contingency Tables & Stratified Analysis, 2000-2005

Variables	CMH & CI	Chi-Square (p-value)	Breslow Day (p-value)
Ownership x TATL (2.5Q) controlling for Geographic location (5/8Q)	$5.25 \leq 7.24 \leq 10.01$	165.54 (0.0001)	13.81 (0.0002)
Orthopedic Group Procedures x TATL (5/8Q) controlling for ownership	$1.12 \leq 1.68 \leq 2.49$	6.01 (0.0142)	21.92 (0.0001)
Cardiac Group Procedures x TATL (5/8Q) controlling for Ownership	$1.42 \leq 2.18 \leq 3.32$	12.32 (0.0004)	8.46 (0.0036)

Ownership: Investor Owned Hospital = 1; else = 0
Orthopedic Group Procedures (0.75Z): Orthopedic Group Procedures Z-Score $\geq 0.75 = 1$; else = 0.
Cardiac Group Procedures (0.75Z): Cardiac Group Procedures Z-Score $\geq 0.75 = 1$; else = 0.
Geographic location (5/8Q): County Median Income Breakpoint $\geq 5/8Q$ for the median income distribution for 67 Florida counties; County Median Income $\geq 5/8Q = 1$; else = 0.

Results in Table 13 indicate a low p-value (0.0002) for the Breslow-Day test for ownership and TATL ratio controlling for geographic location. This may indicate two-way interaction between ownership and geographic location.

Findings also suggest there is interaction between orthopedic group procedures and ownership in their association with the TATL ratio (Breslow-Day = 21.92, p < 0.0001) as well as cardiac group procedures and ownership (Breslow-Day = 8.46, p < 0.0036).

These findings present a sound basis to incorporate these interacting terms in model development.

Correlation Matrices

A follow-up method is used to buttress findings from contingency tables regarding the variable ownership and orthopedic and cardiac group procedure variables. A correlation matrix to determine magnitudes of association between the TATL ratio and each variable, stratified by ownership is shown in Table 14.

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	Pearson Coefficients-Association with TATL		Spearman Coefficients-Association with TATL	
TATL	Investor Owned	Not-for-Profit	Investor Owned	Not-for-Profit
Cardiac Group Procedures	0.331 <.0001	-0.00298 0.9474	0.442 0.0001	0.04714 0.2957
Orthopedic Group Procedures	0.466 <.0001	-0.02875 0.5238	0.497 0.0001	-0.00122 0.9783

For each variable listed, whether the association is assessed by Pearson linear or Spearman ordinal (via rankings) correlations, the coefficients show a significant association under the investor owned stratum. A Pearson coefficient of 0.331 (p < 0.0001) and Spearman coefficient of 0.442 (p < 0.0001) are shown for the association between the TATL ratio and cardiac group procedures. Pearson and Spearman show, respectively, coefficients of 0.466 (p < 0.0001) and 0.497 (p < 0.0001) for the association between the TATL ratio and orthopedic group procedures.

No significant association is found using the Pearson or Spearman correlation matrices between the TATL ratio and either of the cardiac or orthopedic group procedure variables in the not-for-profit category.

Comparison of Discretionary Procedure Mean Percentages

Cardiac and orthopedic group procedures, reimbursed by conventional Medicare represent small percentages per hospital. Keep in mind that the denominator in the percentage calculation is *total* procedures per hospital under *all* payment sources. This is very large compared to the numerator of cardiac or orthopedic group procedures reimbursed only by conventional Medicare.

But even though percentages of cardiac and orthopedic procedures are small, they are still significantly different with respect to hospital ownership and TATL ratio.

An additional test was performed to compare the mean percentages of cardiac and orthopedic procedures based on ownership and TATL ratio.

The ownership variable and TATL variable were combined to form a special variable to represent *investor owned hospitals with TATL ratios $\geq 5/8Q$.* This variable was formed so t-tests could be carried out to compare the means of cardiac group procedure percentages and orthopedic group procedure percentages between investor owned hospitals with TATL ratios $\geq 5/8Q$ vs. all other hospitals (i.e., all not-for-profit hospitals and investor owned hospitals with TATL ratios $< 5/8Q$).

The results of the tests are shown in Table 15

Table 15
Mean Percentage Differences between Investor Owned Hospitals with High TATL Ratios and All Other Hospitals, Cardiac & Orthopedic Group Procedures, Reimbursed by Conventional Medicare, 2000-2005

Discretionary Procedures	Investor Owned, TATL ratios $\geq 5/8Q$	All Other Hospitals	t-test (p-value)
Cardiac Group Procedures	1.6%	0.9%	3.48 (0.0006)
Orthopedic Group Procedures	2.67%	1.95%	5.23 (0.0001)

Means for cardiac group procedures for investor owned hospitals with TATL ratios $\geq 5/8Q$ vs. all other hospitals is 1.6% and 0.9%, respectively. A Swaitherwhite t-test was performed (i.e., the folded F-test indicated unequal variances, $p < 0.0001$, so a pooled t-test was not used) and yielded t = 3.48 (p = 0.0006).

This indicates that mean percentages of cardiac group procedures are significantly higher in investor owned hospitals with high TATL ratios vs. all other hospitals (not-for-

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profit hospitals with high and low TATL ratios and investor owned hospitals with TATL< 5/8Q).

Mean percentages of orthopedic group procedures for investor owned hospitals with TATL ratios ≥ 5/8Q vs. all other hospitals were 2.67% and 1.95%. A pooled t-test was performed (i.e., the folded F-test did not indicate unequal variances, $p < 0.8858$) and yielded $t = 5.23$ ($p < 0.0001$). This indicates that mean percentages of orthopedic group procedures are significantly higher in investor owned hospitals with high TATL ratios vs. all other hospitals (total not-for-profit hospitals with high and low TATL ratios and investor owned hospitals with TATL< 5/8Q).

Statements of Hypotheses for Part 1

Now that the data structure, parameters, variables, DRG selection criteria, and preliminary analyses have been described, hypotheses can be delineated.

Several hypotheses were formulated in connection with the research objectives and preliminary analyses presented in Part 1. Hypotheses for Part 1 addressing the association between the TATL ratio and cardiac and orthopedic group procedures financed by conventional Medicare are written as follows:

1) There is a statistically significant positive association between the continuous dependent variable TATL ratio and ownership, controlling for other variables which may also be associated with the TATL ratio.
2) There is a statistically significant positive association between the continuous dependent variable TATL ratio and the two-way interaction term of ownership and *cardiac* group procedures, controlling for other variables which may also be associated with the TATL ratio.
3) There is a statistically significant positive association between the continuous dependent variable TATL ratio and the two-way interaction term of ownership and *orthopedic* group procedures, controlling for other variables which may also be associated with the TATL ratio.

4) There is a statistically significant positive association between the continuous dependent variable TATL ratio and the two-way interaction term of ownership and geographic location, controlling for other variables which may also be associated with the TATL ratio.

   These hypotheses include interacting variables, so it is assumed that all pertinent main effects and constitutive terms will remain in the model.

Now that hypotheses for Part 1 have been delineated they will be tested via regression models which are reported in a discussion on model results for Part 1 in Chapter 7. Preceding the testing of hypotheses and model results for Part 1 is a discussion on model development for Part 2 which is provided in Chapter 6.

Chapter 6

Research Methods - Model Development for Part 2

Preliminary Analysis for Part 2

The discussion of research methods now shifts from an examination of volumes and percentages of discretionary procedures reimbursed by conventional Medicare to an investigation of total charges for certain discretionary procedures reimbursed by Medicare HMO.

The population parameter for Part 1 was investor owned and not-for-profit Florida acute care general hospitals reimbursed by conventional Medicare, 2000-2005. One of two population parameters for Part 2 is patient discharge cases in acute care general hospitals reimbursed by Medicare HMO, 2000-2005. A second population parameter in Part 2 is defined by two discretionary procedures, CABG and valve replacements, of which are discussed more fully later in this chapter.

Part 2 of the analysis will test the association between total charges, as a continuous dependent variable and the dichotomous independent variable hospital ownership. The analysis will address the question as to whether investor owned hospitals charge significantly greater amounts for the same DRG codes and extent of medical services than their not-for-profit counterparts.

Wennberg's surgical signature theory was discussed in the literature review and refers to the geographic variability not only of the prevalence of Medicare reimbursed discretionary procedures, but also of Medicare spending levels that cannot be explained by the disease status of the population or the extent of medical services provided.

One of the objectives of Part 2 is to determine if investor owned hospitals, as well as not-for-profits, assess significantly higher charges under the Medicare HMO program in the context of Wennberg's surgical signature theory. This should address the question if investor owned hospitals charge more for the same services, and if these charges increase disproportionately by geographic area.

The analysis of total charges in Part 2 began, just as it had in Part 1, with a review of *discretionary* procedures represented by DRG codes from Appendix 1. Part 2 imposed the same criteria of selecting DRG codes that could be defined as discretionary based on clinical and geographic (variability) grounds. As it turned out the same DRG codes that were determined to be important for the study under conventional Medicare in Part 1 were also found to be useful in the study of total charges under Medicare HMO in Part 2.

Just as it was in Part 1, model development in Part 2 is preceded by a review of descriptive statistics and extensive bivariate and nonparametric analyses to develop strong groundwork for the selection of variables and structuring of models.

Descriptive Statistics for Continuous Variables Used in Part 2

The preliminary analysis for Part 2 begins with a review of descriptive statistics of the continuous variables that will be used in model development for Part 2. Listed in Table 16 is the dependent variable, patient charges, and independent variable LOS.

Table 16
Descriptive Statistics for Continuous Variables used in Part 2

Variable	Mean	Standard Deviation	Minimum	Maximum
Patient Charges	$102,488	63,696	3,744	810,610
Length of Stay (LOS)	10.327	6.360	1.0	92.0

The table shows that mean patient charges are $102,488 with a standard deviation of $63,696. This variable has a very broad range with a minimum of $3,744 and maximum of $810,610. Mean days of hospitalization is 10.327 days with a standard deviation of 6.360 days. Minimum LOS is one day with a maximum of 92.0 days.

It was surprising that the minimum value for LOS was one day, as it was thought that the minimum value may be higher. Upon closer examination it was found that 33 observations had LOS equal to one day. Of these observations, three were discharged to home care under the supervision of a home healthcare organization while the others were discharged to home without further supervision.

As the preliminary analysis ensues more information will be provided about these two variables. Additional information forthcoming will be even more meaningful because it will show patient charges and LOS stratified by hospital ownership and procedures (i.e., CABG vs. valve replacements).

Selection of DRG Codes for Part 2

Analysis of Mean Charges for DRG Codes Reimbursed by Medicare HMO

The selection of DRG codes entailed a review of differences of mean total charges between investor owned and not-for-profit facilities. An examination of these differences in mean charges is shown in Table 17 using percentage changes and t-tests. Two of the t-tests shown in the table are pooled t-tests, but all others are Satterthwaite t-

tests. The Satterthwaite t-test was used for tests where the significant folded F-test indicated unequal variances.

Before reviewing the table, it should be pointed out that any reader familiar with hospital reimbursement amounts under Medicare (conventional or HMO) will find these amounts excessive. What is actually reimbursed under Medicare HMO tends to be only a fraction of total patient charges. Reimbursement levels are also important because they, not charges, represent actual amounts of federal spending. Therefore, levels of reimbursement under Medicare HMO will be addressed in model development for Part 2 in Chapter 8. But keep in mind that the focus of Part 2's investigation is on total patient charges, and the inconsistencies in charging patterns based on hospital ownership and geography. Table 17 is now presented below.

Table 17
Analysis of Mean Total Charges for Selected Medicare HMO Procedures by Ownership, 2000-2005

Procedure	Investor Owned	Not-for-Profit	Differences Actual (%)	t-test (P values)
Valve Replacement	168,685	114,004	54,681 (48.0%)	17.89 (0.0001)
CABG	126,402	81,734	44,668 (54.7%)	33.01 (0.0001)
PCI	57,233	42,980	14,253 (33.2%)	32.27 (0.0001)
Joint & Limb	47,134	34,899	12,235 (35.1%)	35.85 (0.0001)
Hip & Femur	39,324	29,216	10,108 (34.6%)	20.63 (0.0001)
Spinal Fusion	62,567	58,861	3,706 (6.3%)	1.77 (0.0764)
Knee Procedures	53,734	43,727	10,007 (22.9%)	5.86* (0.0001)
Prostatectomy	20,317	14,935	5,382 (36.0%)	10.73 (0.0001)
Mastectomy	21,408	15,439	5,969 (38.7%)	10.50* (0.0001)

Pooled t-tests where variances are equal. All other tests were Swaitherwaite t-tests, as Folded F-tests showed that variances of total charges between investor owned and not-for-profit hospitals were found to be unequal.

With the exception of spinal fusion (t = 1.77, p = 0.0764), results of t-tests indicate that investor owned facilities assess total charges for each procedure significantly higher than their not-for-profit counterparts. Percentage differences for each of the means of CABG and valve procedures respectively are approximately 48.0% & 54.7% greater. For PCI, investor owned hospitals charge about 33.2% more than not-for-profits.

Investor owned hospitals charge between 34% & 39% more for joint & limb procedures, hip & femur procedures, prostitectomies, and mastectomies, and 23% more for knee procedures.

Large as well as statistically significant differences for mean charges between investor owned and not-for-profit facilities provide a strong basis for using these procedures in model development for total charges.

Selection of CABG & Valve Replacements as Population Parameters

It has already been stated that population parameters for models in Part 2 are patients treated with CABG and valve replacement procedures under Medicare HMO, 2000-2005.

It should be addressed why CABG and valve procedures were selected as population parameters and not the other discretionary procedures listed back on Table 17. These procedures were chosen because they best adhered to research criteria regarding DRG code selection. They show the highest dollar amounts for total patient charges, and the highest percentage differences between investor owned and not-for-profit hospitals.

Consequently, CABG (DRG codes 106, 107, 109, 547, 548, 549, 550) and valve replacement procedures (DRG codes 104, 105), reimbursed by Medicare HMO, 2000-

2005, represent population parameters, and procedures performed under these DRG codes will populate the dataset for analyses in Part 2.

Review & Selection of Potential Covariates

Model development will feature ownership as the explanatory variable. Just as in Part 1, models in Part 2 need to control for factors that in addition to ownership are associated with the dependent variable, total charges.

After a review of preliminary analyses, the selection of covariates included LOS and geographic sector. LOS is a continuous variable while geographic sector is a dichotomy representing the south region vs. the combined north & central regions, with north and central regions as the base level.

Controlling for Patient Disease Severity

LOS and multiple diagnoses were both considered as covariates because they represent measures of patient severity. Total patient charges will increase corresponding to additional days of hospitalization or in connection with greater numbers of secondary diagnoses. There was a problem using both variables in the same model because they are each associated with charges and with each other. Because these variables are related and redundant, a determination had to be made to select the variable that had the strongest correlation with total charges.

To do this, a correlation matrix was created using total charges, LOS, and multiple diagnoses. The results are shown below in Table 18.

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Table 18

Pearson & Spearman Correlation Coefficients, Associations between Total Charges & Potential Variables for Model Development, 2000-2005

	Total Patient Charges Pearson (p-value) Spearman (p-value)	**LOS** Pearson (p-value) Spearman (p-value)	**Multiple Diagnoses** Pearson (p-value) Spearman (p-value)
Total Patient Charges			
Pearson (p-value)	1.00	0.648 (0.0001)	0.331 (0.0001)
Spearman (p-value)	1.00	0.550 (0.0001)	0.390 (0.0001)
LOS			
Pearson (p-value)	0.648 (0.0001)	1.00	0.376 (0.0001)
Spearman (p-value)	0.550 (0.0001)	1.00	0.482 (0.0001)
Multiple Diagnoses			
Pearson (p-value)	0.331 (0.0001)	0.376 (0.0001)	1.00
Spearman (p-value)	0.390 (0.0001)	0.482 (0.0001)	1.00

Not surprisingly, the Pearson correlation coefficient for LOS is very high at 0.648 ($p < 0.0001$) for the linear association between charges and LOS. The association between ordinal rankings using the Spearman correlation coefficient is 0.550 ($p < 0.0001$).

The linear association between charges and multiple diagnoses is also fairly high at 0.331 with ordinal (rankings) association even higher at 0.390($p < 0.0001$). Although the coefficients for multiple diagnoses are high, they are still not nearly as high as LOS.

What is also noticeable, and as previously discussed, is the association between LOS and multiple diagnoses, Pearson = 0.376 ($p < 0.0001$) and Spearman = 0.482 ($p < 0.0001$) indicating high association between these two covariates.

Ultimately, LOS was selected as the covariate in model development because it demonstrated much higher correlation with total patient charges.

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Charges per Hospital Day

The mean average LOS for CABG procedures is 9.907 days with a standard deviation of 5.816 days. There is a minimum of two days and a maximum of 92 days. Valve procedures show a mean average of 11.404 days with a standard deviation of 7.47 days, a minimum of one day and a maximum of 71 days.

Investor owned hospitals show a higher mean LOS for CABG procedures of 10.113 days, while not-for-profits show a mean of 9.806 days. Investor owned hospitals also show slightly higher mean average LOS for valve replacement procedures. Not-for-profits show a mean of 11.308 days, and investor owned hospitals show a mean of 11.644 days.

What is different between investor owned hospitals and not-for-profits with respect to LOS is charges per day of hospitalization. LOS and total charges were used to calculate total charges per patient day for valve replacements and CABG procedures, stratified by ownership (i.e., total charges ÷ total days of hospitalization), which is presented in Table 19.

Table 19
Charges Per Patient Day - Valve Replacement & CABG Procedures, Investor Owned vs. Not-for-Profit Hospitals, Medicare HMO, 2000-2005

Charges/LOS	Valve Replacements		CABG	
	Investor Owned	Not-for-Profit	Investor Owned	Not-for-Profit
Mean Charges/LOS	$18,143	$12,515	$13,526	$9,246
Standard Deviation	$17,730	$11,529	$5,820	$6,129
Coefficient of Variation	0.98	0.92	0.43	0.66

Mean charges per patient day for valve replacements in investor-owned hospitals is $18,143 compared to $12,515 in not-for-profits. Average charges per patient day in

investor owned hospitals are $13,526 for CABG procedures compared to $9,246 in not-for-profit hospitals.

The preliminary findings in Table 19 indicate that higher mean total patient charges by investor owned hospitals are not due to higher average LOS. A similar table (not shown) was constructed for mean total patient charges by numbers of secondary diagnoses. It was found that mean total patient charges were also much higher for each diagnostic level for investor owned hospitals. This indicates that mean higher charges are not due to investor owned hospitals caring for sicker patients (i.e., those with higher numbers of secondary diagnoses).

Geographic Region (Florida Inspection Area)

As already mentioned, the geographic region variable was collapsed from a three-level to a dichotomous variable where combined north and central regions represent the base level. However, it is still useful to review the disparities in charges between each region.

Geographic region turned out to be a very important variable because it was found that total charges for valve replacement and CABG procedures differ significantly with respect to geographic sector. Figure 4 is a Pareto chart showing mean charges on the left y-axis and volumes on the right y-axis.
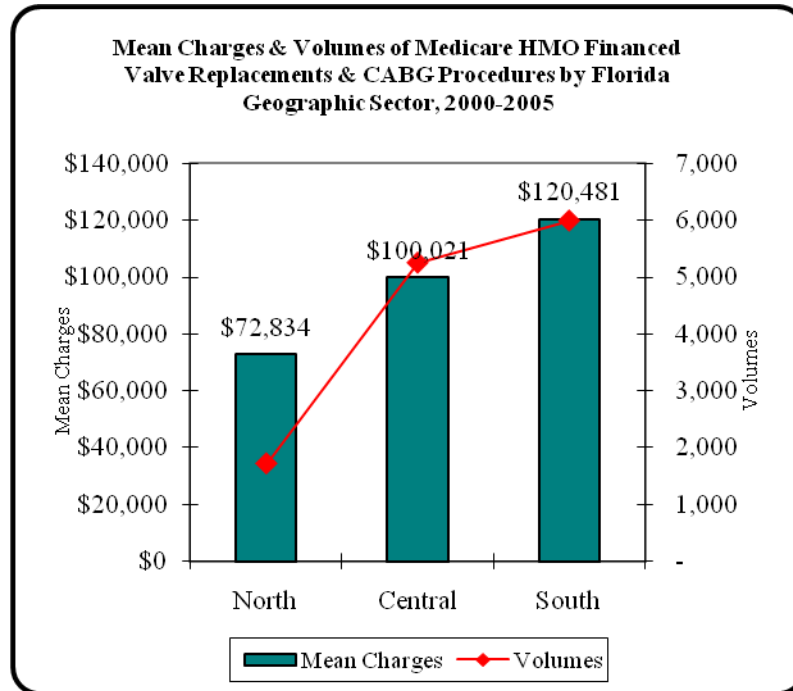
Figure 4
Source: AHCA Patient Discharge Dataset, 2000-2005

Mean charges, covering years 2000-2005, for valve replacement and CABG procedures run $72,834 in North Florida while they are $100,021 in central Florida and over 120,000 in south Florida.

Volumes also differ with respect to geographic sector, as there are around 2,000 valve replacement and CABG procedures performed in north Florida, over 5,000 in central, and a little over 6,000 in south Florida.

Figures 5 and 6 are also Pareto charts showing mean charges and volumes by sector for each individual procedure. These two charts report the same information as Figure 4, but charges are broken down separately for CABG and valve procedures.
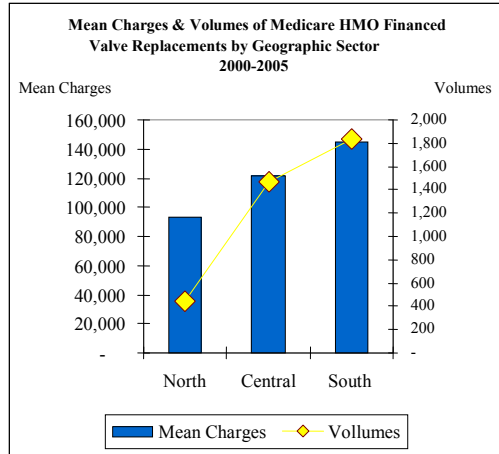
Figure 5
Source: AHCA Patient Discharge Dataset, 2000-2005
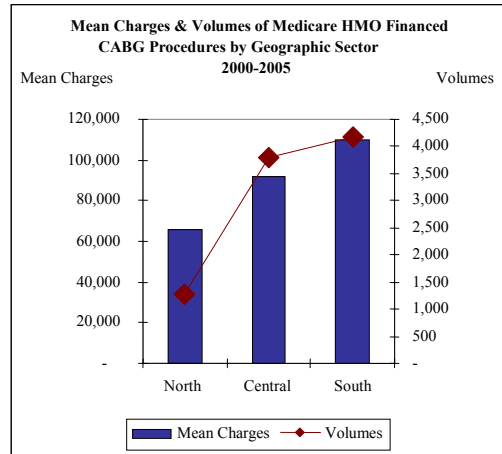
Figure 6
Source: AHCA Patient Discharge Dataset, 2000-2005

Differences in mean charges as well as volumes by geographic sector are consistent with Wennberg's surgical signature theory. Recall that a certain aspect of this theory, discussed in the literature review, is that certain types of discretionary procedures and related federal spending significantly differ by geographic region with no link to disease status of the population. It is possible that differences in volumes and patient charges, shown in figures 5 and 6, are consistent with the surgical signature theory.

It has been demonstrated so far that patient charges are broadly variable with respect to hospital ownership and geography. Figure 7 now shows a comparison of Medicare HMO total patient CABG and valve replacement charges by geographic region, stratified by ownership.

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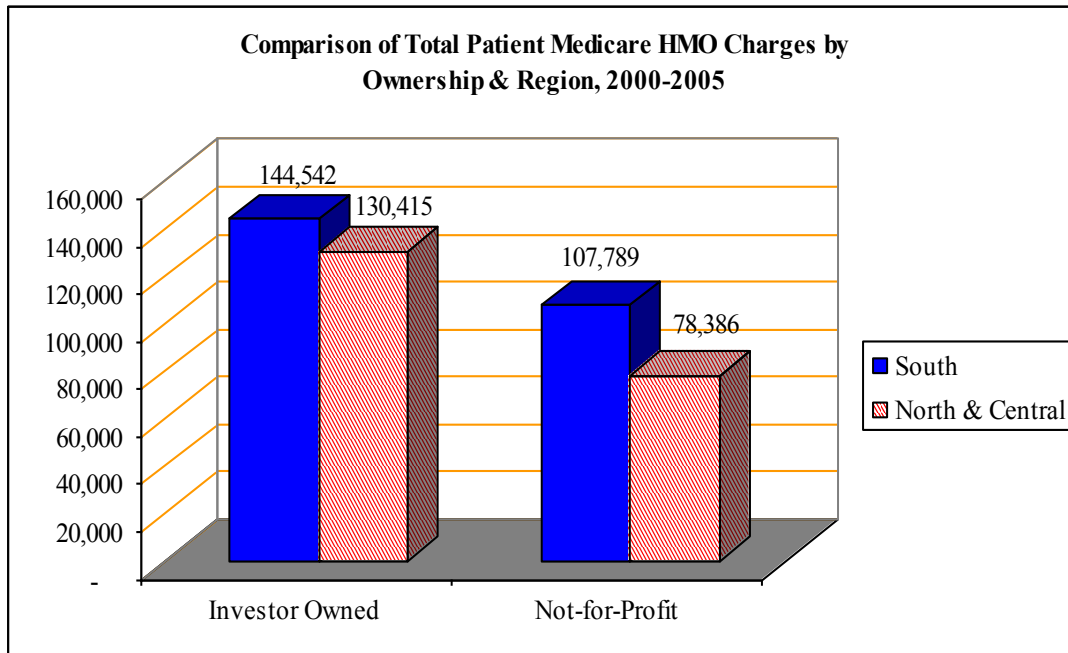
Figure 7
Source: AHCA Discharge Dataset, 2000-2005

It appears from this chart that investor owned hospitals are not the only ones increasing Medicare HMO charges in certain regions of Florida. Though not as high as investor owned hospitals, southern Florida not-for-profits also assess higher CABG and valve replacement charges relative to not-for-profits in the north and central regions.

Total patient charges increase by approximately $14,000 (10.8%) between the south geographic region and other regions for investor owned hospitals. But not-for-profits increase charges in general by almost $30,000 (37.5%) for procedures occurring in hospitals located in the southern regions vs. those in the central and northern regions.

Contingency Tables

Similar to methods used in Part 1, covariates were also tested using contingency tables in Part 2. For total charges to be used in the contingency table it had to be converted from a continuous to a categorical variable. As discussed under "Independent & Dependent Variables for Part 2," the breakpoint to dichotomize high vs. low total

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patient charges is 5/8Q, half the distance between the second and third quartile in the distribution of total charges. Results of the first contingency table analyses are shown in Table 20. These tables are used to test the association between total charges and ownership and total charges and south geographic region.

Table 20
2x2 Contingency Table Analysis for Total Charges and Ownership &
Geographic Region, Medicare HMO Financed Valve Replacement & CABG
Procedures, 2000-2005

Variables	**Odds Ratio & CI**	**Chi-Square (p-value)**
Ownership x Total Patient Charges	$3.35 \leq 3.67 \leq 3.99$	913.94 (< 0.0001)
South Geographic Region x Total Patient Charges	$1.67 \leq 1.83 \leq 1.99$	201.53 (< 0.0001)

- Ownership: Investor owned hospital = 1; Not-for-profit= 0.
- Total Patient Charges: High total charges $\geq$ 5/8Q; Low total Charges < 5/8Q
- South Geographic Sector: South = 1; Central or North = 0

The association between ownership and total charges shows an odds ratio of 3.67 ($p < 0.0001$) indicating that the odds of total charges amounting to $\geq$ 5/8Q is 3.67 times greater in investor owned hospitals relative to not-for-profits. Another odds ratio, 1.83 (p < 0.0001) is then observed between total patient charges and south geographic region. The odds of a south county hospital assessing charges $\geq$ 5/8Q is 1.83 times the odds of charges being assessed at $\geq$ 5/8Q for hospitals in a north or central region.

These odds ratios demonstrate a positive association between total charges and ownership and total charges and south geographic region. This indicates that ownership and geographic region will be sound variables in model development.

Homogeneity of the Odds Ratios

As in Part 1, contingency tables are again used to pre-test the presence of interaction for the model development stage. This is done via stratifying the analysis and then testing for the homogeneity of the odds ratio via a Breslow-Day test. Table 21

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presents results of stratified contingency table analysis. As stated in Part 1, it is the

Breslow Day test that is the most meaningful information on the table, as it is often

advisable to calculate a separate odds ratio for each table when interaction is present.

Table 21
Breslow Day Test to Assess Interaction using a 2x2 Contingency Stratified Table,
CABG & Valve Replacements Financed by Medicare HMO, 2000-2005

Variables	CMH & CI	Chi-Square (p-value)	Breslow Day (p-value)
Ownership x Total Charges controlling for South Geographic Sector	$3.26 \leq 3.56 \leq 3.86$	872.46 (< 0.0001)	36.98 (0.0001)

The table shows results of the contingency table testing the association between

total patient charges and south geographic sector controlling for ownership. A Breslow

Day test value of 36.98 (p = 0.0001) indicates the presence of interaction between

ownership and south geographic region. It provides sound rationale to test the interaction

of these two variables in model development.

Statements Hypotheses for Part 2

Now that the preliminary analyses have been completed, hypotheses will be stated

for Part 2 which addresses charges for CABG and valve replacement procedures financed

by Medicare HMO. These hypotheses are written as follows.

1) There is a statistically significant positive relationship between the continuous
   dependent variable, total patient charges and LOS for CABG and valve
   replacement procedures reimbursed by Medicare HMO, 2000-2005,
   controlling for other variables which may also be associated with total patient
   charges.
2) There is a statistically significant positive relationship between the continuous
   dependent variable, total patient charges and ownership for CABG and valve
   replacement procedures reimbursed by Medicare HMO, 2000-2005,
   controlling for other variables which may also be associated with total patient
   charges.
3) There is a statistically significant positive relationship between the continuous
   dependent variable, total patient charges and geographic sector for CABG and
   valve replacement procedures reimbursed by Medicare HMO, 2000-2005,

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controlling for other variables which may also be associated with total patient charges.

4) There is a statistically significant positive relationship between the continuous dependent variable, total patient charges and the two-way interaction term for ownership and geographic sector for CABG and valve replacement procedures reimbursed by Medicare HMO, 2000-2005, controlling for other variables which may also be associated with total patient charges.

Now that hypotheses for Part 2 have been delineated they will be tested via regression models of which will be presented in Chapter 8. Prior to the discussion on model results for Part 2 is a presentation on model results for Part 1 which is provided in Chapter 7.

Chapter 7

Model Results for Part 1
Testing the Association between the TATL Ratio and Discretionary Procedures
(Reimbursed by Conventional Medicare)

Organization of Model Findings

Model results for Part 1 will feature Model 1-A, a main effects model and Model

1-B, an interaction model. The presentation of model findings is followed by a

discussion on regression diagnostics for Model 1-B.

Model 1-A: Main Effects Model

Crude estimates indicated that investor owned hospitals with high TATL ratios

carry out certain discretionary cardiac and orthopedic group procedures reimbursed by

conventional Medicare at higher rates (not volumes) than other hospitals. This will now

be further tested in the development of Model 1-A which contains the covariates

discussed in Chapter 3. Model 1-A, a main effects MLS model is expressed as follows:

Regression Equation for Model 1-A

$$\hat{y}_{TATL} = \beta_0 + \beta_1 X + \beta_2 P + \beta_3 C + \beta_4 R + \epsilon$$

Where: X = Ownership
P = Geographic location
C = Z-Cardiac Group Procedures
R = Z-Orthopedic Group Procedures

Model 1-A was employed, and an examination of initial findings is shown below

in Table 22.

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Table 22
Model 1-A: Main Effects Model

Source	DF	Sum of Squares	Mean Square	F-Value	Pr>F
Model	4	5,647	1,411.8	91.28	<0.0001
Error	886	13,703	15.46		
Corrected Total	890	19,351			
Root MSE	3.93				
Dependent Mean	3.93		R^2	0.2918	
CV	100.12		Adjusted R^2	0.2886	

The main effects model shows a global F test of 91.28 (p < 0.0001) indicating that the parameter estimate of at least one variable in the model is significant.

Findings also show a dependent mean, 3.93 equaling the mean average of the TATL ratio for all observations of the dependent variable. The *(textbook)* ideal for the CV in the regression output is 10.0 (Sincich 2004). Regressions using *real world* data rarely derive a CV of 10.0, but Model 1-A's CV of 100.12 is high even for real world data.

There is an R^2 of 0.2918 and adjusted R^2 of 0.2886 which is fairly low regarding linearity and model fit. It should be pointed out that the R^2 is very close to the adjusted R^2. This may be important in model results because a large distance between the R^2 and the adjusted R^2 sometimes indicates there are too many variables in the model, and perhaps one or more of them should be excluded (Sincich 2005).

Table 23 presents parameter estimates, p-values, and VIF for Model 1-A. At the bottom of this table there is documentation provided on the coding of variables in Model 1-A.

Table 23
Model 1-A: Main Effects Model Parameter Estimates

Variables	Parameter Estimates	Standard Errors	t-Values	Pr > |t|	VIF
Intercept	1.55623	0.23721	6.56	<.0001	0
Ownership	4.03304	0.26578	15.17	<.0001	1.00531
Geographic location	0.99093	0.27618	3.59	0.0004	1.07026
Z-Cardiac Procedures Group	0.80545	0.13447	5.99	<.0001	1.04047
Z-Orthopedic Procedures Group	0.85122	0.13738	6.20	<.0001	1.08599

Coding for Variables:
- Ownership: Investor owned hospital = 1; Not-for-Profit = 0
- Cardio Group Procedures: Z-score transformed percent of patients per hospital treated under a DRG code identified as a cardiac group procedure in this study.
- Orthopedic Group Procedures: Z-score transformed percent of patients per hospital treated under a DRG code identified as an orthopedic procedure in this study.
- Geographic location: Median income ≥ 5/8Q = 1; Else = 0

VIF, was very low in Model 1-A, ranging roughly between 1.0 and 1.08 for all independent variables, indicating no problem with multicollinearity.

Parameter estimates for ownership and geographic location, shown in Table 23, are significant and very high. Ownership shows a parameter estimate of 4.03 indicating that investor owned hospitals on the average have TATL ratios that are four points above the average TATL ratio of not-for-profits.

Hospitals located in higher income counties (≥ 5/8Q of the median income distribution for all Florida counties), on the average, have TATL ratios that are almost one (0.99) point higher than facilities located in lower income counties.

Cardiac and orthopedic group procedures have significant but lower betas of 0.81 & 0.75 respectively. Bear in mind that cardiac and orthopedic group procedures are coded as z-scores. So in the interpretation of the betas, hospitals that perform these procedures at a rate of 1Z higher than the mean (z = 0) are shown to have TATL ratios

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respectively 4/5 of a point and 3/4 of a point higher than hospitals that perform these procedures at a rate of z = 0.

Model 1-B: Interaction Model

The main effects model was very useful in evaluating variables and gaining further insights into the workings of the data, but beyond this it became less relevant in light of the findings in the subsequent interaction model, 1-B. Thus, Model 1-B is the model used to test the hypotheses delineated for Part 1 of this investigation.

The MLS regression equation for Model 1-B is shown as follows.

Regression Equation for Model 1-B

$$\hat{y}_{TATL} = \beta_0 + \beta_1 X + \beta_2 P + \beta_3 C + \beta_4 R + \beta_5 XP + \beta_6 XC + \beta_7 XR$$

Where: X = Ownership
                        P = Geographic location
                        C = Z-Cardiac Group Procedures
                        R = Z-Orthopedic Group Procedures

Partial F-tests were very helpful in evaluating the inclusion and usefulness of certain interactive variables. The use of partial residuals helped evaluate and determine unnecessary the inclusion of a quadratic term(s) in the model.

Initial findings of Model 1-B are shown below.

Table 24
Model 1-B: Interaction Model

Source	DF	Sum of Squares	Mean Square	F-Value	Pr>F
Model	7	7,867.30	1,123.90	86.42	<0.0001
Error	883	11,483	13.00		
Corrected Total	890	19,351			
Root MSE	3.61				
Dependent Mean	3.93		R^2	0.4066	
Coefficient of Variation (CV)	91.80		Adjusted R^2	0.4019	

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Table 24 shows that the interaction model 1-B has seven degrees of freedom (i.e., seven variables) due to interaction terms added in the model compared to the main effects model which had four. The dependent (TATL ratio) mean in the interaction model is of course identical to that of the main effects model at 3.93.

The interaction model is a better fitting model than the main effects model. The root MSE and CV are slightly smaller in the interaction model at 3.61 and 91.80 compared to 3.93 and 100.12 in the main effects model. Likewise the adjusted R^2 is 0.4019 in the interaction model compared to 0.2886 in the main effects model, reflecting better goodness of fit and a higher percentage of explanation of the variance in the data by the model.

Significance of the Interaction Model Using the F-Test

Before proceeding with a review of parameter estimates, it should first be determined if the interaction model is significant relative to the main effects model. A method to test the significance of the interaction model is the general F-test.

The formula for the F-test is as follows:

$$F = \frac{(R_2^2 - R_1^2)/(k_2 - k_1)}{(1 - R_2^2)/(N - k_2 - 1)}$$

Sources: Aichen & West 1991, Young 2006, Jaccard & Turrisi 2003

The test was calculated yielding a very high F value of 55.76 (p < 0.0001) with $R_1^2 = 0.2886$ and $R_2^2 = 0.4019$; $df_1 = k_2 - k_1$ (7 − 4) = 3 and $df_2 = N - k_2 - 1$ (891 − 7 − 1) = 883.

The F-test indicates that Model 1-B is significant relative to Model 1-A.

Parameter Estimates

Now that the significance of the interaction model 1-B has been established the

parameter estimates for this model are shown in Table 25.

Table 25
Model 1-B: Interaction Model Parameter Estimates

	Variable	Parameter Estimate	Standard Error	t-Value	P<| t |	VIF
B_0	Intercept	2.03691	0.25435	8.01	<.0001	0
B_1X	Ownership	2.766	0.38406	7.2	<.0001	2.49652
B_2P	Geographic location	0.0957	0.34185	0.28	0.7796	1.95004
B_3C	Z-Cardiac Group Procedures	0.0004	0.20616	0	0.9984	2.90873
B_4R	Z-Orthopedic Group Procedures	-0.0779	0.16577	-0.47	0.6385	1.88050
B_5XP	Ownership x Geographic location	2.2326	0.50934	4.38	<.0001	3.45155
B_6XC	Ownership x Z-Cardiac Group Procedures	1.1402	0.25742	4.43	<.0001	2.90506
B_6XR	Ownership x Z-Orthopedic Procedures Group	2.3385	0.25543	9.16	<.0001	1.85193

Coding for Variables:
- Ownership: Investor owned hospital = 1; Not-for-Profit = 0
- Cardio Group Procedures: Z-score transformed percent of patients per hospital treated under a DRG code identified as a cardiac group procedure in this study.
- Orthopedic Group Procedures: Z-score transformed percent of patients per hospital treated under a DRG code identified as an orthopedic procedure in this study.
- Geographic location: Median income $\geq 5/8Q = 1$; Else = 0

Table 25 shows that VIF is very low, less than the (conservative) rule-of-thumb of

5.0, indicating that the conversion to z-scores for cardiac and orthopedic group

procedures was effective in managing multicollinearity.

Table 25 shows a parameter estimate for ownership of 2.77. Recall that the beta

for ownership in the main effects model, 1-A was 4.06. The smaller beta for ownership

in the interaction model is due to a more thorough explanation of the relationship

between the TATL ratio and ownership by the inclusion of variables that interact with

ownership.

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Parameter estimates for z-orthopedic group procedures and z-cardiac group procedures are very low and not significant. But they still must remain in the model because they are constitutive terms in connection with interaction variables, ownership x z-orthopedic group procedures and ownership x z-cardiac group procedures. The same is true for the variable geographic location. Marginal effects for interacting variables will be discussed in the following section.

Interpreting Marginal Effects of Interaction Terms in Model 1-B

*Marginal Effects of the Interaction Term Orthopedic
Group Procedures x Ownership*

Brambor, Clark & Golder (2006) have pointed out that many researchers establish interaction models, but then do not go on to calculate the marginal effects of the interaction terms. To avoid this type of shortcoming in the investigation, marginal effects were calculated for the interaction terms in Model 1-B.

In examining the interaction terms, the models can be presented according to four conditions in connection with the interaction of orthopedic group procedures and ownership: $R = 1Z, X = 1$; $R = 0Z, X = 0$; $R = 1Z, X = 0$; $R = 0Z, X = 1$ (where $R =$ orthopedic group procedures and $X =$ ownership).

Table 26 shows marginal effects of each condition.

Table 26
Marginal Effects for the Interaction Term Orthopedic Group Procedures x Ownership,
Four Conditions

	Variable	R=1Z, X=1	R=0Z, X=0	R=1Z, X=0	R=0Z, X=1
B_0	Intercept	2.037	2.037	2.037	2.037
B_1X	Ownership	2.766			2.766
B_2P	Geographic location	0.096	0.096	0.096	0.096
B_3C	Z-Cardiac Group Procedures	0.000	0.000	0.000	0.000
B_4R	Z-Orthopedic Group Procedures	-0.0779		-0.078	
B_5XP	Ownership x Geographic location	2.233			2.233
B_6XC	Ownership x Z-Cardiac Group Procedures	1.140			1.140
B_7XR	Ownership x Z-Orthopedic Procedures Group	2.339			
	Totals	10.533	2.133	2.055	8.272

Where R = Z-Orthopedic Group Procedures and X = Ownership

The marginal effect of each condition is as follows: R = 1Z, X = 1 = 10.533; R = 0Z, X = 0 = 2.133; R = 1Z, X = 0 = 2.055; and R = 0Z, X = 1 = 8.272.

An important difference is found between models where X = 1, R = 1 and X = 0, R = 0, which is shown below.

$$\beta_0 + \beta_1 + \beta_2P + \beta_3C + \beta_4 + \beta_5P + \beta_6C + \beta_7$$

$$- \beta_0 + \beta_2P + \beta_3C = 10.533 - 2.133 = 8.40$$

The true difference between the models, where z-orthopedic group procedures = 1Z and ownership = 1 vs. z-orthopedic group procedures = 0Z and ownership = 0 amounts to 8.40 TATL ratio points. This is a very large difference between TATL ratios which is due chiefly to ownership.

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Marginal Effect of Orthopedic Group Procedures When Ownership = 1

To determine the contribution of orthopedic group procedures, two other models are compared. This includes z-orthopedic group procedures = 1Z and ownership = 1 vs. z-orthopedic group procedures = 0Z and ownership = 1. The difference between these two models is:

$$\beta_0 + \beta_1 + \beta_2 P + \beta_3 C + \beta_4 + \beta_5 P + \beta_6 C + \beta_7$$

$$- \beta_0 + \beta_1 + \beta_2 P + \beta_3 C + \beta_5 P + \beta_6 C = 10.53 - 8.272 = 2.261$$

The marginal effect of the interaction term for orthopedic group procedures and ownership is 2.261 TATL ratio points.

The interaction term can also be written $\hat{y} = \beta_0 + \beta_1 X + \beta_4 R + \beta_7 RX$ (where R = z-orthopedic group procedures and X = ownership) of which the marginal effect may be interpreted $\partial Y/\partial R = \beta_4 + \beta_7 X$ *(i.e., β_4 at X)* (Jaccard & Turrisi 2003, Aichen & West 1991). The marginal effect may then be calculated -0.0779 + 2.339 (X) = 2.261.

It should be understood that the focal variable in this case is orthopedic group procedures, and the modifying variable is ownership. In other words, the marginal effect is determined by the association between the TATL ratio and orthopedic group procedures at 1Z (one standard deviation above the mean of z = 0) when ownership is present (i.e., ownership = 1) (Jaccard & Turrisi 2003).

So in general, investor owned hospitals will have TATL ratios that are 2.26 points higher if they perform conventional Medicare reimbursed orthopedic group procedures at 1Z above the mean.

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*Standard Error & **t**-Value for the Marginal Effect*

Recall from Table 25 that the parameter for interaction term *XR* is significant (p < 0.0001). But this does not necessarily mean that the marginal effect of the interaction is significant (Brambor Clark & Golder 2007, Jaccard & Turrisi 2003). To determine the significance of the marginal effect of orthopedic group procedures on the TATL ratio when ownership is present, the following formula is employed. This formula shows the standard error for the association between the TATL ratio and orthopedic group procedures when ownership = 1 (i.e., B_4 at X) (Aichen & West 1991).

$$\sigma_{\partial Y/\partial R} = [var(B_4) + X^2 var(B_7) + 2Xcov(B_4 B_7)]^{1/2}$$

The standard error formula contains variances for B_4 and B_7 and a covariance for $(B_4 B_7)$ (Jaccard & Turrisi 2003). These variances and covariance are shown in Appendix 7 which provides a variance-covariance matrix for Model 1-B. The appendix also shows the calculations in connection with the standard error formula. From this formula it is determined that the standard error for orthopedic group procedures when ownership = 1 is 0.1943. It had already been determined that the marginal effect (B_4 at X) is 2.261.

To determine the significance of the marginal effect a t-value is computed.

$$t = (B_4 \text{ at } X) / \text{SE} (B_4 \text{ at } X)$$

$$= 2.261 / 0.1943 = 11.633.$$

The t-value is distributed at N – k – 1 degrees of freedom, where k is the number of predictor terms in the interactive model (in this case k = 7, so *df* = 891 – 7 –1 = 883).

The marginal effect of the interaction term is determined to be significant with $t = 11.633$ (p-value < 0.0001) (Aiken West 1991, Jaccard & Turissi 2003).

This indicates that investor owned hospitals that perform orthopedic group procedures at 1Z above the mean have, on the average, TATL ratios that are 2.261 points higher than investor owned hospitals that perform orthopedic group procedures at the mean ($z = 0$).

Marginal Effects of the Interaction Term Cardiac Group Procedures x Ownership

A second interaction term is now tested featuring z-cardiac group procedures x ownership. Table 27 is constructed to show the marginal effects under four conditions, C = 1Z, X = 1, C = 0Z, X = 0, C = 1Z, X = 0, C = 0Z, X = 1 (where C = z-cardiac group procedures and X = ownership).

Table 27
Marginal Effects for the Interaction Term Cardiac Group Procedures x Ownership, Four Conditions

	Variable	C=1, X=1Z	C=0Z, X=0	C=1Z, X=0	C=0Z, X=1
B_0	Intercept	2.037	2.037	2.037	2.037
B_1X	Ownership	2.766			2.766
B_2P	Geographic location	0.096	0.096	0.096	0.096
B_3C	Z-Cardiac Group Procedures	0.0004		0.0004	
B_4R	Z-Orthopedic Group Procedures	-0.078	-0.078	-0.078	-0.078
B_5XP	Ownership x Geographic location	2.233			2.233
B_6XC	Ownership x Z-Cardiac Group Procedures	1.140			
B_7XR	Ownership x Z-Orthopedic Procedures Group	2.339			2.339
	Totals	10.5334	2.0550	2.0554	9.393
Where C = Z-Cardiac Group Procedures and X = Ownership					

Marginal effects for each condition include: C = 1Z, X = 1 = 10.533; C = 0Z, X = 0 = 2.0550; C = 1Z, X = 0 = 2.0554; and C = 0Z, X = 1 = 9.393.

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The true difference between models where X = 1, C = 1Z and X = 0, C = 0Z is shown as follows.

$$\beta_0 + \beta_1 + \beta_2 P + \beta_3 + \beta_4 R + \beta_5 P + \beta_6 + \beta_7 R$$

$$-\beta_0 + \beta_2 P + \beta_4 R = 10.5334 - 2.0550 = 8.4780$$

The difference between the models, where z-cardiac group procedures = 1Z and ownership = 1 vs. z-cardiac group procedures = 0Z and ownership = 0 amounts to 8.4780 TATL ratio points.

Marginal Effect of Cardiac Group Procedures When Ownership = 1

To determine the contribution of cardiac group procedures a comparison is made between the models where cardiac group procedures = 1Z and ownership = 1 vs. cardiac group procedures = 0Z and ownership = 1. The difference between these two models is:

$$\beta_0 + \beta_1 + \beta_2 P + \beta_3 + \beta_4 R + \beta_5 P + \beta_6 + \beta_7 R$$

$$-\beta_0 + \beta_1 + \beta_2 P + \beta_4 R + \beta_5 P + \beta_7 R$$

$$= 10.5334 - 9.3930 = 1.1404$$

In this case, the focal variable is cardiac group procedures, so the marginal effect will be determined by the association between the TATL ratio and cardiac group procedures at 1Z (one standard deviation above the mean, z = 0) when ownership is present (i.e., ownership = 1).

The interaction term is then written $\hat{y} = \beta_0 + \beta_3 C + \beta_1 X + \beta_6 CX$ (where C = cardiac group procedures and X = ownership) of which the marginal effect is interpreted $\partial Y / \partial C = \beta_3 + \beta_6 X$. The marginal effect may then be calculated .0004 + 1.40(X) = 1.1404. This indicates that, on the average, investor owned hospitals that

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perform cardiac group procedures at 1Z have TATL ratios that are 1.1404 points higher than other investor owned hospitals that perform cardiac group procedures at the mean (Z = 0).

For the marginal effect for cardiac group procedures when ownership = 1 *(β_3 at X)* to be meaningful a test of significance must be performed, just as it was previously for orthopedic group procedures when ownership = 1. This first requires the calculation of a standard error for the marginal effect of which the formula is written below.

$$\sigma_{\partial Y/\partial C} = [var(B_3) + X^2 var(B_6) + 2X cov(B_3 B_6)]^{1/2}$$

As already mentioned, Appendix 7 provides the variance-covariance matrix for Model 1-B and shows marginal effects and standard error calculations for $\partial Y/\partial C$. From this formula it is demonstrated that the standard error for cardiac group procedures when ownership = 1 is 0.1541. The marginal effect for the interaction between cardiac group procedures and ownership is 1.1404. To determine the significance of the marginal effect (B_3 at X = 1) a t-value distributed with N – k – 1 (883) degrees of freedom is computed.

$$t = (B_3 \text{ at X}) / \text{SE} (B_3 \text{ at X})$$

$$= 1.1404 / 0.1541 = 7.4003 \ (p < 0.0001)$$

The marginal effect of the interaction term for cardiac group procedures and ownership is found to be significant with t = 7.4003 (p < 0.0001).

This indicates that investor owned hospitals that perform cardiac group procedures at 1Z above the mean have, on the average, TATL ratios that are 1.1404 points higher than investor owned hospitals that perform cardiac group procedures at the mean level (z = 0).

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Discussion of Findings for Part 1

Regression is a technique used for observatory studies so causation cannot be established. But positive *association* was demonstrated between TATL ratios and rates of cardiac group and orthopedic group procedures. A positive association was also found for the interaction between cardiac group procedures and ownership as well as the interaction for orthopedic group procedures and ownership. The model showed that the TATL ratio was, on the average, 1.1404 points higher when cardiac group procedures were administered at 1Z above the mean ($Z = 0$) in investor owned hospitals. The model also showed that the TATL ratio was on the average 2.261 points higher when orthopedic group procedures were administered at a rate of 1Z higher than the mean ($Z = 0$) among investor owned hospitals.

Testing for Unnecessary & Marginally Necessary Procedures

Recall from the literature review the example of Tenet's debacle due to unnecessary heart procedures. One of the objectives of this investigation was to determine if a portion of discretionary procedures performed by profitable investor owned hospitals are *unnecessary* or *marginally necessary*. However, evidence was not uncovered to indicate that procedures were being performed that were medically unwarranted.

Investor owned hospitals with strong balance sheets (i.e., high TATL ratios) perform cardiac group and orthopedic group procedures at higher *rates per hospital* (not higher volumes) than not-for-profits or unprofitable investor owned hospitals. But it was found in the preliminary analysis that less profitable not-for-profit hospitals carry out by far the highest *volumes* of these procedures.

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To make inferences about the medical necessity of these procedures it would have to be demonstrated that profitable investor owned hospitals perform volumes of cardiac group and orthopedic group procedures at levels that exceed the medical needs of the population. This inference cannot occur if volumes of procedures performed by investor owned hospitals do not exceed those of other types of hospitals.

Gaming or Good Management

Orthopedic and cardiac group procedures generally represent small percentages per hospital relative to the number of total procedures performed. Higher TATL ratios may be associated to higher percentages of cardiac and orthopedic procedures, but it is also likely that other factors contribute to these high ratios. But a significantly positive association has also been demonstrated between TATL ratios and the interacting variables of ownership and orthopedic group procedures and ownership and cardiac group procedures. It is then likely that the performance of these procedures contribute to long term profitability.

Certain examples in the literature review may point to higher percentages of certain types of discretionary procedures being an example of gaming Medicare, emphasizing certain profitable DRG codes in the patient mix while avoiding others.

Keep in mind that investor owned hospitals tend to have fewer beds than not-for-profits resulting in fewer total discharges for inpatient care. This explains why certain investor owned hospitals that emphasize these types of discretionary procedures have higher rates of discretionary procedures without generating higher volumes. But does this mean that many investor-owned hospitals attempt to fill their beds with patients

being treated with procedures represented by lucrative DRG codes, while less profitable patients are shifted to not-for-profits?

The literature review also cited many researchers who contend that good management explains why in general investor owned hospitals are financially stronger than not-for-profits. An emphasis on certain types of discretionary DRG codes may just reflect another example of good management practice.

What can be rendered from this analysis is that investor owned hospitals with high TATL ratios tend to offer packages of *discretionary cardiac and orthopedic services* that are attractive to specialists and their patients.

Part 1 Regression Diagnostics

Bagley White & Golomb (2001) have issued criticisms on numerous (peer reviewed) studies in the literature, some of which included no regression diagnostics or validation analysis, no testing for multicollinearity, and no testing for the needed inclusion of higher order terms.

Multicollinearity and specification errors (testing to include higher order terms) have already been discussed in connection with Model 1-B. In addition to these diagnostics, other potential regression violations were also tested and included outliers and influential observations, other aspects of specification errors, and heteroscedasticity.

In model development, multicollinearity was assessed and resulted in the transformation of observations to z-scores for cardiac group procedures and orthopedic group procedures. Problems with multicollinearity have been partly addressed via the inclusion of VIF with each model. In addition both adjusted and non-adjusted intercept

collinearity diagnostics were carried out. The results of collinearity diagnostics in

connection with Model 1-B using an intercept adjustment are shown in Appendix 8.

Outliers - Press Statistic

A good summary measure available in testing outliers and influential observations

is the predicted residual sum of squares (PRESS). The PRESS sum of squares is the sum

of squares of residuals using models obtained by estimating the equation with all other

observations, i.e., $(y_i - \hat{y}_{i-1})$ (Freund & Little 2000). Table 28 provides information

regarding the PRESS statistic.

Table 28 *Sum of Residuals, Sum of Squared Residuals &* *PRESS for Model 1-B*	
Sum of Residuals	0.0
Sum of Squared Residuals	11,483
Predicted Residual SS (PRESS)	11,703

In diagnosing residuals using PRESS, the sum of residuals should equal zero

which it does in Table 28. The sum of squared residuals (SSR) should be the same as the

Error SS in the regression output for Model 1-B. Recall that the Error SS for Model 1-B

is 11,483, which is equal to the sum of squared residuals in Table 28.

The PRESS statistic should also be compared to the SSR. When the PRESS

statistic is appreciably larger than the SSR, there is rationale to suspect that some

influential observations and outliers exist. For Model 1-B the PRESS statistic is only

slightly larger than the SSR, so it can be concluded that this test does not indicate there

are observations that unduly influence model results. Univariate statistics including

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normal probability plots, box plots, and stem-leaf plots were also reviewed for potential anomalies and none were observed.

Studentized Residuals & Cook's Distance (d)

Additional testing for outliers began with a review of studentized residuals and Cook's d statistic. Careful scrutiny was applied to observations that exceed residual test thresholds. These include studentized residuals $\leq$ -2.5 or $\geq$ 2.5 [or 5 asterisks which equals $\geq$ | 2.5 |, and Cooks d $\geq$ 4/n (i.e., d $\geq$ 4/891)]. Overall there were only around 25 observations with residuals that exceeded either of these thresholds. There were also a few studenized residuals in close to proximity to -2.0 or 2.0.

Influence Statistics

Influence statistics are helpful because outliers are not always readily detectable by an examination of residuals alone. In some cases the least squares estimation procedure may pull the estimated regression response toward observations that have extreme values in either x or y dimensions (Freund, Littell, 2000).

Influence statistics were carried out including hat-diag, covariance ratio, DFFITS, and DFBETAS. Only a very small number of observations exceeded prescribed thresholds, e.g. for DFFITS observations that $\geq 2\ [(m\ +\ 1)/n]^{1/2.}$

Specification Errors

A specification error occurs when a specified model does not contain all of the essential parameters. This might occur when only linear terms are specified in the model, but actual associations are curvilinear. The analysis of residuals and particularly partial residuals indicated no need to include one or more squared terms in the model or any additional interaction terms.

There are, however, some concerns regarding another type of specification error in a model that does not include all relevant main effects variables. One of the research objectives in this project was to form parsimonious models. Although this is a worthwhile objective, rigid adherence to parsimony should not occur at the expense of excluding important information. To be assured that a specification error did not occur in Part 1, a technical appendix is added, Appendix 9, where regression models are set up to include the variables used in Part 1 plus three additional variables which include hospital occupancy, labor costs represented by manhours per adjusted patient day, and market concentration measured by the Herfindahl-Hirshman Index (HHI).

In the concluding remarks of Appendix 9 it is explained that model results, parameter estimates and marginal effects via interaction terms, are very similar in the expanded models shown in the technical appendix relative to the parsimonious models presented in the body of this document for Part 1. This enhances confidence in model validity and in the findings derived from Part 1.

Heterogeneous Variances

An underlying regression assumption is that all random errors have the same variances. A review of residuals indicated no systematic residual patterns, such as nonrandom residual distributions, recognizable patterns in the magnitudes of the variances, or increases or decreases in variation of larger values of the outcome variable (Freund, Littell, 2000).

Weaknesses of Part 1 Models

All research projects have inherent weaknesses, and this study is no different. These weaknesses are described in the following paragraphs.

Randomly Splitting the Data to Assure Model Validity

Many researchers will enhance confidence in the validity of their findings by first randomly splitting a certain portion of the data, then building the regression model on one split dataset and then applying the prediction equation to the other (Sincich, 2005). Splitting the data was not performed in this analysis chiefly because the size of the project with two parts 1 and 2 was getting out of hand. Additional activities would expand the project even further. An examination using split data might be beneficial in a follow-up replication study.

Other methods such as a thorough review of residual analysis, particularly the use of studentized (jackknife) residuals, and a strong knowledge of the data using extensive preliminary analyses were found to also be good methods for evaluating model validity.

Grouping DRG Codes

The models used in Part 1 featured two variables, cardiac and orthopedic group procedures that were comprised of grouped DRG codes. This was a strong point of the investigation in that it allowed several DRG codes to be tested at one time in the models. It also avoided further problems with multicollinearity since many medical procedures, such as CABG and valve replacements, were shown to be highly correlated.

But this was also a weakness because findings would have been more precise had only one DRG code or at least one surgical procedure been tested at a time.

Procedure Volumes

There was also a problem of different sized volumes of certain procedures within cardiac group and orthopedic group procedures.   Back in the preliminary analysis for Part 1, tables 7 & 8 provided numbers of observations for each procedure comprising

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cardiac group and orthopedic group procedures. Of the 185,603 discharges for cardiac group procedures, valve replacements and CABG procedures showed 20,551 and 50,158 cases while PCI showed 114,894. Findings using the cardiac group procedures variable would be weighted more heavily by PCI.

There was a similar problem with orthopedic group procedures of which the total number of 222,525 observations was comprised in part by 136,121 major joint and limb reattachments (DRG 209).

A mitigating factor is that the larger PCI and major joint and limb reattachment volumes are more diversely distributed in their performance across types of hospital ownership. This means that bias generated by their inclusion and preponderance in cardiac and orthopedic group procedure variables would be toward the null hypothesis.

County Median Income as a Proxy for Geographic location

The proxy for geographic location in this study was Florida county median income levels. Although this proxy served well in the models, it may have been advantageous to have used a more refined and detailed proxy *(if one had been available)*. Median income levels by county planning areas (i.e., contiguous census tracts within a county aggregated by natural geographic boundaries or community characteristics) may have further elucidated investor owned hospitals' use of discretionary procedures and their association with the TATL ratio. Hospital locations within affluent planning areas may have generated more precise observations than hospital locations in higher income counties.

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Rigid Adherence to Parsimony

In the discussion on specification error under the subsection, Regression Diagnostics, there is a reference to Appendix 9, a technical appendix which presents models using the same variables in Part 1, with three additional variables to reflect patient occupancy, labor costs, and market concentration.

It is possible that a rigid adherence to parsimony in Part 1 may have led to creating models that ignored variables that were both relevant to the dependent variable and valuable to the analysis. If a specification error has occurred, the technical appendix represents an attempt to correct it. The reader is cordially invited to review parsimonious models in Part 1 in the body of the document, as well as the expanded models in Appendix 9.

Chapter 8

Model Results for Part 2
Testing the Association between Total Charges & Ownership for CABG & Valve
Replacement Procedures *(Reimbursed by Medicare HMO)*

Model 2-A: Main Effects Model

Now that hypotheses have been stated based on findings in the preliminary

analyses which helped identify and test outcome, explanatory, and control variables in

Chapter 6, the investigation can proceed to the first main effects model in Part 2. The

dependent variable in this model is total patient charges, which is a continuous variable,

so an MLS regression equation is used (Mendenhall & Sincich 2003).

The MLS equation for the main effects model in 2-A includes four terms, three of

which include ownership, LOS, and south geographic region.   An additional term

includes valve procedure, which is a term used to adjust for differences in charges

between valve replacements and CABG procedures. It is coded valve procedure = 1 and

CABG (as the base level) = 0.

The MLS equation for the main effects model, 2-A, is written as follows:

Regression Equation for Model 2-A

$$y_{Charges} = \beta_0 + \beta_1 X + \beta_2 S + \beta_3 L + \beta_4 V + \epsilon$$

Where:
   X = Ownership
   S = South geographic sector
   L = LOS
   V = Valve procedure

The regression procedure was undertaken using the prediction equation for Model

2-A. Findings for the main effects model are shown in Table 29.

Table 29
Model 2-A: Main Effects Model

Source	DF	Sum of Squares	Mean Square	F-Value	Pr>F
Model	4.0	2.87E + 13	7.17E + 12	4,101.02	<.0001
Error	12,415	2.17E + 13	1.748E + 09		
Corrected Total	12,419	5.04E + 13			
Root MSE	41,813				
Dependent Mean	102,488		R^2	0.5692	
CV	40.80		Adjusted R^2	0.5691	

As shown in Table 29 mean total charges (i.e., dependent mean) for all cases in

the dataset is $102,488. The model shows an adjusted R^2 of 0.5691 reflecting goodness of

fit where close to 57% of the variance is explained by the model. The model shows a CV

of 40.80. As discussed previously the ideal for the CV is 10.0 (Sincich 2005). The CV

of 40.80 in connection with Model 2-A is greater than the ideal of 10.0, but is still

acceptable for real world data.

Parameter estimates for Model 2-A are shown in Table 30.

Table 30
Model 2-A: Main Effects Model Parameter Estimates

Parameters	Parameter Estimate	Standard Error	t-Value	P > | t |	VIF
Intercept	9,585	835.24	11.48	<0.0001	0
Ownership	43,351	810.63	53.48	<0.0001	1.00639
South	19,714	754.94	26.11	<0.0001	1.00629
LOS	6,219	59.37	104.75	<0.0001	1.01274
Valve	21,174	840.75	25.18	<0.0001	1.01399

Coding for Variables:
- Ownership: Investor owned hospital = 1, Not-for-Profit = 0;
- LOS: Continuous variable (days from admission to discharge);
- Geographic Region: South = 1, North & Central = 0;
- Valve Procedure: Valve replacement = 1, CABG procedure = 0.

Model 2-A shows the parameter estimate for ownership at $43,351 indicating that, on the average, investor owned hospitals assess total charges $43,351 higher than not-for-profits. Total charges for each additional one day in the hospital are $6,219 as shown by the parameter estimate for LOS.

Geographic region shows a beta of 19,714 for the south Florida geographic sector indicating that in general charges in the south sector are $19,714 greater than the base level northern & central Florida. The dummy variable valve procedure yields a beta of 21,174, representing that charges for valve replacements in general are $21,174 more than the base level CABG procedures.

Model 2-B: Interaction Model

The main effects model demonstrated that total patient charges are significantly higher for investor owned hospitals relative to not-for-profits and for hospitals located in the southern region of Florida relative to the central and northern regions.

Model 2-B is an interaction model that contains only one interaction term, ownership x south geographic region. The necessity for including a quadratic term in

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connection with LOS, the only continuous independent variable, was explored and was

found unwarranted.

The regression equation for Model 2-B is written below.

Regression Equation for Model 2-B, Interaction Model

$$y_{Charges} = \beta_0 + \beta_1 X + \beta_2 S + \beta_3 L + \beta_4 XS + \beta_5 V + \epsilon$$

Where:
  X = Ownership
  S = South geographic region
  L = LOS
  XS = Ownership x south geographic region
  V = Valve procedure

Findings were derived based on the interaction model 2-B and are presented

below in Table 31.

Table 31
Model 2-B: Interaction Model

Source	DF	Sum of Squares	Mean Square	F-Value	Pr>F
Model	5	2.87E + 13	5.75E + 12	3,293.43	<0.0001
Error	12,414	2.17E + 13	1.745E + 09		
Corrected Total	12,419	5.04E + 13			
Root MSE	41,768				
Dependent Mean	102,488		R^2	0.5702	
CV	40.75		Adjusted R^2	0.5700	

Model 2-B shows an adjusted R^2 of 0.5700 indicating that roughly 57% of the

variance in the data can be explained by the model. The R^2 and CV (40.75), are close to

the R^2 and CV in the main effects model, 2-A.

Before proceeding with an examination of parameter estimates an F-test is carried

out to compare the interaction model 2-B with the main effects model 2-A. The test

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yielded F = 17.42 (p < 0.0001) for $R_1^2 = 0.5691$ and $R_2^2 = 0.5700$ with df $_1 = k_2 - k_1 = (5 - 4) = 1$ and df$_2 = N - k_2 - 1$ (12,420 – 5 – 1) = 12,414.

The F test is sufficiently large enough to warrant using the interaction model, but it should be mentioned that the distance between the R^2 in these two models is very close, and a significant F value was yielded only because of the large df$_2$ which was due to a large number of observations (N = 12,420) used in models 2-A and 2-B.

Even though the R^2 in each model is close, the interaction model still generates very useful results. It generates findings that help to address certain research questions and issues that had been initiated in the problem statement and literature review. Therefore, reporting the interaction model is consistent with the objectives of this study.

Findings of the interaction model, 2-B, are shown in Table 32.

Table 32
Model 2-B: Interaction Model Parameter Estimates

Parameters	Parameter Estimate	Standard Error	t-Value	P > |t|	VIF
Intercept	8,478	860	9.85	<.0001	0
Ownership	47,505	1,130	42.03	<.0001	1.9611
South Sector	22,429	913	24.56	<.0001	1.4762
LOS	6,214	59	104.76	<.0001	1.0130
Ownership x South Sector	-8,529	1,619	-5.27	<.0001	2.5127
Valve	21,046	840	25.05	<.0001	1.0148

As shown in Model 2-B, there is a parameter estimate for ownership of $47,505. Recall that ownership's beta in Model 2-A was slightly less, $43,351. What accounts for the larger beta in Model 2-B is the inclusion of the interaction term, ownership x south geographic sector.

What is observed by the interaction term is that the distance in mean patient charges narrows between investor owned hospitals and not-for-profits in the south region. This indicates though investor owned hospitals generally assess higher charges than not-

for-profits in all regions, not-for-profits in the south region charge higher than not-for-profits in the north and central regions.

This finding is also consistent with the preliminary analysis shown in Figure 7 which showed mean charges stratified by ownership and location. This chart showed a narrowing of the distance of charges between investor owned and not-for-profits in the south region.

Days of hospitalization are almost identical in the interaction model as the main effects model. This indicates that differences in charges with respect to hospital ownership and geographic region are not due to disease severity, as operationalized by LOS.

Interpreting Marginal Effects of Interaction Terms in Model 2-B

The interaction model for ownership x south geographic region is expressed as $y_{Charges} = \beta_0 + \beta_1 X + \beta_2 S + \beta_4 XS$. In this case, the focal variable is ownership and the modifying variable is south region. The marginal effect is shown as $\partial Y/X$ (β_1 at S = $\beta_1 + \beta_4 S$) = 47,505 + (-8,529)S = 38,976. This indicates that in general investor owned hospitals, located in the south region, assess charges at \$38,976 higher than not-for-profits, located in the south region (Jaccard & Turisi 2003).

A standard error and t-value must be computed to determine if the marginal effect of ownership and south region is significant. The standard error calculation was performed using the formula shown below.

The formula (Jaccard & Turisi 2003) incorporates variances for B_1 and B_4 and the covariance for ($B_1 B_4$) which is derived from the variance-covariance matrix shown in Appendix 10. The appendix also shows the calculations using this formula.

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$$\sigma\partial Y/\partial X = [var(B_1) + S^2 var(B_4) + 2S cov(B_1 B_4)]^{1/2}$$

The formula for $\sigma\partial Y/\partial X$ yields a standard error of 1,160.   To determine the significance of the marginal effect a t-value is computed as follows:

$$t = (B_1 \text{ at } S) / \text{SE}(B_1 \text{ at } S)$$

$$= 38,976. / 1,160 = 33.60 \ (p < 0.0001)$$

The t-value, distributed at $N - k - 1$ $(12,420 - 5 - 1 = 12,414)$ degrees of freedom, is very high and the marginal effect is significant at $p < 0.0001$.

From this model it can be concluded that investor owned hospitals assess significantly higher charges under the Medicare HMO program for CABG and valve replacement procedures. The interaction term ownership x south region indicates that although investor owned hospitals assess higher charges in the south region, the distance is narrowed in amounts between investor owned and not-for-profit hospitals. Not-for-profits are shown to accelerate charges at a higher rate (not monetary value) than investor owned hospitals in the south region.

Discussion of Findings for Part 2

It is clear from models 2-A and 2-B that investor owned hospitals assess significantly higher charges than not-for-profits in the performance of CABG and valve replacement procedures reimbursed by Medicare HMO. It is also unambiguous that investor owned and not-for-profit hospitals, located in the southern Florida region, assess higher charges for the same services relative to their hospital counterparts in central and north Florida. In fact, though investor owned hospitals assess higher charges in all geographic regions, the distance between amounts of charges narrows between investor owned and not-for-profit hospitals in the south region.

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It has also been established that higher charges in connection with ownership or geographic region are not due to increased days of hospitalization or the administration of more intensive medical services.

Total Charges vs. Reimbursed Charges

A comment was made previously in connection with Table 17 that average total charges for valve replacement and CABG procedures are excessively higher than what is actually reimbursed by Medicare HMO.

The AHCA financial data (electronic file) provides financial data for hospitals according to each payment source. Amounts are listed for inpatient and outpatient services in terms of total revenue, revenue deductions, and net revenue. Percentages were calculated for Medicare HMO *inpatient* net revenue [Medicare HMO net inpatient revenue percentage = (Medicare HMO gross inpatient revenue – deductions from Medicare HMO gross inpatient revenue) / Medicare HMO gross inpatient revenue]. It was found that in general not-for-profit hospitals realize only around 30% of their Medicare HMO gross revenue, while investor owned hospitals realize, on the average, only 24%.

These percentages of net revenue were calculated not for all hospitals, only the investor owned and not-for-profit hospitals represented in the study population for Part 2. In other words, these included only hospitals that performed valve replacement or CABG procedures reimbursed by Medicare HMO.

Because total patient charges are much higher in investor owned hospitals it would be expected that percentages of reimbursements under Medicare HMO would be

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lower than that of not-for-profits. As already mentioned, reimbursements are, in fact, lower for investor owned hospitals.

Likewise, because charges increase for both investor-owned and not-for-profit hospitals in the southern region of Florida, it would be anticipated that net revenue percentages should decrease relative to those in the north and central regions. But this does not occur, as shown in Table 33.

Table 33
Percentage of Net Revenue for Inpatient Services, Investor Owned vs. Not-for-Profit
Hospitals in the South Region vs. Combined North & Central Regions,
Medicare HMO Inpatient Services, 2000-2005

Region	Investor Owned	Not-for-Profit
South	23.88%	29.86%
North & Central	24.81%	30.84%

Source: AHCA (2000-2005) Financial Analysis Annual Electronic Reports

The table shows that net revenue, on the average, for investor owned hospitals, located in the southern region, is only about one percentage point (23.88% vs. 24.81%) lower than net revenue in the north and central regions. Similarly, there is only about one percentage point (29.86% vs. 30.84%) difference for the south vs. north & central regions for not-for-profit hospitals.

One important question arises regarding the differential between total patient charges and reimbursements. Data to calculate percentages of net revenue are provided for Medicare HMO inpatient services, not specifically for valve replacements and CABG procedures. So it is not possible to determine if the average 30% and 24% levels of Medicare HMO reimbursement for not-for-profits and investor owned hospitals, respectively, apply specifically to valve replacements and CABG procedures.

However, if these percentages are accurate it would mean that reimbursements are higher in the south region irrespective of disease severity or the extent of medical services provided. It would also mean that reimbursements under the Medicare HMO program occur with wide variability with little attention to anomalies in federal spending.

It has been stated that one of the goals of Part 2 (Chapter 6) was to test Wennberg's theory of the surgical signature. As discussed, this theory entails geographic disparities in per capita rates and federal expenditures in connection with discretionary procedures. The findings in Part 2 add credence to Wennberg's surgical signature theory.

Part 2 Regression Diagnostics

The same set of tools used for regression diagnostics in Part 1 (Chapter 7) are employed again in Part 2. Diagnostic results provided in this section are in connection with Model 2-B.

Outliers

Part 2 begins its presentation on diagnostics with a discussion on potential outliers. The PRESS statistic is used again as a summary measure. As stated in Part 1, PRESS is the sum of squares of residuals using models obtained by estimating the equation with all other observations; that is $(y_i - yhat_{i-1})$ (Freund, Littell 2000). Information on PRESS is shown in Table 34 below.

Table 34
Sum of Residuals, Sum of Squared Residuals & PRESS for Model 2-B

Sum of Residuals	0.0
Sum of Squared Residuals	21,657,280,000,000
Predicted Residual SS (PRESS)	21,692,210,000,000

The sum of residuals in Table 34 should equal zero, which it does. The sum of squared residuals should be the same as the Error SS in the regression output for Model 2-B. The Error SS under Model 2-B was 21,657,280,000,000 (2.17E+13) which equals the sum of squared residuals shown in the table.

The PRESS statistic is now compared with the sum of squared residuals, as influential observations and outliers would be indicated if PRESS is appreciably larger. But as shown in the table, PRESS is only slightly larger than the sum of squared residuals with a miniscule difference possibly even due to rounding. It can be concluded that information derived from Table 34 does not indicate the presence of influential observations or outliers.

Studentized Residuals & Cook's Distance (d)

Studentized residuals and Cook's d were also used to perform additional tests for outliers.   Observations in connection with Model 2-B were reviewed that exceeded prescribed thresholds where studentized residuals $\geq |2.0|$ (4*) or Cook's d $\geq 4/N$ (i.e., 4/12,414) (Freund, Littell 2000).

Influence Statistics

Influence statistics including hat-diag, covariance ratio, DFFITS and DFBETAS were used to identify and examine observations that exceeded prescribed thresholds. A small number of observations were identified as potentially influential, but overall no major problems regarding influential observations or outliers occurred.

Specification Errors

As mentioned in the regression diagnostic discussion under Part 1, a specification error occurs when a model lacks all essential parameters, which may occur when the true association is curvilinear, and the model includes only linear terms.

Residual analysis and in particular partial residuals were very helpful in determining if models contained all necessary parameters. The incorporation of quadratic terms in models for Part 2 was tested and their inclusion in the final model was determined to be unwarranted.

Heterogeneous Variables

An assessment was done to determine if random errors have equal variances. Charts were analyzed to detect non-random residual patterns, obvious patterns in the magnitudes of the variances, and increases or decreases of larger values of the outcome variable (Freund, Littell 2000). Overall, no major violations of heterogeneity were observed.

Multicollinearity

Appendix 11 presents an annotated assessment of multicollinearity in connection with Model 2-B. Problems with multicollinearty have been discussed, and VIF has been presented with each model. In addition, both adjusted and non-adjusted intercept collinearity diagnostics were performed for each model. The collinearity diagnostics presented in this appendix is intercept adjusted in connection with Model 2-B.

As discussed under Part 1 of the study, the rule-of-thumb in reducing problems of multicollinearity was to aim for $VIF \leq 10$ and even $VIF \leq 5$ if possible. VIF was less than 3.0 in connection with all parameter estimates for models 2-A & 2-B. Overall, no

major problems with multicollinearity were detected for the main effects model 2-A or interaction model 2-B.

Weaknesses of Models in Part 2

As with Part 1, Part 2 also had certain weaknesses in analysis and model development. These are described in the following paragraphs.

Assessing Validity by Randomly Splitting the Data

Just as it was discussed in Part 1 (Chapter 7), a good strategy to evaluate model validity is to randomly split the data, develop the model for one portion of the data and then apply the prediction equation to the other portion. As it was mentioned under Part 1, this was not done because of the magnitude of this project. Had this project been only one part instead of two then random splitting of the data would have been done.

Other methods used to evaluate the validity of the model included a thorough review of regression diagnostics and residual analysis as well as a substantial review of the data preceding model development via extensive preliminary bivariate and nonparametric analyses.

Total Patient Charges vs. Reimbursements

It has been discussed that actual amounts reimbursed for each patient was not reported in the AHCA Discharge dataset, only total charges. Reimbursements are only known more generally in connection with Medicare HMO inpatient services, shown in the AHCA Financial (electronic) data. Meaningful findings were still derived in Part 2 especially considering wide disparities in levels of total patient charges with respect to ownership and geographic sector. But more specific information about reimbursements at the patient level would have been helpful.

Chapter 9

Conclusion

It should be asseverated that this study does not take the position that there is anything wrong with solvency or profitability. Financial strength in hospitals saves lives and aids in offering better quality of care to patients. There are many previous studies with compelling findings regarding the association between healthcare quality and hospital profitability as well as the association with poor quality and low profitability.

The Agency for Healthcare Research and Quality (2005) examined medical errors in the files of approximately one million patients who had undergone surgery in 176 Florida hospitals between 1996 and 2000. The study concluded that a decrease in a hospital's profit margin resulted in a higher risk of errors in the treatment of patients before, during, and after surgery.

It can be concluded that financially healthy hospitals make valuable contributions to medicine and to patients' welfare. There is also nothing wrong with making a profit with Medicare, as long as it is done within legal and ethical parameters. What is perplexing is that as discussed in the literature review in Chapter 2 there is a consensus among researchers that Medicare is not a profitable revenue source for hospitals. Yet a number of profitable short term general hospitals in Florida show Medicare to comprise a large, even majority, percentage of their revenue base.

This study has attempted to shed light on two strategies certain hospitals use to make a profit with Medicare. It was found in Part 1 of this study that certain investor owned hospitals perform significantly higher rates per hospital of certain types of discretionary cardiac and orthopedic group procedures, and these higher rates are positively associated with TATL ratios, representing long-term financial health. Perhaps these investor owned hospitals are gaming conventional Medicare by emphasizing DRG codes that represent certain discretionary procedures.

But there are some researchers who contend that the types of procedures performed in hospitals are irrelevant to solvency and profitability. Copious citations in the literature review point to the association between financial strength and good management practices. The most notable of these researchers, Cleverly, assets that better financial health in investor owned hospitals is a product exclusively of good management, and that it is entirely irrespective of patient mix or payer sources.

But Part 1 of this investigation demonstrated a positive association between the TATL ratio and discretionary cardiac and orthopedic procedures. So perhaps in addition to good management, financial health is also due to systematic targeting of the most profitable DRG codes. It could also be argued that an emphasis on the most lucrative medical procedures is in fact good management. Perhaps certain hospitals merely demonstrate the acumen to structure their patient mix to maximize volumes of DRG codes that are the most profitable under conventional Medicare.

In Part 2 it was found that investor owned hospitals assess significantly higher total patient charges than not-for-profits for CABG and valve replacement procedures

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under the Medicare HMO program.   Higher charges could not be explained by patient disease severity or the provision of more extensive medical services.

On the flipside it was also found that the investor owned hospitals that assess significantly higher charges also have appreciably higher percentages of deductions from total revenue. Although the deductions from revenue attenuate the argument that investor owned hospitals are overcharging, it does not address the question of why these charges are assessed so high in the first place.

It also does not address why total patient charges accelerate for both investor owned and not-for-profit hospitals in the southern region of Florida.

Evidence was not uncovered in Part 1 which might indicate that investor owned hospitals are performing procedures unnecessarily or at rates that *exceed* the medical needs of the Florida population. Generating research findings that indicate unnecessary or marginally necessary surgical procedures are being performed in investor owned hospitals is an ambitious objective, one that would likely require many investigations before a clear image might (or might not) emerge of gaming patients' welfare.

But the crux of this investigation was less ambitious with the aim of identifying a couple of strategies hospitals, chiefly investor owned, employ to make a profit with Medicare. Certain types of discretionary procedures under conventional Medicare increase per capita with respect to hospital ownership. Likewise, investor owned hospitals and all hospitals located in the southern region of Florida assess excessive charges for medical services under the Medicare HMO program, irrespective of patient disease severity and days of hospitalization.

Wennberg's (2005) surgical signature theory was described in the literature review and referenced several times in this document. In the context of discretionary procedures, this theory refers to fluctuating levels of per capita rates and federal spending that are not clearly linked to the disease status of the population. The findings in this investigation lend support to Wennberg's surgical signature theory.

Policy Recommendations

This study would not be complete without some recommendations that may help to improve health policy. This final section discusses some preemptive methods that could be undertaken to uncover potential gaming activities by routine monitoring and subsequent identification of inordinate rates of certain discretionary procedures.

A Few Caveats on Interpretation

It should be taken into account that this project is an observational study using secondary data. Associations can be drawn, but causation cannot be established. It should also be considered that this study is a pioneering effort, meaning there are very few prior studies dealing with gaming in this context – increasing rates of procedures and inflating charges. Most studies in the literature address gaming in the context of up-coding.

It should also be recalled that no inferences could be demonstrated in this study to indicate that any unnecessary cardiac or orthopedic procedures occurred. What was demonstrated was that a positive association exists between the TATL ratio and cardiac and orthopedic group procedures exclusively in investor owned hospitals. It is possible that this association is indicative of gaming, but it is also feasible that the association has occurred due to very good management in certain investor owned hospitals.

Administrators in these hospitals have perhaps structured their patient mix to maximize DRG codes that tend to be profitable, while minimizing those that are not. This reflects managerial acumen, and there is no legal or ethical violation unless it could be demonstrated that surgeries are being performed that are not clinically warranted.

There was strong evidence that investor owned hospitals assessed higher charges than not-for-profits under the Medicare HMO program, and that both investor-owned hospitals and not-for-profits assessed higher patient charges in the southern sector of Florida than the other sectors. These findings raised very good questions, but it could not be shown definitively if higher charges were resulting in higher and unwarranted reimbursements.

Recommendations to Federal Agencies

Now that these caveats, discussed in the previous section of this chapter, have been taken into account, there are some practical recommendations resulting from this research.

Recommendations should not only be offered to hospital administrators and corporate board members, but also to Medicare's Office of the Inspector General (OIG) and personnel and officials involved in regulatory and oversight functions of conventional Medicare and Medicare HMO programs.

Recommendations to Medicare would include routine monitoring of rates of certain discretionary procedures, the objective of which would be to identify anomalous fluctuations. Gaming, if it occurs, may be elucidated, especially on a large scale, by examining per-capita rates in certain geographic areas that unexplainably exceed those of other areas, or that show sudden inordinate increases. Hospitals or hospital referral

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regions (HHRs) demonstrating appreciably higher rates than other hospitals or regions would be the focus of further investigation.

Anomalies may be found not only in rates, but also in patient charges for discretionary procedures. In Part 2 of the narrative, figures 5-7 provide patient charges for the south, central, and north geographic sectors of Florida. These charts in themselves shed light on a geographic area of interest – the south sector of Florida. Medicare should begin examining mean patient charges and reimbursement levels by geographic area to determine if reimbursement amounts are warranted.

A Brief Example of Ongoing Monitoring of Rates of Discretionary Procedures Reimbursed by Medicare

A brief hypothetical demonstration of how Medicare could monitor rates of discretionary procedures using real-world data is shown in Figure 8. This figure provides CABG rates per 1,000 Medicare enrollees by Florida HRR, 2005. Each bar on the chart is accompanied by a vertical error bar which ranges from one standard deviation below the mean to one standard deviation above.
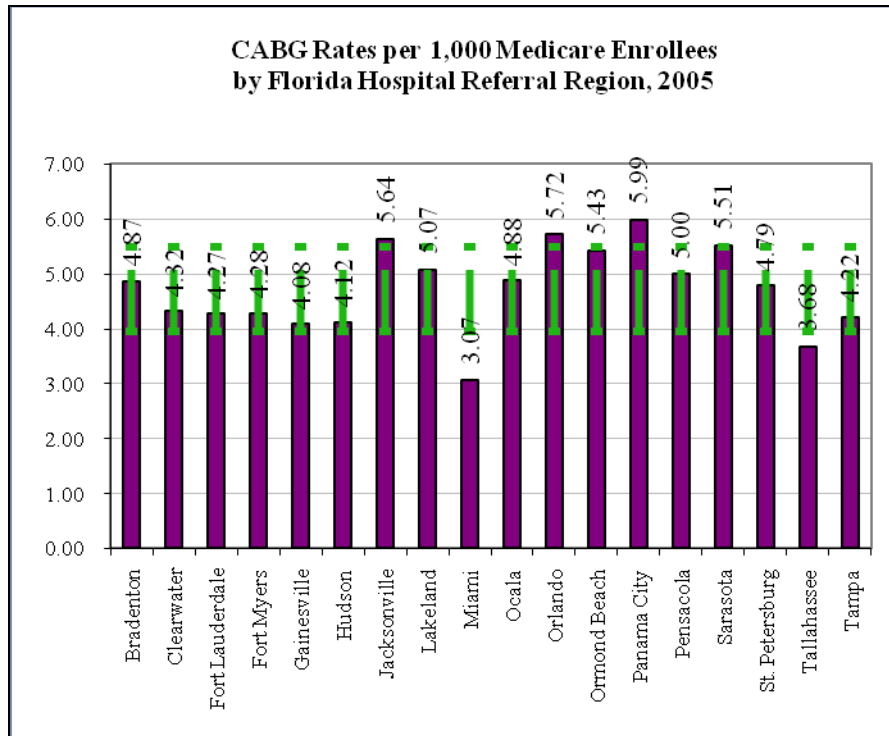
Figure 8
Source: Dartmouth Atlas of Healthcare, 2005

The CABG rate for the Panama City HRR, at 5.99, is the highest on the chart and also exceeds the upper limit (one standard deviation) of the error bar. Perhaps further review of Panama City is warranted, but it would not be the most judicious use of investigative resources because Panama City only has 27,000 Medicare enrollees (Dartmouth 2005). Therefore, priority would be given to another HRR with high CABG rates and with high numbers of enrollees.

Figure 8 shows that the Orlando HRR has a CABG rate of 5.72, and the Jacksonville HRR shows a rate of 5.64. As it turns out, these two HRRs have Medicare enrollments, respectively, of over 400,000 and almost 150,000 (Dartmouth 2005). Because the Orlando and Jacksonville HRRs have both high numbers of Medicare enrollees and high CABG rates they would have the highest priority for Medicare's review.

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At this point auditors should focus on the Orlando and Jacksonville HRRs, and determine which hospitals comprising these regions contribute most heavily to the high rate of CABG surgery.

Recommendations to Hospital Administrators

Recommendations extending to hospital administrators would also include a review of rate fluctuations of discretionary procedures. They should be aware if rates of discretionary procedures at their hospital are appreciably higher than rates of these procedures in comparable hospitals in the region. If rates of certain procedures are not excessive they would likely not be targeted by Medicare for further inquiry. If rates of certain discretionary procedures are disproportionately higher than other hospitals, regions, or state average, administrators should understand that they may be on Medicare's radar.

Even if a hospital is potentially on Medicare's radar due to high rates of certain discretionary procedures, there is no reason to reduce the performance of these procedures if they are financially worthwhile to the hospital. However, administrators must perform their due diligence to assure that higher rates never represent unwarranted rates. This would compel them to perform the same regional review as was just prescribed for Medicare to determine where their hospital falls in terms of numbers of enrollees and rates of certain discretionary procedures.

If they are located in a region with inordinately high CABG rates they should determine how much their hospital contributes to that rate. If the contribution is substantial then both a financial and clinical dimension should be included in their

internal performance audit procedures of surgical operations. This would also entail convincing their board of directors that such audit standards are necessary.

Tenet's Rate of CABG Procedures Compared to the California State Average

In the literature review there was a lengthy discussion on Redding Medical Center, a subsidiary of Tenet Healthcare, Inc. To conclude the discussion on the importance of monitoring rates of discretionary procedures by geographic area by both federal officials and hospital administrators, there is no better example to cite than Tenet. Monitoring rates of discretionary procedures, as it was shown in the hypothetical example using Figure 8, may have helped to circumvent unnecessary surgeries and other disreputable acts by Tenet.

The performance of unnecessary and marginally necessary procedures at Tenet began to come to light when two men were diagnosed with severe life-threatening artery blockage by a Redding physician who recommended immediate bypass surgery. The two men sought second medical opinions, and it was found that both were in good health, had clean arteries, and were not in need of bypass surgery (Chan 2002).

The two men reported their suspicious diagnoses to the Federal Bureau of Investigation (FBI). Results of the FBI's investigation indicated that half of the heart operations performed at Redding were unnecessary. The two men then prevailed in a qui-tam lawsuit filed under the False Claims Act (Chan 2002).

Redding's situation continued to unravel when 750 patients filed a law suit alleging they had undergone surgical procedures that were determined to be medically unnecessary, specifically CABG, valve replacements, and catheterizations (Darmiento, 2002).

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Although malpractice and malfeasances occurred at Redding where physicians and hospital administrators were directly culpable, Medicare indirectly deserves at least some of the blame for negligence; for not responsibly monitoring the variability of certain procedures by geographic region, a sin of omission. Figure 9 compares CABG discharges per 1,000 Medicare enrollees for the Redding HRR, the HRR of which Redding Hospital was located, and the California state average, 1992-2003.
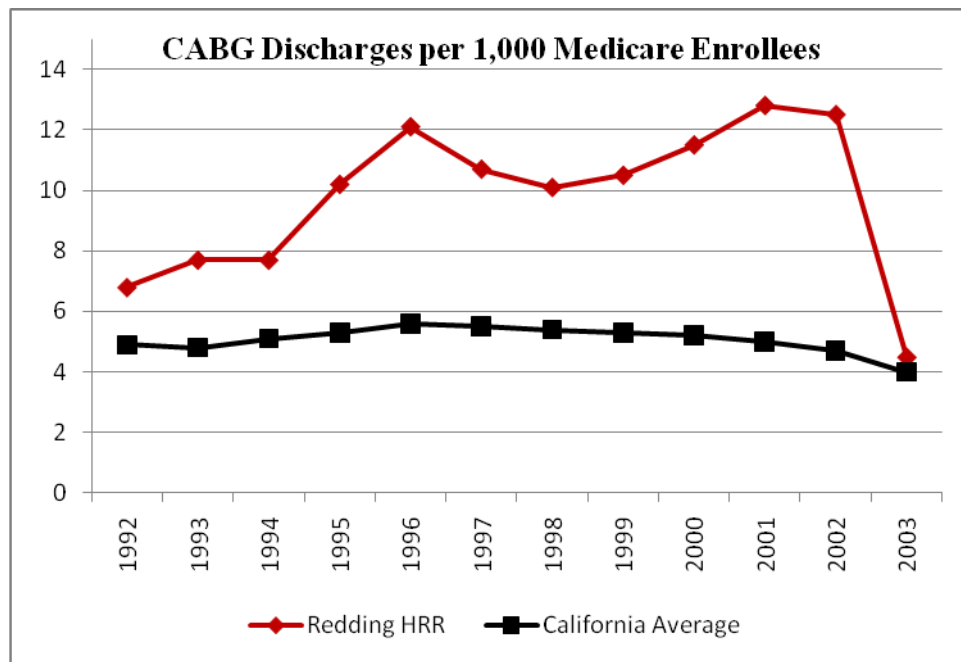
Figure 9
Source: Dartmouth Atlas of Healthcare: Studies of Surgical Variation, Cardiac Surgery Report, 2005

The Redding HRR shows substantially higher rates of CABG surgery relative to the state average, and this disproportionate rate was largely due to activities occurring at Redding Medical Center. It is reasonable to assume that Medicare should have been alerted of the disparities in rates as early as 1992. By 1995 and 1996 Redding HRR's rates were double that of state averages. The rate then remained at least four points higher in the Redding HRR relative to the mean rate of CABG procedures occurring in

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California. The Redding HRR peaked in 2002 when it exceeded more than 12 CABG surgeries per 1,000 Medicare enrollees. Very similar excessive rates of aortic and mitral valve replacements occurred at Redding in the same time period (Dartmouth, 2005). The question beckons as to how Medicare missed these anomalies?

A subsequent question is how did Redding administrators not know there were malfeasances occurring? In addition to unwarranted surgeries, other violations uncovered at Redding Medical Center included false billings, inflated charges, and gross misuse of the Medicare outlier methodology (Darmiento 2002).

Tenet's misuse of the Medicare outlier program was first made public in a report issued by a UBS Warburg (investment banking and securities) analyst. The report was the result of rifling through Medicare records (i.e., Tenet's policy was never to release its Medicare outlier data) and discovering that Tenet's Medicare outlier payments were at much higher levels than those of its competitors. It was estimated that Medicare outlier payments comprised 16.7 percent or $418 million of Tenet's total Medicare reimbursements for the year ended September 30, 2002 (Darmiento 2002). If an investment and securities analyst could figure out Tenet's violations of the outlier program, it is very likely upper-level Tenet administrators had full knowledge of Tenet's behavior.

It is likely that Tenet's actions grew insidiously over time from mild abuses of Medicare to nefarious behaviors that entailed wholesale fraud and the endangerment of patients. A corporate culture that refused to tolerate abuses of Medicare and skillful in-house auditing of clinical and financial operations would have avoided Tenet's debacle and the horrible events that led up to it.

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Appendices

Appendix 1
Rates of Surgical Procedures per 1,000 Medicare Enrollees, All Florida Hospital Referral Regions, 2003

All Florida Hospital Referral Regions	HRR	All Surgical Discharges	Hip Fracture Repair	Resection for Colon Cancer	Coronary Angiography	CABG	Carotid Endarterectomy	Cholecystectomy	Hip Replacement
National Average		102.12	7.53	1.76	22.77	5.18	3.02	4.29	3.18
State Average		108.56	7.46	1.77	25.64	5.42	3.6	4.44	3.27
Bradenton	115	117.94	7.71	2.14	28.13	5.49	4.87	6.6	3.75
Clearwater	116	107.44	7.47	2.09	27.38	5.04	3.54	4.03	3.18
Fort Lauderdale	118	105.83	7.54	1.66	24.6	4.95	2.96	3.67	3.91
Fort Myers	119	109.99	6.74	1.63	21.98	4.94	3.93	4.13	4.2
Gainesville	120	108.00	8.1	1.77	26.72	5.04	2.68	4.58	2.51
Hudson	122	119.24	8.07	1.81	34.2	6.15	4.87	5.78	3.14
Jacksonville	123	107.4	7.81	1.9	32.2	5.98	4.25	3.95	2.68
Lakeland	124	105.35	7.57	1.82	31.1	4.73	2.9	4.18	2.78
Miami	127	101.39	7.21	1.75	22.08	3.36	1.59	4.51	2.08
Ocala	129	110.41	6.9	1.86	27.6	5.6	4.75	4.82	3.17
Orlando	130	111.75	7.16	1.84	26.59	6.47	4.07	4.8	3.27
Ormond Beach	131	97.53	8.02	1.72	22.56	5.73	2.17	3.66	3.49
Panama City	133	126.96	9.73	1.73	36.4	7.97	3.37	5.03	3.07
Pensacola	134	122.13	8.48	1.66	26.76	5.9	3.69	4.88	2.82
Sarasota	137	103.84	7.45	1.75	18.28	5.83	3.26	3.61	4.14
St. Petersburg	139	111.09	8.09	1.97	20.72	4.48	4.9	5.58	3.19
Tallahassee	140	101.69	7.94	1.62	21.96	5.03	3.06	5	2.25
Tampa	141	104.08	7.4	1.7	26.64	5.46	3.98	4.69	2.68
Mean		109.56	7.74	1.8	26.44	5.45	3.6	4.64	3.13
Standard Deviation		7.72	0.67	0.15	4.83	0.95	0.95	0.79	0.6
Coefficient of Variation		**0.07**	**0.09**	**0.08**	**0.18**	**0.17**	**0.26**	**0.17**	**0.19**

Source: Dartmouth Atlas of Healthcare, Data Tables, Hospital referral regions (HRRs):

    Regional markets for Tertiary Medical Care

Retrieved on September 24, 2006 from http://www.dartmouthatlas.org/

Appendix 1 presents similar data from the same source as shown in Charts 1-3 in the literature review. Data used for Appendix 1 are from 2003 while data from Charts 1-3 are from 2005. It was determined that 2003 would be appropriate for the presentation in Appendix 1 because the study period is 2000-2005, and 2003 occurs in the middle of the study period.

Appendix 1
Rates of Surgical Procedures per 1,000 Medicare Enrollees, All Florida Hospital Referral Regions, 2003

All Florida Hospital Referral Regions	Knee Replacement	Mastectomy for Cancer*	PCI	Lower Extremity	Abdominal Aortic Aneurysm Repair	TURP for BPH**	Back Surgery	Valve Replacement
National Average	6.88	1.19	11.27	1.41	0.97	5.23	4.02	1.39
State Average	6.71	1.06	12.91	1.36	1.05	4.54	4.52	1.54
Bradenton	7.51	1.12	14.46	1.22	1.11	5.72	6.7	1.28
Clearwater	6.28	1.12	17.93	1.42	1.23	3.95	3.4	2.01
Fort Lauderdale	5.62	0.73	11.51	1.21	0.92	4.42	3.76	1.73
Fort Myers	9.55	0.67	11.8	1.49	1.33	4.87	6.77	1.47
Gainesville	6.24	1.64	14.8	1.1	1.08	5	6.38	0.96
Hudson	7.38	1.11	17.87	1.13	0.93	4.39	3.83	2.06
Jacksonville	5.98	0.9	14.34	1.41	1.36	4.28	3.27	1.51
Lakeland	6.58	1.36	12.86	1.1	0.95	4.99	3.87	1.74
Miami	4.07	1.02	10.34	1.13	0.64	5.09	2.55	1.23
Ocala	6.99	1.52	14.74	1.11	1.04	3.44	5.22	1.74
Orlando	6.83	1.16	13.95	1.33	1.03	3.8	4.12	1.52
Ormond Beach	6.83	0.93	10.17	1.72	0.95	2.65	4.31	1.54
Panama City	6.8	Suppressed***	13.06	1.33	Suppressed***	11.51	5.19	1.72
Pensacola	8.76	1.11	14.18	2.58	1.27	4.36	6.5	1.3
Sarasota	8.12	1.21	11.59	1.64	1.04	5.4	6.2	1.72
St. Petersburg	6.59	1.45	9.84	1.8	1.14	6.82	4.44	1.61
Tallahassee	6.74	1.6	9.65	1.26	0.95	5.78	5.15	0.75
Tampa	5.72	1.22	11.32	1.42	1.08	5.28	3.77	1.28
Mean	6.81	1.17	13.02	1.41	1.06	5.1	4.75	1.51
Standard Deviation	1.22	0.28	2.49	0.36	0.18	1.86	1.31	0.34
Coefficient of Variation	**0.18**	**0.24**	**0.19**	**0.26**	**0.17**	**0.37**	**0.28**	**0.22**

* Per 1,000 Female Medicare Enrollees, ** Per 1,000 Male Medicare Enrollees, ***Suppressed indicates there is not enough data in the HRR to protect patients' identity.

Source: Dartmouth Atlas of Healthcare, Data Tables, Hospital referral regions (HRRs): Regional markets for Tertiary Medical Care

Retrieved on September 24, 2006 from http://www.dartmouthatlas.org/

Appendix 1
Rates of Surgical Procedures per 1,000 Medicare Enrollees, All Florida Hospital Referral Regions, 2003

Coefficients of Variation for Certain Discretionary Procedures, 2003

Procedure	Coefficient
CABG	0.17
Hip Replacement	0.19
Knee Replacement	0.18
Mastectomy	0.24
PCI	0.19
TURP for BPH	0.37
Back Surgery	0.28
Valve Replacement	0.22
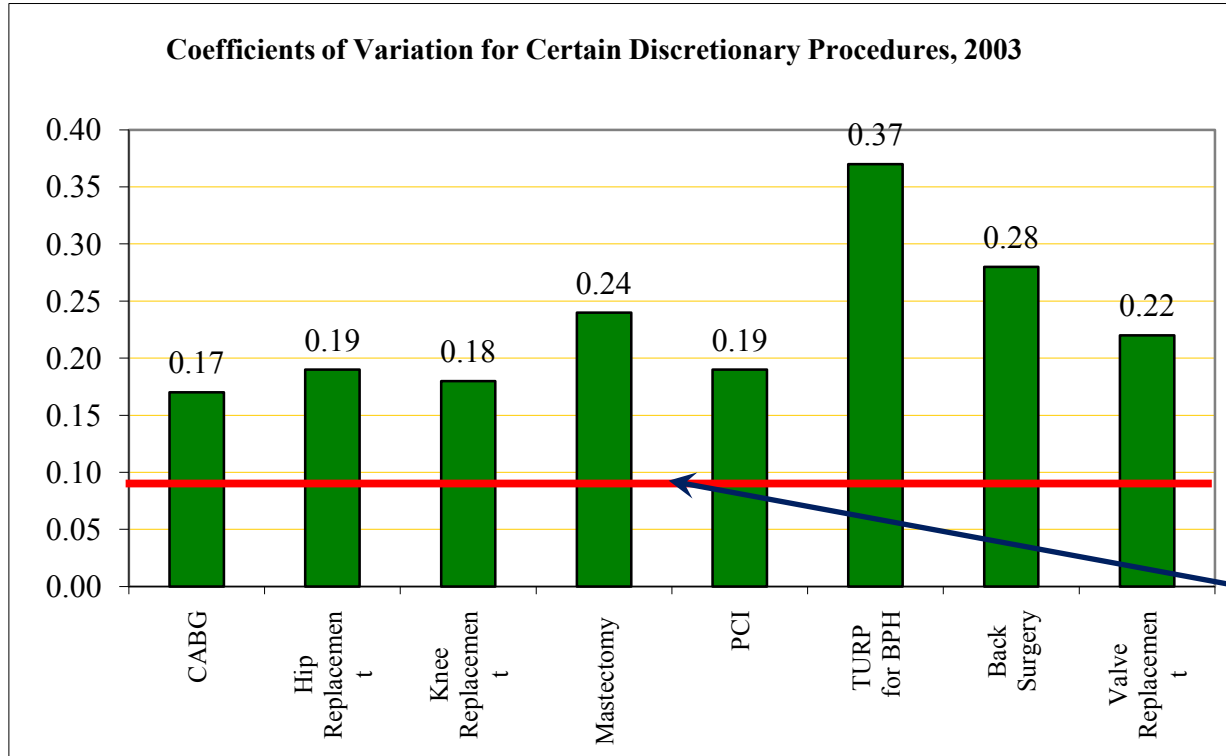
The chart shows a graphic presentation of the data presented on the previous two pages. The chart does not include all medical procedures shown in Appendix 1, only those that are discussed further in the investigation.

The solid horizontal line shows the coefficient of variation for the benchmark hip fracture repair at 0.09. All other procedures have coefficients of variation far above the benchmark figure.

Source: Dartmouth Atlas of Healthcare, Data Tables, Hospital referral regions (HRRs): Regional markets for tertiary medical care.
Downloaded from the internet on September 24, 2006 at address:

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Medicare Reimbursements for Inpatient Short Stays per Enrollee, Florida HRR's, 2000-2005

City Name	HRR	Reimbursement per Enrollee			Reimbursement per Enrollee		
		Reimbursements 2000	Reimbursements 2005	%Change 2000-2005	Z-Score Reimbursements 2000	Z-Score Reimbursements 2005	Z-Score %Change 2000-2005
Bradenton	115	2,350	2,110	-10.2%	(0.41)	(1.19)	(0.95)
Clearwater	116	2,503	2,824	12.8%	(0.02)	0.37	0.44
Fort Lauderdale	118	2,710	2,687	-0.8%	0.50	0.07	(0.39)
Fort Myers	119	2,261	2,328	3.0%	(0.64)	(0.71)	(0.16)
Gainesville	120	2,744	2,989	9.0%	0.59	0.73	0.20
Hudson	122	2,533	2,431	-4.0%	0.05	(0.49)	(0.58)
Jacksonville	123	2,765	2,956	6.9%	0.64	0.66	0.08
Lakeland	124	2,272	2,758	21.4%	(0.61)	0.23	0.95
Miami	127	3,688	3,905	5.9%	3.00	2.74	0.02
Ocala	129	2,220	2,411	8.6%	(0.75)	(0.53)	0.18
Orlando	130	2,492	2,900	16.4%	(0.05)	0.54	0.65
Ormond Beach	131	2,011	2,428	20.7%	(1.28)	(0.49)	0.91
Panama City	133	3,030	3,007	-0.8%	1.32	0.77	(0.38)
Pensacola	134	2,359	2,491	5.6%	(0.39)	(0.35)	0.00
Sarasota	137	2,128	1,720	-19.2%	(0.98)	(2.04)	(1.49)
St. Petersburg	139	2,386	2,707	13.5%	(0.32)	0.12	0.47
Tallahassee	140	2,154	2,351	9.2%	(0.91)	(0.66)	0.21
Tampa	141	2,617	2,756	5.3%	0.27	0.22	(0.02)
Adjusted State Average		2,578	2,743	6.4%			
Unadjusted State Mean Avg		2,512	2,653	5.6%			
Standard Deviation		392	458	16.6%			
Coefficient of Variation		0.156	0.172	10.4%			

Source: http://www.dartmouthatlas.org/

Appendix 2

Medicare Reimbursements for Inpatient Short Stays per Enrollee, Florida HRR's, 2000-2005

**Medicare Reimbursements for Inpatient Short Stays per Enrollee
Percentage Change, 2000-2005**

Lakeland & Ormond Beach show percentage growth in excess of 20% between 2000 & 2005

Source: http://www.dartmouthatlas.org/
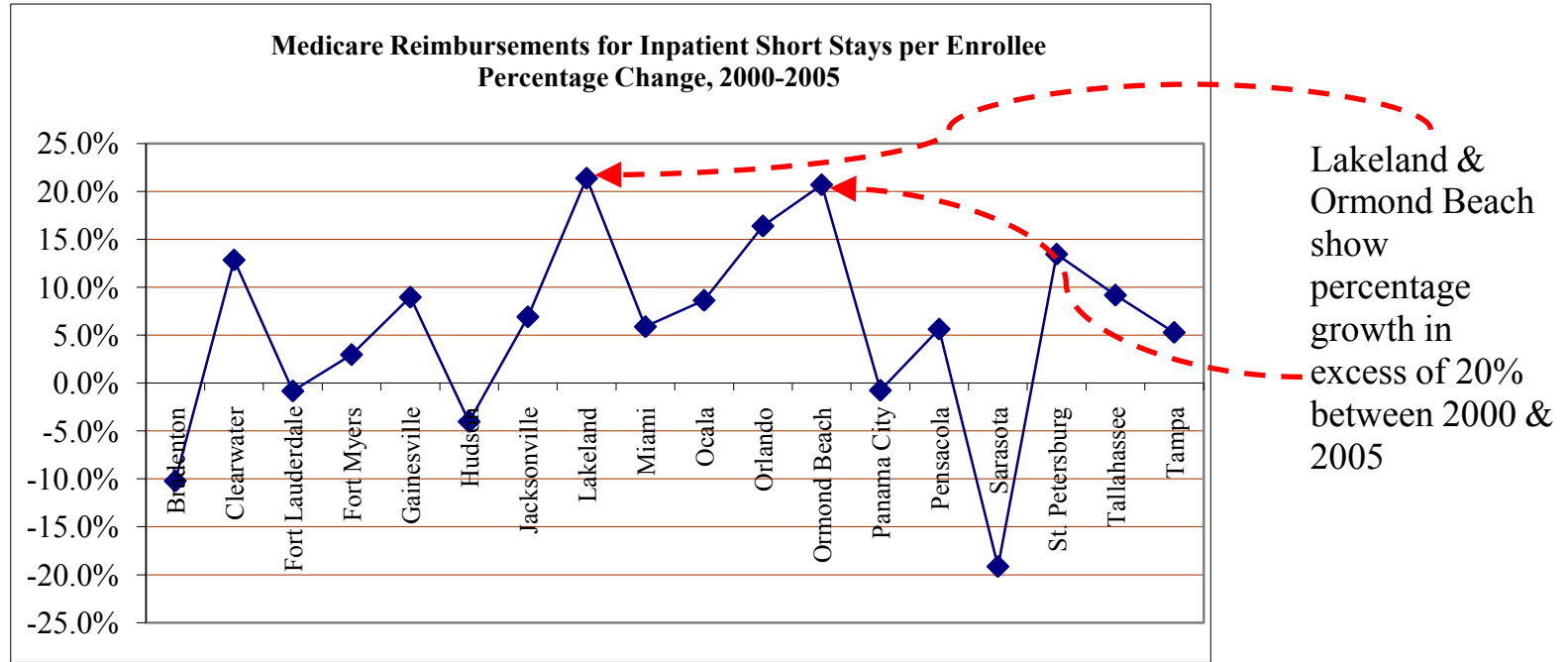
The five-year percentage change between 2000 & 2005 for Medicare reimbursements for inpatient short-term stays per enrollee show substantial fluctuation between Hospital Referral Regions. Growth is higher than 20% in Lakeland and Ormond Beach.   St Petersburg and Clearwater show close to 15%. Sarasota shows a decline of almost 20%. Hudson also shows a decline but by less than 5%.

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Medicare Reimbursements for Inpatient Short Stays per Enrollee, Florida HRR's, 2000-2005

Medicare Reimbursements for Inpatient Short Stays per Enrollee Z-Scores per HRR, 2000

Miami is 3 and Panama City is almost 1.5 standard deviations above the mean.

Source: http://www.dartmouthatlas.org/

This chart shows Medicare reimbursements for short-term hospital stays for each HRR in Florida converted to z-scores, 2000. The chart shows that Miami is 3 standard deviations above the mean with Panama City almost 1.5 standard deviations. Fort Lauderdale, Gainesville, and Jacksonville are each around 0.50 standard deviations above the mean. Ormond Beach is close to 1.5 standard deviations below the mean with Sarasota at almost 1 standard deviation below. The chart shows much fluctuation between Florida HRR's with respect to short term inpatient Medicare reimbursement per enrollee in 2000.

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Medicare Reimbursements for Inpatient Short Stays per Enrollee, Florida HRR's, 2000-2005

Medicare Reimbursements for Inpatient Short Stays per Enrollee
Z-Scores per HRR, 2005

Source: http://www.dartmouthatlas.org

Miami is again shown to have the highest standard deviation above the mean.

Sarasota shows that it is a little more than 2 standard deviations below the mean.

This chart shows Medicare reimbursements for short-term hospital stays for each HRR in Florida converted to z-scores, 2005. Just like the 2000 chart Miami is close to 3 standard deviations above the mean with Panama City almost 1.0 standard deviations above. Sarasota is more than 2 standard deviations below the mean. Although there is still wide fluctuation in the 2005 chart, it doesn't show the extent of variation as was seen in the 2000 chart.

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Appendix 3

Correlation Matrices, TATL Ratio & Selected Discretionary Procedures

Pearson Correlation Coefficients, N = 891 (Prob > | r | under H0: Rho=0)

	TATL	CABG%	PCI%	Valve Repl.%	Fusion%	Hip & Femur%	Joint & Limb%	Knee Proc%	Mastectomy%	Prostate Proc%
TATL	1	0.21904	0.22828	0.20818	0.25655	0.20145	0.19437	0.10465	0.16364	0.22529
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	0.0018	<.0001	<.0001
CABG%	0.21904	1	0.68367	0.93267	0.26449	0.04595	0.13811	0.025	0.14222	0.10612
	<.0001		<.0001	<.0001	<.0001	0.1706	<.0001	0.4561	<.0001	0.0015
PCI%	0.22828	0.68367	1	0.65751	0.26299	0.0348	0.13333	0.1094	0.07686	0.06435
	<.0001	<.0001		<.0001	<.0001	0.2994	<.0001	0.0011	0.0218	0.0548
Valve Repl.%	0.20818	0.93267	0.65751	1	0.25317	0.04819	0.14192	0.03011	0.14089	0.10773
	<.0001	<.0001	<.0001		<.0001	0.1506	<.0001	0.3694	<.0001	0.0013
Fusion%	0.25655	0.26449	0.26299	0.25317	1	0.39632	0.50064	0.27941	0.33878	0.29032
	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001
Hip & Femur%	0.20145	0.04595	0.0348	0.04819	0.39632	1	0.75331	0.28689	0.51225	0.42486
	<.0001	0.1706	0.2994	0.1506	<.0001		<.0001	<.0001	<.0001	<.0001
Joint & Limb%	0.19437	0.13811	0.13333	0.14192	0.50064	0.75331	1	0.36702	0.42016	0.41234
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
Knee Proc%	0.10465	0.025	0.1094	0.03011	0.27941	0.28689	0.36702	1	0.08723	0.07706
	0.0018	0.4561	0.0011	0.3694	<.0001	<.0001	<.0001		0.0092	0.0214
Mastectomy%	0.16364	0.14222	0.07686	0.14089	0.33878	0.51225	0.42016	0.08723	1	0.46431
	<.0001	<.0001	0.0218	<.0001	<.0001	<.0001	<.0001	0.0092		<.0001
Prostate Proc%	0.22529	0.10612	0.06435	0.10773	0.29032	0.42486	0.41234	0.07706	0.46431	1
	<.0001	0.0015	0.0548	0.0013	<.0001	<.0001	<.0001	0.0214	<.0001	

High Pearson correlation coefficients are seen between valve replacement and CABG at 0.93. A high correlation is also observed between valve replacement and PCI at 0.66 and between CABG and PCI at 0.68. High Pearson correlation coefficients are also observed between hip & femur and joint and limb at 0.75 and between joint & limb and fusion at 0.50.

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Appendix 3

Correlation Matrices, TATL Ratio & Selected Discretionary Procedures

Spearman Correlation Coefficients, N = 891 (Prob > | r | under H0: Rho=0)

	TATL	CABG%	PCI%	Valve Repl.%	Fusion%	Hip & Femur%	Joint & Limb%	Knee Proc%	Mastectomy%	Prostate Proc%
TATL	1	0.22896	0.2186	0.22776	0.25362	0.18534	0.24102	0.21276	0.14491	0.23637
		<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
CABG%	0.22896	1	0.88233	0.95561	0.44184	-0.01802	0.18476	0.15605	0.13957	0.19681
	<.0001		<.0001	<.0001	<.0001	0.591	<.0001	<.0001	<.0001	<.0001
PCI%	0.2186	0.88233	1	0.87223	0.5214	0.05011	0.25493	0.21158	0.17048	0.20759
	<.0001	<.0001		<.0001	<.0001	0.135	<.0001	<.0001	<.0001	<.0001
Valve Repl.%	0.22776	0.95561	0.87223	1	0.45688	-0.00474	0.19277	0.15479	0.15283	0.20332
	<.0001	<.0001	<.0001		<.0001	0.8877	<.0001	<.0001	<.0001	<.0001
Fusion%	0.25362	0.44184	0.5214	0.45688	1	0.4336	0.62188	0.42865	0.39627	0.42466
	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001	<.0001	<.0001
Hip & Femur%	0.18534	-0.01802	0.05011	-0.00474	0.4336	1	0.80528	0.46811	0.54058	0.5056
	<.0001	0.591	0.135	0.8877	<.0001		<.0001	<.0001	<.0001	<.0001
Joint & Limb%	0.24102	0.18476	0.25493	0.19277	0.62188	0.80528	1	0.55669	0.5752	0.5526
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001	<.0001
Knee Proc%	0.21276	0.15605	0.21158	0.15479	0.42865	0.46811	0.55669	1	0.32861	0.34445
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001	<.0001
Mastectomy%	0.14491	0.13957	0.17048	0.15283	0.39627	0.54058	0.5752	0.32861	1	0.56564
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001		<.0001
Prostate Proc%	0.23637	0.19681	0.20759	0.20332	0.42466	0.5056	0.5526	0.34445	0.56564	1
	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001	

High Spearman correlation coefficients are shown between valve replacement and CABG at 0.96. A high Spearman coefficient is also shown between valve replacement and PCI at 0.87 and between CABG and PCI at 0.88. High Pearson correlation coefficients are also observed between hip & femur and joint and limb at 0.81 and between joint & limb and fusion at 0.62.

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Appendix 4
HUD Prescribed Median Income Levels by Quartiles for Total (67) Florida Counties

Quartile	2000	2001	2002	2003	2004	2005
1	$35,200	$36,950	$38,050	$39,100	$41,000	$41,000
2	$42,600	$44,100	$46,300	$46,600	$48,600	$48,650
3	$48,500	$50,550	$52,650	$52,600	$54,300	$55,000
4	$59,100	$65,000	$69,800	$61,400	$63,300	$63,300
5/8Q	**$45,550**	**$47,325**	**$49,475**	**$49,600**	**$51,450**	**$51,825**
Mean	$42,034	$43,846	$45,716	$45,500	$47,397	$48,011
St Dev	$7,672	$8,284	$8,910	$7,548	$7,543	$7,594

Source: U.S. Dept. of Housing & Urban Development

Shown above are quartiles for the distribution of median income limits for all counties in Florida for each year, 2000-2005. Quartiles listed include 1st-4th quartiles and also the 5/8 quartile which is half the distance between the 2nd & 3rd quartile. The 5/8 quartile is listed in addition to the other four quartiles because it is used as a breakpoint in the analysis.

Geographic Location in Part 1 was operationalized by using median income per Florida County as a proxy. In model development, plant location was used as a categorical variable with the breakpoint defined at 5/8Q.

Florida county median income levels, 2000-2005, were obtained from the U.S. Dept. of Housing & Urban Development (www.hud.gov).

Appendix 5
Total Medicare HMO Patient Charges,
Valve Replacement & CABG Procedures, Mean Charges by Quartile, 2000-2005

Quartile	2000	2001	2002	2003	2004	2005
1	48,543	55,095	66,257	72,440	87,090	98,255
2	63,491	72,415	90,931	105,210	124,680	135,127
3	87,247	99,596	124,383	149,477	173,892	180,904
4	356,229	783,196	573,612	648,020	731,168	913,265
5/8Q	75,369	86,006	107,657	127,343	149,286	158,015
Mean	74,143	84,343	104,781	121,816	141,848	153,562

Total charges was used as both a continuous and categorical variable.
For categorical analysis, total charges was converted to a dichotomy.
The breakpoint to define high vs. low total charges was at 5/8Q.

A special provision was used for Total Charges in categorical analysis
because charges increase appreciably each year. To adjust for these
increases the 5/8Q breakpoint was annualized, where the 5/8Q
breakpoint equals $75,369 for year 2000, 86,006 in 2001, 107,657 in
2002, etc.

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Appendix 6		
AHCA 11 Inspection Regions by Florida Geographic Sector		
Sector	**Inspection Region**	**Florida Counties**
North	1	Escambia, Okaloosa, Santa Rosa, Walton
	2	Bay, Calhoun, Franklin, Gadsden, Gulf, Holms, Jackson, Jefferson, Leon, Liberty, Madison, Taylor, Wakulla, Washington
	3	Alachua, Bradford, Citrus, Columbia, Dixie, Gilchrist, Hamilton, Hernando, Lafayette, Lake, Levy, Marion, Putnam, Sumter,
	4	Baker, Clay, Duval, Flagler, Nassau, St. Johns, Volusia
Central	5	Pasco, Pinellas
	6	Hardee, Highlands, Hillsborough, Manatee, Polk
	7	Brevard, Orange, Osceola, Seminole
South	8	Charlotte, Collier, De Soto, Glades, Hendry, Lee, Sarasota
	9	Indian River, Martin, Okeechobee, Palm Beach, St. Lucie
	10	Broward
	11	Dade, Monroe

Source: http://ahcaxnet.fdhc.state.fl.us/nhcguide/static/state_inspection.html

The north geographic sector is comprised of inspection regions 1-4 which are comprised of 41 Florida counties. Inspection areas 5-7 comprise the central geographic sector which contains 11 Florida counties. The south sector is comprised of inspection areas 8-11 and include 15 Florida counties.

Variance-Covariance Matrix - Model 1-B

		B$_0$	B$_1$X	B$_2$P	B$_3$C	B$_4$R	B$_5$XP	B$_6$XC	B$_7$XR
	Variables	Intercept	Ownership	Plant Location	Z-Cardiac Grp	Z-Orth Grp	Ownership x Plant Location	Ownership x Z-Cardiac Grp	Ownership x Z-Orth Grp
	Parameter Estimates	2.03691	2.76579	0.09568	0.000404	-0.077899	2.23255	1.14022	2.33852
B$_0$	Intercept	0.0647	-0.0647	-0.06683	0.006073	0.007504	0.06683	-0.00607	-0.0075
B$_1$X	Ownership	-0.0647	0.1475	0.06683	-0.006073	-0.007504	-0.15118	0.00708	0.01687
B$_2$P	Plant Location	-0.06683	0.06683	0.11686	-0.00629	-0.014402	-0.11686	0.00629	0.0144
B$_3$C	Z-Cardiac Group	0.00607	-0.00607	-0.00629	0.042503	-0.004756	0.00629	-0.0425	0.00476
B$_4$R	Z-Orth Group	0.0075	-0.0075	-0.0144	-0.004756	0.027478	0.0144	0.00476	-0.02748
B$_5$XP	Ownership x Plant Location	0.06683	-0.15118	-0.11686	0.00629	0.014402	0.25943	-0.01098	-0.02836
B$_6$XC	Ownership x Z-Cardiac Group	-0.00607	0.00708	0.00629	-0.042503	0.004756	-0.01098	0.06626	-0.00953
B$_7$XR	Ownership x Z-Orth Group	-0.0075	0.01687	0.0144	0.004756	-0.027478	-0.02836	-0.00953	0.06524

Marginal Effects & Standard Errors for Orthopedic Group Procedures x Ownership

Orthopedic Group Procedures when Ownership = 1

Marginal Effect (B$_4$ when X = 1) = -0.077899 + X(2.33852) =   2.2606

$$\sigma_{\partial Y/\partial Z} = [var(B_4) + X^2 var(B_7) + 2X cov(B_4 B_7 X)]^{1/2}$$

$$= \sqrt{0.027478 + X^2(0.06524) + 2X(-0.027478)} = \quad 0.1943$$

t = 2.2606 / 0.1943 =   11.6332

Variance-Covariance Matrix - Model 1-B

Marginal Effects & Standard Errors for Cardiac Group Procedures x Ownership

Cardiac Group Procedures when Ownership = 1

Marginal Effect (B_3 when X = 1) = -0.000404 + X(1.14022) = 1.1406

$\sigma_{\partial Y/\partial C} = [var(B_3) + X^2 var(B_6) + 2X cov(B_3 B_6 X)]^{1/2}$

$= \sqrt{0.042503 + X^2(0.06626) + 2X(-0.042503)} =$ 0.1541

t = 1.1406 / 0.1541 = 7.4003

Marginal Effects & Standard Errors for Geographic Location x Ownership

Plant Location when Ownership = 1

Marginal Effect (B_2 when X = 1) = 0.09568 + X(2.2326) = 2.3283

$\sigma_{\partial Y/\partial C} = [var(B_2) + X^2 var(B_5) + 2X cov(B_2 B_5 X)]^{1/2}$

$= \sqrt{0.11686 + X^2(0.25943) + 2X(-0.11686)} =$ 0.3776

t = 2.3283 / 0.3776 = 6.166

Appendix 8
Part 1, Model 1-B - Collinearity Diagnostics (Intercept Adjusted)

Proportion of Variation

No.	Eigen value	Condition Index	Ownership	Plant Location	Z-CGP*	Z-OGP*	Ownership x Plant Location	Ownership x Z-CGP*	Ownership x Z-OGP*
1	2.27838	1	0.01059	0.02675	0.02887	0.0327	0.02124	0.02737	0.03349
2	1.64416	1.17717	0.07403	0.01788	0.02302	0.01423	0.05671	0.02454	0.015
3	1.44932	1.25381	0.01042	0.01248	0.04609	0.10339	0.00030739	0.04872	0.09102
4	0.91108	1.58138	0.11975	0.34395	0.00053634	0.01353	0.00028198	2.57E-07	0.05398
5	0.37885	2.45232	0.05096	0.00115	0.03311	0.61607	0.03346	0.02533	0.57571
6	0.1876	3.48496	0.01665	0.01478	0.79894	0.13953	0.02604	0.80264	0.13621
7	0.15061	3.8894	0.7176	0.58301	0.06943	0.08056	0.86196	0.07141	0.09458

Eigen values close to zero signify serious problems of multicollinearity. But no Eigen values shown in this matrix appear to be close to zero.

As a rule of thumb a condition index > 30 indicates serious problems of multicollinearity. None of the condition index values are even above 3.9.

*CGP: Cardiac Group Procedures
*OGP: Orthopedic Group Procedures

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Appendix 9

Technical Appendix
Circumventing a Possible Specification Error
Supplement to Part 1, Models 1-A & 1-B

Introduction

In the Regression Diagnostics section under Part 1 (Chapter 7), specifically under the discussion on Specification Error (page 134) a reference is made to Appendix 9. This is a technical appendix that is added to the analysis to help avoid the possibility of a specification error in this project.

A specification error occurs in a model that does not include a certain variable(s) when its presence is warranted. Specification errors are often discussed in the context of incorporating a higher order term(s) when there is a curvilinear, as opposed to a linear, association. Higher order terms may also refer to interacting variables that should have been placed in the model.

Another type of specification error may occur when certain variables are not included, but are theoretically grounded and conceptually relevant to the model. Excluding one or more of these variables may result in a specification error as well as attenuated confidence in the model's validity.

One of the objectives in this project has been to formulate parsimonious models; to create efficient models using only a few variables that directly contribute to the model and address hypotheses. This objective was carried out in the development of models 1-A and 1-B in Part 1 of the narrative (Chapter 7). But the enforcement of objectives for parsimony and model efficiency should not occur at the price of foregoing otherwise valuable information, especially when an expanded model may include additional

variables of which theory and prior research has established their association with the dependent variable.

If a specification error occurred in models 1-A and 1-B in Part 1 due to the exclusion of important variables, then an important question arises in connection with these models: can similar results be obtained with additional, relevant variables entered into the model, or will an expanded model provide new information that may alter conclusions reached earlier in Part 1? This question will be addressed via two additional models, entitled Model 1-C and Model 1-D in this appendix.

If the inclusion of additional variables results in, for example, lower betas or perhaps even insignificant p-values for the association between the total assets/total liabilities (TATL) ratio and cardiac and orthopedic group procedures, then it may be concluded that the models in Part 1 are less reliable than initially imagined. On the other hand, if the associations between the TATL ratio and cardiac and orthopedic group procedures are similar in the presence of these additional variables, then greater confidence can be placed in these associations, evidenced by both parsimonious and expanded models.

Adding this technical appendix which tests Part 1 models using three additional and very relevant variables is an important endeavor. These three additional variables will reflect labor costs, hospital occupancy, and market conditions. Without this appendix questions may arise as to whether the analysis was incomplete and if model validity and results could be fully trusted.

Recap of Part 1 Variables

Before these three additional variables are presented, it is necessary to provide a recap of the variables that were already used in models 1-A and 1-B in Part 1 of the narrative. These original variables included the dependent variable TATL ratio, and independent variables ownership, geographic location, cardiac group procedures, and orthopedic group procedures. A brief summary of these variables are restated in the next few brief paragraphs.

The TATL ratio (total assets ÷ total liabilities) is the reciprocal of the debt ratio, (total liabilities ÷ total assets). Total liabilities include current and long-term liabilities, and total assets include current and fixed assets as well as other assets such as goodwill if relevant.

As the inverse to the debt ratio, the TATL ratio is an indicator of liquidity vs. leverage and is a measure of both cash-flow and balance sheet solvency. Essentially, it is a measure of long-term financial health and stability.

Cardiac group procedures represent a set of DRG codes under Major Diagnostic Category (MDC) 5 and include valve replacements, coronary artery bypass grafts (CABG), and percutanious coronary interventions (PCI). Orthopedic group procedures represent DRG codes under MDC 8 and include major joint & limb reattachment, hip & femur procedures, spinal fusions, and knee procedures. A full listing of these procedures with corresponding DRG codes can be found on Table 6 in Chapter 3 of the narrative.

Both cardiac and orthopedic group procedure variables are expressed as percentages which are calculated for each hospital via cardiac procedures reimbursed by conventional Medicare ÷ total procedures including all payers. Percentages of orthopedic

group procedures are calculated in the same fashion for each hospital via orthopedic group procedures reimbursed by conventional Medicare ÷ total procedures including all payers.

Ownership is a dummy variable to contrast investor owned from not-for-profit hospitals with not-for-profits as the base level. Geographic location is a dummy variable to contrast hospitals located in higher income vs. lower income counties with hospitals in lower income counties as the base level. The breakpoint to determine higher income counties is the $\geq \frac{5}{8}$ median income quartile for the median income distribution for all Florida counties.

Three Additional Variables

As mentioned in the Introduction of this appendix, there are three additional dimensions that could be explored in connection with models in Part 1. These include labor costs, market conditions, and facility sizing. These three dimensions will be operationalized by three different continuous variables. Labor costs will be measured by the variable manhours per adjusted patient day for each hospital. Market conditions will be measured by the Herfindahl-Hirshman Index (HHI) for HMOs for each county, and facility sizing will be measured by hospital occupancy percentage for each hospital. These three variables will be discussed more fully in the following three subsections.

Labor Costs – Manhours per Adjusted Patient Day

There are lengthy discussions regarding labor costs and the efficient use of resources in hospitals in the literature review in Chapter 2 of the narrative. These discussions provide much information on the association between a strong balance sheet, reflected in a high TATL ratio, and labor costs.

Several variables were explored which represent labor costs and include hospital average annual LOS, salary per adjusted admission, full-time-equivalency (FTE), and salary per FTE. However, the best variable that was found to reflect labor costs was manhours per adjusted patient day. This variable is a ratio represented as follows.

Manhours per adjusted patient day
= Manhours ÷ {(Total of acute and intensive care patient days)
÷ [(Total inpatient revenue – Inpatient sub-acute revenue) ÷ Gross revenue]}

Manhours are defined as one work year, which is 2080 hours for one full time employee multiplied by the number of fulltime equivalent employees. Adjusted patient days are the sum of acute patient days and intensive care patient days divided by the ratio of inpatient revenues generated from acute, intensive, ambulatory, and ancillary patient services to gross revenue (AHCA 2005).

It is intuitive that measures of hospital profitability would be inversely related to labor costs, and evidence supporting this supposition is replete in the literature. It was also surmised that investor owned hospitals would have fewer mean average manhours per adjusted day relative to not-for-profits. An examination of the AHCA financial dataset, 2000-2005, revealed that investor owned hospitals have a mean average of 22.90 manhours per adjusted patient day with a standard deviation of 10.98. Not-for-profits, on the other hand, show a mean average of 26.36 manhours per adjusted patient day with a standard deviation of 10.27.

These differences between investor owned and not-for-profit hospitals were supported by Sear (1991) who found that hospital profitability and solvency are associated with reduced manhours per adjusted patient day. Sear examined 50 investor owned and 60 not-for-profit hospitals in Florida for the period from 1982 through 1988.

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The results indicated that "investor-owned hospitals used significantly fewer FTE staff per bed, had significantly fewer manhours per adjusted patient day, and paid significantly less in wages and had significantly higher operating margins (profit) than did the not-for-profit institutions."

Observing mean differences between investor owned and not-for-profit hospitals with respect to mean average man-hours per adjusted day, and noting Sear's findings, in the model development phase of the analysis it was conjectured that interaction may exist between ownership and manhours per adjusted patient day. Tests showed that the variable, manhours per adjusted patient day, was a good control variable in that it had a strong inverse correlation with the TATL ratio. However, interaction was not found for ownership x adjusted manhours per patient day.

Facility Sizing – Patient Occupancy

It is advantageous for a hospital to be of optimum size, not to contain more beds than are necessary, but just enough beds to meet patient demand. "The nontrivial costs of building, staffing, and maintaining unused beds are unnecessary and are ultimately borne by the health care consumer….considerable savings are possible by eliminating beds in an over-bedded hospital (saving variable costs) and by preventing the construction of unneeded beds (saving both fixed and variable costs)" (Hancock, Magerlein, Storer, et al 1978).

A good measure for optimum facility size is hospital occupancy. Even if a hospital performs procedures that are very profitable in terms of DRG reimbursement, profitability will still be enervated if patient occupancy is low.

Patient occupancy is a calculation used to show the actual utilization of an inpatient health facility for a given period of time. "Occupancy rate and average length of stay are common measures of efficiency which provide a rough measurement of how well hospitals are utilizing their primary resource; bed capacity" (Plante 2009).

Occupancy rate is available in the AHCA financial data as an annual adjusted mean percentage of occupancy for licensed staffed acute beds during a reporting period (e.g., one year) (AHCA 2005). The formula for occupancy is shown as follows:

$$\textit{Number of total inpatient service days}$$
$$\div \textit{Bed days available}$$

Total inpatient service days (i.e., days of care) are the sum of each daily inpatient census for the reporting period. Bed days available are equal to the number of staffed beds multiplied by the number of days in the reporting period. For example, a hospital with 50 beds would have an annual 18,250 bed days available (50 x 365) (Pennsylvania DOH 2001).

In addition to facility sizing there is another reason why occupancy is important in the development of models in Part 1 and in this appendix. Recall that in the narrative it was discussed that investor owned hospitals, on the average, have fewer beds than not-for-profit hospitals. The AHCA financial dataset, 2000-2005, shows that the mean average for beds in investor owned hospitals is 207 with a standard deviation of 120 and a maximum of 531. In contrast, not-for-profits, which included religious and other not-for-profit and hospital district hospitals, showed a mean average of 301 beds with a standard deviation of 230 and a maximum of 955.

Since investor owned hospitals have fewer beds, averaging a hundred beds less than not-for-profits, then by performing higher rates of certain discretionary procedures,

certain investor owned hospitals not only fill their beds with more profitable DRG codes, but also use fewer beds for less profitable codes.

What was surprising in examining the AHCA financial data was that not-for-profits showed slightly higher occupancy rates than investor owned hospitals. It was expected that the mean occupancy rate in investor owned hospitals would exceed that of not-for-profits. The mean occupancy rate for all hospitals in the study, 2000-2005, was 46.19 percent, while not-for-profits showed 47.10 percent, and investor owned hospitals showed only 44.83 percent.

The difference in occupancy rate changes when the analysis is stratified not only by ownership, but also by TATL ratio levels. Recall that in the narrative the TATL ratio distribution was segmented into quartiles. When occupancy is reviewed to only include investor owned hospitals with TATL ratios equal to or exceeding the $\frac{5}{8}$ TATL ratio quartile then mean occupancy jumps up to 49.27 percent. Occupancy was then examined to include only investor owned hospitals with TATL ratios equal to or exceeding the third TATL ratio quartile and the mean rate jumped again to 50.58 percent.

Based on a review of occupancy rates stratified by ownership and TATL ratio it was determined that interaction existed between ownership and occupancy in their association with the dependent variable. This is discussed further in the Preliminary Analyses and Model Development sections in this appendix.

Occupancy, as reported in the AHCA financial data, 2000-2005, was determined to be a useful control variable with a positive association between it and the TATL ratio.

Market Concentration – HMO Herfindahl-Hirschman Index (HHI)

The models presented in this technical appendix attempt to adjust for market conditions by incorporating an additional variable, the HMO HHI. Market conditions in the context of HMO markets refer to the number of health plans competing with each other in a geographic area. Fewer available health plans reduce a hospital's flexibility and negotiating leverage, leading to lower reimbursement, while a broad selection of plans gives a hospital a bargaining advantage.

As will be discussed subsequent to the Model Development section, the inclusion of the HMO HHI is only one aspect of market conditions. In future research there should also be consideration in using the hospital HHI in addition to the HMO HHI.

A Brief Discussion of the HHI

Before proceeding with the analysis, a brief discussion of the HHI is presented. The HHI, attributed to economists Orris C. Herfindahl and Albert O. Hirschman, has been applied in research on market competition, technology management, and antitrust law (Szpiro 1987, The Brandes Institute 2004). "The HHI is one of the most commonly used indicators to detect anticompetitive behavior in industries. In fact, an increase in the value of the index is usually interpreted as an indicator of actions which may lessen competition or even create a monopoly" (Matsumoto, Merlone, Sxidarovsky).

A low HHI indicates that market concentration is low which indicates vigorous competition reflecting that a large number of firms are operating with small market shares. In contrast, a high HHI indicates greater market concentration where economic output is carried out by a small number of firms resulting in weak competition (Rhoades 1993).

The HHI has been used in previous research in measuring horizontal integration of healthcare markets. Horizontal integration often raises antitrust concerns because a newly combined firm will have a larger market share than either firm did before merging (Whinston 2006).

From an economic and sometimes legal perspective, a high degree of concentration reflecting a lack of competition may be evidence of an industry's antitrust concerns. In general the HHI can be a warning signal of possible antitrust problems as well as the emergence of a monopoly or oligopolies within an industry (Zimmerman 2009). For this reason the HHI is used by the federal government to monitor the effects on markets due to mergers and acquisitions. "Transactions that increase the HHI by more than 100 points in concentrated markets presumptively raise antitrust concerns under the Horizontal Merger Guidelines issued by the U.S. Department of Justice and the Federal Trade Commission" (www.justice.gov).

Calculating the HHI

The HHI is written as follows:

$$HHI = \sum_{i=1}^{N} (MS_i)^2$$

MS is the market share of firm i in the market, and N is the number of firms (Rhodes 1993). An example of the HHI calculation would be if a market had only two firms, and each had 50 percent market share. The HHI would equal $0.50^2 + 0.50^2 = 0.50$ (Pogodzinski 2010, Pilsbury & Meaney 2009).

Depending on the preference of the researcher, HHI observations may be expressed as a decimal or as a whole number. When whole numbers are used 10,000

represents the maximum value, representing the existence of a monopoly in which one firm has 100 percent of the market, that is, the $HHI = (100)^2 = 10,000$. Conversely, the HHI takes on a very small value theoretically approaching zero if the market is purely competitive where there are many firms with small market shares. For example, in a market with 100 firms where each have a one percent share of the market the $HHI = (1_1) + (1_1) \ldots (1_{100}) = 100$ (Rhoades 1993).

When expressed as a decimal the HHI ranges from 0 to 1.0 representing a continuum of market concentration which progresses from a large number of very small firms to a single monopolistic firm. As the HHI approaches zero it is an indication of perfect competition, and as an HHI approaches 1.0 it indicates market domination by an oligopoly or monopoly. Increases in the HHI indicate an increase in market power and a decrease in competition. Conversely, a decrease in the HHI represents decreasing market power and an increase in competition (Pogodzinski 2010).

Market concentration is often represented by HHI intervals. It is usually considered that an HHI below 0.01 (or 100 when using whole numbers) represents a highly competitive market. An HHI below 0.1 (1,000) represents a non-concentrated index. An HHI between 0.1 and 0.18 (1,000 to 1,800) indicates moderate concentration, and an HHI above 0.18 (> 1,800) indicates high market concentration (Pogodzinski 2010, National Grid 2009), and perhaps market domination by a monopoly or oligopoly (Powell 2007, U.S. DOJ & Federal Trade Commission 1997).

The HHI and Healthcare Markets

The interpretation of the HHI, discussed above, is not totally consistent with hospital and HMO markets. Healthcare, specifically HMO, markets tend to show higher HHIs per city or county. For example, an examination of the HMO HHI data for all counties in Florida, 2000-2004, reveals a mean of 0.2982 (or 2,982). This is consistent with average HHIs in many other parts of the nation. Table 1 provides a breakdown of HMO/PPO HHIs for 2008 and Hospital Discharge HHIs for 2007 by several cities and states across the country.

Table 1
A Delineation of HMO/PPO HHI, 2008 & Hospital System Discharge HHI, 2007
A Survey of Various Cities Across the Nation

City/State	HMO/PPO HHI, 2008	Hospital System Discharge HHI, 2007
Sarasota, FL	1,734	2,436
Honolulu, HI	6,357	1,349
Boise, ID	3,159	2,740
Grand Rapids, MI	4,299	2,623
Knoxville, TN	2,221	1,483
New Port News, VA	1,844	2,302
Fresno, CA	2,260	1,318
San Francisco, CA	2,024	1,659
Fort Wayne, IN	3,112	2,236
Macon, GA	5,507	1,555
Lafayette, LA	4,045	1,014
Beaumont, TX	3,289	2,884
Corpus Christi, TX	2,678	3,226

Source: Pyenson, B., Kosuke, I., Goldberg, S. et al (March 2010) "High Value for Hospital Care: High Value for All," National Business Group on Health

As shown in Table 1, none of the HMO/PPO HHIs listed show an HHI less than 1,800, a threshold which denotes a monopoly or oligopoly in many other industries. Healthcare markets behave somewhat differently than many other markets.

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HHI's Usefulness as a Control Variable

As already mentioned, the HHI is useful as a control variable because it reflects healthcare market concentration, the tendency of a market to be dominated (the extent to which price and output are controlled) by a few large firms. In this case the HMO HHI is a useful control variable reflecting market penetration of HMO plans and their tendency of controlling contract terms and reimbursement levels to hospitals. Therefore, it was anticipated that there would be an inverse association between hospitals' TATL ratio and market concentration.

Although an inverse association between the TATL ratio and the HMO HHI was anticipated, a positive, albeit weak, association is what was found. This anomaly was investigated, and reasons why this unexpected association may have occurred is further discussed following the Model Development section.

Data Integrity: Three Caveats

Before proceeding with model development a few caveats regarding the dataset should be disclosed. First, an HMO HHI was available for each county in Florida, but only for years 2000-2004; data for 2005 was unavailable. But keep in mind that there is not considerable variation by county in the HHI from year to year. Since the HMO HHI is not available for 2005, using 2004's HHI for both 2004 and 2005 would be acceptable.

The second caveat is that there are three missing values for hospital occupancy. Data entry for this variable was done manually by the author, and occupancy could be identified for all but three hospitals. This means that the dataset is reduced from 891 to 888 observations. Considering that occupancy is an important variable, and since lost

data only represents three observations, it was determined to keep occupancy in the model.

<center>**Preliminary Analyses**</center>

Descriptive Statistics

The preliminary analysis begins with a presentation of some descriptive statistics, shown in Table 2, for the three additional variables, manhours per adjusted patient day, occupancy, and HMO HHI. Certain types of descriptive statistics have already been provided regarding these three variables, but they are aggregated below so they can be viewed simultaneously in one table. These statistics are presented for total hospitals and hospitals stratified by ownership.

Table 2
Descriptive Statistics for Manhours per Adjusted Patient Day, Occupancy & HMO HHI,
Total, Investor Owned & Not-for-Profit Hospitals, 2000-2005

Variables	All Hospitals		Investor Owned		Not-for-Profits	
	Mean	Std Dev	Mean	Std Dev	Mean	Std Dev
Manhours per Adjusted Patient Day	24.84	10.70	22.96	10.93	26.36	10.27
Occupancy	0.4619	0.2592	0.4494	0.2642	0.4719	0.2549
HMO HHI	0.2982	0.2191	0.3201	0.2409	0.2805	0.1983

An important element in this table is the standard deviation for each variable. As will be discussed, continuous variables in these models are expressed as z-scores. Using the association between the TATL ratio and occupancy percentage as an example, a change in the TATL ratio would not correspond to a one percent change in occupancy. Instead, correct interpretation would be a change in the TATL ratio corresponding to a change in occupancy by one standard deviation, 0.2592.

Preliminary Tests

A number of preliminary tests, many similar to those performed in Part 1 of the narrative, were completed for the analysis presented in this appendix. One of these tests included the calculation of correlation coefficients for the TATL ratio, HMO HHI, occupancy, and manhours per adjusted day, which is shown in tables 3 & 4. These tables provide measures of association using the Pearson correlation test for linear dependence and the Spearman test of ordinal rankings.

Since other variables used in this appendix, such as cardiac and orthopedic group procedures, were already tested under Part 1 of the narrative, they are not presented in tables 3 & 4.

Tests of Association Using Pearson & Spearman Correlation Coefficients

Table 3 presents a correlation matrix using Pearson coefficients for the TATL ratio, HMO HHI, occupancy, and manhours per adjusted patient day.

Table 3
Pearson Correlation Coefficients for TATL, HMO HHI, Occupancy & Manhours per Adj. Day, All Hospitals, 2000-2005

Variables	TATL	HMO HHI	Occupancy	Manhours per Adj. Day
TATL	1	0.07042	0.06643	-0.14506
		(0.0356)	(0.0477)	(<.0001)
HMO HHI	0.07485	1	-0.13257	0.07718
	(0.0255)		(<.0001)	(0.0213)
Occupancy	0.06643	-0.13257	1	-0.0624
	(0.0477)	(<.0001)		(0.0631)
Manhours per Adj. Day	-0.14506	0.07718	-0.0624	1
	(<.0001)	(0.0213)	(0.0631)	

As shown in Table 3 all correlation coefficients between the TATL ratio and HMO HHI, occupancy, and manhours per adjusted patient day are significant ($p < 0.05$)

but not very high. The highest negative coefficient, demonstrating an inverse association, is between the TATL ratio and manhours per adjusted day at -0.145 (p < 0.0001).

It was anticipated that a negative correlation coefficient, reflecting an inverse association, would be found between the TATL ratio and HMO HHI, but the table shows a significantly positive, albeit very low coefficient. There is also an expected negative coefficient shown between the HMO HHI and occupancy at -0.133 (p < 0.0001).

A high negative coefficient, indicating an inverse association, was expected to be found between occupancy and manhours per adjusted day. The supposition was that higher occupancy would result in greater efficiency in labor costs. But the correlation coefficient between occupancy and manhours per adjusted patient day was non-significant (p = 0.0631).

Table 4 shows the same analysis as in Table 3, but using Spearman correlation coefficients.

Table 4
Spearman Correlation Coefficients for TATL, HMO HHI, Occupancy & Manhours per Adj. Day, Total Hospitals, 2000-2005

Variables	TATL	HMO HHI	Occupancy	Manhours per Adj. Day
TATL	1	0.03063	0.12737	-0.26856
		(0.361)	(0.0001)	(<.0001)
HMO HHI	0.03161	1	-0.13975	0.0961
	(0.3460)		(<.0001)	(0.0041)
Occupancy	0.12737	-0.13975	1	-0.09831
	(<0.0001)	(<.0001)		(0.0034)
Manhours per Adj. Day	-0.26856	0.0961	-0.09831	1
	(<.0001)	(0.0041)	(0.0034)	

The Spearman coefficient is higher than the Pearson for the associations between the TATL ratio and occupancy at 0.127 (p < 0.0001).   A higher negative coefficient is

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found between the TATL ratio and manhours per adjusted patient day at -0.269 (p < 0.0001). An anticipated inverse association between the TATL ratio and the HMO HHI was again left unsubstantiated with a positive non-significant coefficient of 0.0316 (p = 0.3460). An inverse association was found again, as it was using the Pearson coefficient, between the HMO HHI and occupancy with a coefficient of -0.1398 (p < 0.0001).

Tests of Association Exclusively for Investor Owned Hospitals

Tests of association, stratified by ownership, were also performed. Tables 5 and 6 provide findings using both the Pearson and Spearman correlation coefficients applied exclusively to investor owned hospitals.

Table 5
Pearson Correlation Coefficients for TATL, HMO HHI, Occupancy & Manhours per Adj. Day, Exclusively for Investor Owned Hospitals, 2000-2005

Variables	TATL	HMO HHI	Occupancy	Manhours per Adj. Day
TATL	1	0.0243	0.1571	-0.1147
		(0.6295)	(0.0017)	(0.0225)
HMO HHI	0.03474	1	-0.1267	0.1725
	(0.4901)		(0.0116)	(0.0006)
Occupancy	0.1571	-0.1267	1	-0.1209
	(0.0017)	(0.0116)		(0.0162)
Manhours per Adj. Day	-0.1147	0.1725	-0.1209	1
	(0.0225)	(0.0006)	(0.0162)	

Pearson coefficients show a non-significant association between the TATL ratio and the HMO HHI when the analysis is stratified to include only investor owned hospitals. The coefficient between the TATL ratio and occupancy is significantly positive with a coefficient of 0.1571, and the coefficient between the TATL ratio and manhours per adjusted patient day is significantly negative, -0.1147 (p = 0.0225) reflecting an inverse association.

The matrix also shows an expected negative coefficient of -0.1267 (p = 0.0116) between manhours per adjusted patient day and occupancy. This reflects that as occupancy increases so does efficiency in the use of personnel. There is also a positive coefficient between the HMO HHI and manhours per adjusted patient day. This reflects that as market concentration increases labor efficiency, in turn, decreases.

Table 6 now shows Spearman rank order correlation coefficients exclusively for investor owned hospitals.

Table 6
Spearman Correlation Coefficients for TATL, HMO HHI, Occupancy & Manhours per Adj. Day, Exclusively for Investor Owned Hospitals, 2000-2005

Variables	TATL	HMO HHI	Occupancy	Manhours per Adj. Day
TATL	1	-0.0191	0.2254	-0.2231
		(0.7046)	(0.0001)	(0.0001)
HMO HHI	-0.0191	1	-0.1518	0.2474
	(0.7046)		(0.0025)	(0.0001)
Occupancy	0.2254	-0.1518	1	-0.2532
	(0.0001)	(0.0025)		(0.0001)
Manhours per Adj. Day	-0.2231	0.2474	-0.2532	1
	(0.0001)	(0.0001)	(0.0001)	

The findings in Table 6 using Spearman coefficients are consistent with respect to the association between the TATL ratio and occupancy, except the Spearman coefficient shows greater magnitude between the two variables with a coefficient of 0.2254 (p < 0.0001).

The association between the TATL ratio and manhours per adjusted patient day also shows greater magnitude using the Spearman coefficient at -0.2231 (p < 0.0001).

The coefficient between the TATL ratio and the HMO HHI was found to be negative, indicating the anticipated inverse association, but with a high p-value (0.7046).

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Because of a large magnitude of difference in association between the TATL ratio and occupancy when stratified by ownership interaction was tested and found between these two variables. This is discussed further in the Model Development section.

Assessment of Control Variables

Manhours per adjusted patient day performed best in the preliminary analyses in its inverse association with the TATL ratio. This was demonstrated by Pearson and Spearman correlation coefficients shown in tables 3-6, as well as other preliminary tests carried out in preparation of this appendix. These tests also revealed a positive association between the TATL ratio and occupancy, as well as elucidated the presence of interaction between ownership and occupancy in their association with the TATL ratio.

The HMO HHI variable did not perform well in preliminary analyses. Association between the TATL ratio and the HMO HHI, depending on the test that was used, was shown to be either non-significant or very small. The positive association between profitability or solvency and the HMO HHI, which was found using the Pearson coefficient in Table 3, is also inconsistent with theory, as there should be an inverse association between the TATL ratio and the HMO HHI. Lower hospital TATL ratios should correspond to higher HMO HHI concentration.

The inability of preliminary tests to show a strong inverse association between the TATL ratio and the HMO HHI does not always mean that an association fails to exist. It is just not demonstrated in the tests employed perhaps due to anomalies in the data or other reasons. Therefore, it was determined for the HMO HHI to remain in the models.

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Further discussion will be provided regarding the unanticipated lack of inverse association between the TATL ratio and the HMO HHI following the presentation of the regression models in the Model Development section.

Model Development

As mentioned earlier, under Part1 in the narrative (Chapter 7) there were a main effects and an interaction model, labeled, respectively, Model 1-A and Model 1-B. Because this appendix is technically a continuation of Part 1 the main effects and interaction model will be entitled Model 1-C and Model 1-D. Keep in mind that models 1-C and 1-D are expanded models that include three additional variables representing labor costs per hospital, patient occupancy per hospital, and market concentration per county for all counties in Florida.

As discussed in the narrative, multicollinearity often accompanies interaction terms. Since Model 1-D is an interaction model, steps were taken to manage variance inflation which included the transformation of continuous variables to z-scores. Although no problems with multicollinearity were anticipated with the main effects model, 1-C, z-scores were also used for continuous variables in this model, so that comparisons could be made readily between models 1-C and 1-D.

Now that additional variables have been identified and tested, they can be used in a main effects model.

Model 1-C: Expanded Main Effects Model

Model 1-C is an expanded main effects model that includes the TATL ratio as the dependent variable and seven independent variables. The regression equation for Model 1-C is written below.

$$\hat{y}_{TATL} = \beta_0 + \beta_1 X + \beta_2 P + \beta_3 C + \beta_4 R + \beta_5 H + \beta_6 O + \beta_7 M + \epsilon$$

Where: X = Ownership
           P = Geographic Location
           C = Z-Cardiac Group Procedures
           R = Z-Orthopedic Group Procedures
           O = Z-Occupancy
           H = Z-HMO HHI
           M = Z-Manhours per Adj. Patient Day

The results of the regression model, 1-C, are shown in Table 7.

Table 7
Model 1-C Main Effects Model

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	7	6,020.18	860.026	56.88	<.0001
Error	880	13,305	15.119		
Corrected Total	887	19,325			
Root MSE	3.888		R^2	0.3115	
Dependent Mean	3.97		Adjusted R^2	0.3061	
Coefficient of Variation	98.747				

Table 7 reports a significant F-value in connection with Model 1-C, indicating that at least one variable in the model is significant. A coefficient of variation of 98.747 is also reported which is much higher than the ideal coefficient of 10.0.

The model shows an adjusted R^2 of 0.3061. This is slightly higher than the

adjusted R^2 that was found for the main effects Model 1-A in the narrative. But the

higher R^2 could be due simply to a greater number of variables in the model.

The parameter estimates are now presented for Model 1-C and are shown in Table

8 below.

Table 8
Model 1-C – Expanded Main Effects Model, Parameter Estimates

	Variable	Parameter Estimate	Standard Error	t-Value	Pr > |t|	VIF
β_0	Intercept	1.517	0.237	6.39	<.0001	0
β_1X	Ownership	3.839	0.269	14.26	<.0001	1.052
β_2P	Geographic Location	1.224	0.283	4.32	<.0001	1.148
β_3C	Z-Cardiac Group Procedures	0.839	0.134	6.26	<.0001	1.057
β_4R	Z-Orthopedic Group Procedures	0.789	0.137	5.76	<.0001	1.100
β_5H	Z-HHI HMO	0.424	0.138	3.06	0.0022	1.120
β_6O	Z-Occupancy	0.331	0.133	2.50	0.0126	1.0278
β_7M	Z-Manhours per Adj. Patient Day	-0.462	0.134	-3.43	0.0006	1.049

All variables in the model are found to be significant and, with the exception of

the HMO HHI, are found in directions and magnitudes that were anticipated. The VIF on

the table indicates no problems with multicollinearity in the model.

The parameter estimate for ownership is 3.84 indicating that, on the average, the

TATL ratio is 3.84 points higher in investor owned hospitals relative to not-for-profits.

For geographic location it is found that hospitals located in higher income counties have

TATL ratios that are 1.2 points higher than those located in lower income counties.

Hospitals located in counties with an HMO HHI at 1Z have TATL ratios that are

4/5 of a point higher than those with an HMO HHI at the mean. As already discussed,

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the directional aberration between the TATL ratio and the HMO HHI will be covered more fully subsequent to the Model Development section.

Hospitals with annual average percentages of occupancy at 1Z have TATL ratios that are about one-third of a point higher than hospitals with percentages of occupancy at the mean ($Z = 0$). As expected, hospitals with manhours per adjusted day at 1Z show TATL ratios at almost a half a point below those with manhours per adjusted patient day at the mean ($Z = 0$).

Betas for cardiac group and orthopedic group procedure percentages show similar results that were shown in Model 1-A under Part 1. In general, hospitals performing cardiac group procedures at 1Z show a TATL ratio of more than 4/5 of a point higher than those that carry out cardiac group procedures at the mean ($Z = 0$). Likewise, hospitals that perform orthopedic group procedures at 1Z show in general TATL ratios that are more than three quarters of a point higher than hospitals that carry out these procedures at the mean ($Z = 0$).

In addition to the preliminary tests, the main effects model further demonstrated the statistical usefulness of the variables employed. The analysis now proceeds to the interaction model which uses these same variables.

Model 1-D: Expanded Interaction Model

The presence of interaction was tested in Model 1-C for all variables in the model, but was found only for ownership x geographic location, ownership x z-cardiac group procedures, ownership x z-orthopedic group procedures, and ownership x z-occupancy.

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The regression equation is written as follows:

Regression Equation for Model 1-D

$$\hat{y}_{TATL} = \beta_0 + \beta_1 X + \beta_2 P + \beta_3 C + \beta_4 R + \beta_5 H + \beta_6 O + \beta_7 M$$

$$+ \beta_8 XP + \beta_9 XC + \beta_{10} XR + \beta_{11} XO + \epsilon$$

Where: X = Ownership

P = Geographic Location

C = Z-Cardiac Group Procedures

R = Z-Orthopedic Group Procedures

O = Z-Occupancy

H = Z-HMO HHI

M = Z-Manhours per Adj. Patient Day

The results of the interaction model are shown below in Table 9.

Table 9
Model 1-D Interaction Model

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	11	8,265.62	751.42	59.52	<.0001
Error	876	11,059	12.625		
Corrected Total	887	19,325			
Root MSE	3.553			R^2	0.4277
Dependent Mean	3.938			Adjusted R^2	0.4205
Coefficient of Variation	90.234				

Results of Model 1-D show a dependent mean (i.e., the mean of the TATL ratio) of 3.94. The model also shows a high CV at 90.23, which, just like the main effects model, is far above the ideal CV of 10.0. Other items listed in Table 9, such as the SSR and SSE will be examined later when the PRESS statistic is presented at the conclusion of Model 1-D.

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Table 9 shows a higher adjusted R^2 of 0.421 which is higher than the adjusted R^2 in the main effects model which was 0.3061.

Before proceeding to Model 1-D's parameter estimates, it is advisable to test the significance of the interaction model relative to the main effects model with an F-test.

The F-test was calculated and yielded a high F value of 46.53 ($p < 0.0001$) with $R_1^2 = 0.3061$ and $R_2^2 = 0.4205$; $df_1 = k_2 - k_1$ (11 − 7) = 4 and $df_2 = N - k_2 - 1$ (888 − 11 − 1) = 876. This test indicates that the interaction model is significant relative to the main effects model.

Now that the F-test has indicated that the interaction model is significant compared to the main effects model, the parameter estimates for Model 1-D are shown in Table 10.

Table 10
Model 1-D – Interaction Model, Parameter Estimates

	Variable	Par. Est.	Std. Error	t-Value	Pr > |t|	VIF
B_0	Intercept	1.959	0.254	7.7	<.0001	0
$\beta_1 X$	Ownership	2.701	0.382	7.07	<.0001	2.535
$\beta_2 P$	Geographic Location	0.370	0.347	1.06	0.2872	2.064
$\beta_3 C$	Z-Cardiac Group Procedures	0.032	0.205	0.16	0.8746	2.970
$\beta_4 R$	Z-Orthopedic Group Procedures	-0.119	0.164	-0.73	0.4673	1.891
$\beta_5 H$	Z-HMO HHI	0.425	0.127	3.34	0.0009	1.131
$\beta_6 O$	Z-Occupancy	0.024	0.164	0.15	0.8836	1.887
$\beta_7 M$	Z- Manhours per Adj. Patient Day	-0.255	0.124	-2.06	0.04	1.070
$\beta_8 XP$	Ownership x Geographic Location	2.124	0.504	4.21	<.0001	3.466
$\beta_9 XC$	Ownership x Z-Cardiac Group Procedures	1.111	0.256	4.33	<.0001	2.966
$\beta_{10} XR$	Ownership x Z-Orthopedic Group Procedures	2.313	0.253	9.15	<.0001	1.859
$\beta_{11} XO$	Ownership x Occupancy	0.752	0.241	3.12	0.0019	1.873

VIF is higher in the interaction model relative to the main effects model, but all terms show VIF < 4.0 which is acceptable and far below the general conservative (rule of thumb) threshold for VIF of 5.0. The use of z-scores in these models has been very effective in managing problems of multicollinearity.

The beta for the HMO HHI is almost unchanged in the interaction model relative to the main effects model. The parameter estimate in the interaction model is 0.425 while it was 0.424 in the main effects model, indicating that hospitals located in counties with HMO HHI at 1Z show TATL ratios that are 0.425 points higher than hospitals located in

counties with HMO HHI at the mean ($Z = 0$). As it has been discussed already, an inverse association between the TATL ratio and the HMO HHI had been anticipated. The unexpected positive association between the TATL ratio and the HMO HHI is more fully discussed following the Model Development section.

Although there is almost no change in the HMO HHI, there is considerable change in manhours per adjusted day. The main effects model showed a parameter estimate for this variable at -0.462. The interaction model shows a beta of -0.255.

Model 1-D: Marginal Effects of Interaction Terms

As already mentioned, four interaction terms were found in the model. The marginal effects for each interaction term are shown below.

Occupancy was not used as a variable in models 1-A and 1-B. Therefore, it seems fitting to examine the marginal effect of ownership x occupancy first and in greatest detail among the interaction terms in Model 1-D.

The interaction term for ownership x occupancy can be written $\hat{y} = \beta_0 + \beta_1 X + \beta_6 O + \beta_{11} XO$ (where O = occupancy and X = ownership) of which the marginal effect may be interpreted $\partial Y/\partial O = \beta_6 + \beta_{11}X$ *(i.e., β_6 at X)* (Jaccard & Turrisi 2003, Aichen & West 1991). The marginal effect may then be calculated $0.024 + 0.752(X) = 0.776$.

The focal variable for this interaction term is occupancy, and the modifying variable is ownership. The marginal effect is determined by the association between the TATL ratio and occupancy at 1Z (one standard deviation above the mean of z = 0) when ownership (investor owned hospital) is present (i.e., ownership = 1) (Jaccard & Turrisi

2003). Under these conditions it is found that the TATL ratio is 0.776, indicating that in general investor owned hospitals with occupancy percentages at 1-Z have TATL ratios that are 0.776 points higher than investor owned hospitals with occupancy percentages at the mean ($Z = 0$).

Three other interaction terms were identified in Model 1-D including ownership x geographic location, ownership x cardiac group procedures, and ownership x orthopedic group procedures. Table 11 provides marginal effects for each of the interaction terms.

Table 11
Delineation of Interaction Terms & Marginal Effects in Connection with Model 1-D

Interaction Terms		Marginal Effects	
Ownership x Occupancy	$\beta_1 X + \beta_6 O + \beta_{11} XO$	$B_6 + \beta_{11} X$	0.024 + 0.752(X) = **0.776**
Ownership x Geographic Location	$B_1 X + \beta_2 P + \beta_8 XP$	$B_2 + \beta_8 X$	0.370 + 2.124(X) = **2.494**
Ownership x Cardiac Group Procedures	$B_1 X + \beta_3 C + \beta_9 XC$	$B_3 + \beta_9 X$	0.032 + 1.111(X) = **1.143**
Ownership x Orthopedic Group Procedures	$B_1 X + \beta_4 R + \beta_{10} XR$	$B_4 + \beta_{10} X$	-0.119 + 2.313(X) = **2.194**

The interaction between ownership and occupancy has already been discussed. The following paragraphs provide brief discussions on each of the other interacting terms.

For each interaction term listed in Table 11 the modifying variable is ownership. The focal variables include geographic location, cardiac group procedures, and orthopedic group procedures

For the interaction term of ownership x geographic location, the focal variable is geographic location. The marginal effect indicates that investor owned hospitals located in higher income counties have TATL ratios that are, on the average, 2.49 points higher than investor owned hospitals in lower income counties.

Investor owned hospitals that perform orthopedic group procedures at 1Z have TATL ratios that in general are 2.19 points higher than investor owned hospitals that carry out these procedures at the mean ($Z = 0$). Likewise, investor owned hospitals that perform cardiac group procedures at 1Z have TATL ratios that in general are 1.14 points higher than investor owned hospitals that carry out orthopedic group procedures at the mean ($Z = 0$).

Model 1-D: Standard Errors Calculated for Marginal Effects of Interaction Terms

Standard errors are now calculated for each marginal effect shown in Table 11 to determine if they are significant. The marginal effect for the interaction term, ownership x occupancy will again be used as an example in applying the standard error formula, while results for the remaining interaction terms are shown in Table 12. The formula to determine the standard error is written below. The variances and covariance used in the formula were extracted from a variance-covariance matrix generated in connection with the model.

$$\sigma_{\partial Y/\partial O} = [var(B_6) + X^2 var(B_{11}) + 2X cov(B_6 B_{11} X)]^{1/2}$$

$$\sigma_{\partial Y/\partial O} = [0.0269 + X^2(0.0580) + 2X(-0.0267)]^{1/2}$$

$$= \mathbf{0.1778}$$

$$t = (B_6 \text{ at } X) / se (B_6 \text{ at } X)$$

$$t = 0.7756 / 0.0.1778 = \underline{\mathbf{4.3619}}$$

$$p < 0.0001$$

The t-value indicates that the interaction term, ownership x z-occupancy, is significant. Marginal effects, standard errors, t-values and p-values are shown in Table 12.

Table 12
Marginal Effects & Significance in Connection with Model 1-D

Interaction Terms	Marginal Effects	Standard Errors	t-Values	p-Values
Ownership x Geographic Location	2.4935	0.3763	6.6269	< 0.0001
Ownership x Z-Cardiac Group Procedures	1.1432	0.1533	7.4588	< 0.0001
Ownership x Z-Orthopedic Group Procedures	2.1939	0.1930	11.3687	< 0.0001
Ownership x Occupancy	0.7756	0.1778	4.3619	< 0.0001

A high t-value and low p-value (< 0.0001) are observed for each interaction term used in Model 1-D. This indicates that all interaction terms used in Model 1-D are significant.

As will be discussed in the Concluding Remarks to this appendix, parameter estimates and marginal effects for original variables, geographic location, cardiac group

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procedures, and orthopedic group procedures, showed only minimal changes in models that included the new variables representing labor costs, occupancy, and market concentration. This exercise with the inclusion of additional variables was necessary to assure that all relevant dimensions in association with the dependent variable were represented in the model. Hopefully, as a result of models 1-C and 1-D greater confidence can be placed in the validity of Part 1 models (1-A–1-D), and in the findings of this study.

The Unexpected Positive Association between the TATL Ratio and the HMO HHI

It has already been explained that an inverse association was anticipated, but was not found between the TATL ratio and the HMO HHI variable. Higher concentrations of HMO dominance (i.e., control of price and output) should result in lower profitability for hospitals which should lead to attenuated bargaining leverage, lower reimbursements, lower profitability, and subsequently a weaker balance sheet, reflected by a lower TATL ratio.

Conversely, hospitals in areas with lower concentrations of HMO HHI will encounter a much larger selection of health plans. Hospitals that can exercise greater market control will be better able to secure more desirable agreements with HMOs which should result in higher reimbursements. Ultimately, these hospitals should have stronger balance sheets, represented by a higher TATL ratio.

This scenario begs the question, why does the data reveal a positive rather than an inverse association between the TATL ratio and the HMO HHI?

This analysis has included only the HMO HHI as a measure of market concentration, but there are more variables than just the HMO HHI that could be applied

to healthcare markets, one of which being the hospital HHI. Therefore, one possible explanation why the TATL ratio has a positive association with the HMO HHI is that perhaps in certain counties where the HMO HHI is high the hospital HHI may be high also. If this supposition is accurate, the inclusion of the hospital HHI would be very useful in subsequent research.

There are multiple aspects of market concentration.   HMOs have the advantage if health plans are few in number limiting a hospital's selection. On the other hand, a hospital with extensive market share may have greater leverage in negotiating managed care contracts despite a limited selection of plans. Since health care markets tend to be regional, if a hospital, for example, controls 85% of the acute care capacity in the region, every health plan would be required to include the hospital in its network (Cleverly & Cameron 2002). Even if only one or a small number of health plans were available in an area, a hospital with a substantial market share may still experience a puissant negotiating advantage.

Regression Diagnostics for Model 1-D

A full set of regression diagnostic tools used in parts 1 and 2 in the narrative (chapters 7 & 8) were applied to the main effects and interaction models, 1-C and 1-D, in this appendix.

Outliers - Press Statistic

As explained in the narrative, a very good summary measure for testing outliers and influential observations is the predicted residual sum of squares (PRESS). The PRESS statistic in connection with Model 1-D is presented in Table 13.

Table 13	
Sum of Residuals, Sum of Squared Residuals & PRESS for Model 1-D	
Sum of Residuals	0.0
Sum of Squared Residuals	11,059
Predicted Residual SS (PRESS)	11,380

The diagnosis in Table 13 shows that the sum of residuals equals zero which it should. The sum of squared residuals (SSR) of 11,059 should also be equal to the Error SS in the regression output for Model 1-D, which it is.

If the PRESS statistic is substantially larger than the SSR it would indicate a reason to suspect the existence of certain outliers and influential observations in connection with Model 1-D. However, the comparison shows that PRESS is only slightly greater than the SSR. PRESS shows 11,380 while the SSR shows 11,059. This indicates no rationale to be wary of outliers or influential observations (Freund, Littell 2000).

In addition to PRESS, additional diagnostics were performed to detect potential anomalies which included univariate statistics, specifically normal probability plots, box plots, and stem-leaf plots. As a result no potential aberrations were observed.

Influence Statistics

Influence diagnostics were also performed which included hat-diag., covariance ratio, DFFITS, and DFBETAS. Just as had been the case with Model 1-B in Part 1 of the

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narrative, only a small number of observations were found to exceed prescribed thresholds.

Studentized Residuals & Cook's Distance (d)

Additional testing for outliers began with a review of studentized residuals and Cook's d statistic. Careful observation was focused on observations that exceed residual test thresholds. These include studentized residuals $\leq$ -2.5 or $\geq$ 2.5 [or 5 asterisks which equals $\geq |2.5|$, and Cooks d $\geq 4/n$ (i.e., d $\geq 4/888$)]. There were 47 observations with residuals that exceeded either of these thresholds. All but 13 showed studentized residuals that remained within the $\leq$ -2.5 or $\geq$ 2.5 threshold.

Heterogeneous Variances

An examination of residuals was carried out to assess homoscedasticity. There were no observations of systematic residual patterns, nonrandom residual distributions, recognizable patterns in the magnitudes of the variances, or increases or decreases in variation of larger values of the outcome variable (Freund, Littell 2000).

Multicollinearity

Multicollinearity was tested and has already been discussed using VIF for models 1-C and 1-D. Some researchers prescribe a rule-of-thumb that VIF should not exceed 5.0, while others recommend 10.0 as a VIF threshold. VIF corresponding to all parameter estimates in Model 1-D were well below the lower threshold of 5.0, so VIF levels indicated no detection of multicollinearity.

In addition to VIF both adjusted and non-adjusted intercept collinearity diagnostics were performed, and there was no evidence of problems with multicollinearity in the models.

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Specification Errors

Additional interaction terms or other higher order terms, such as the inclusion of a quadratic term, were found to be unwarranted in the models.

This appendix was added to the dissertation to help assure that another type of specification error, failure to include other dimensions that may be associated to the TATL ratio, did not occur. This was the rationale for including three additional variables, manhours per adjusted patient day, occupancy, and the HMO HHI. This strategy to avoid a specification error in this context is discussed further in Concluding Remarks to this appendix.

Concluding Remarks

The preceding discussion on regression diagnostics ended with a brief statement regarding testing for specification errors in the models. As stated in the introduction to this appendix, specification errors are most often discussed in the context of interaction terms that should have been included, or when squared terms should be incorporated in the model because the association is curvilinear as opposed to linear. But this appendix has been included to address an additional type of specification error. These types of errors may also occur when certain variables are not included in the model, but have a theoretical association and/or have been determined to be associated with the dependent variable in prior research.

Models 1-A and 1-B presented in Part 1 of the narrative (Chapter 7) included the independent variables ownership, geographic location, cardiac group procedures, and orthopedic group procedures. An association was determined between the dependent

variable, the TATL ratio, and each of the independent variables. Additional variables included in models, 1-C and 1-D, have also shown an association to the TATL ratio.

The most important outcome from the models, 1-C and 1-D, in this appendix is that variables were incorporated in the models from several relevant theoretical and prior-tested dimensions representing labor costs, occupancy, and market concentration. The inclusion of these variables adds rigor and engenders greater confidence in the findings.

With the inclusion of these additional variables the betas for cardiac group procedures and orthopedic group procedures changed only slightly. Furthermore, there was little change in the marginal effects of ownership x cardiac group procedures and ownership x orthopedic group procedures.   The association between the TATL ratio and cardiac group procedures performed in investor owned hospitals (i.e., when ownership = 1) was almost the same in the presence of additional independent variables HMO HHI, occupancy, and manhours per adjusted day in the model. The same is true for the association between the TATL ratio and orthopedic group procedures when ownership = 1.

Findings gleaned from expanded models 1-C and 1-D, which add three critical variables, buttress the findings in models 1-A and 1-B in the narrative. This instills greater confidence in the findings from all of the models in connection with Part 1, 1-A through 1-D. It also enhances credibility in the conclusions drawn from this study.

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Variance-Covariance Matrix - Model 2-B

	Variables	B$_0$	B$_1$X	B$_2$S	B$_3$L	B$_4$XS	B$_6$V
		Intercept	Ownership	South	LOS	Ownership x South	Valve
	Parameter Estimates	8,478	47,505	22,429	6,214	(8,529)	21,046
B$_0$	Intercept	740,272	(351,146)	(339,258)	(33,724)	340,208	(138,763)
B$_1$X	Ownership	(351,146)	1,277,769	366,334	(1,741)	(1,277,125)	10,030
B$_2$S	South	(339,258)	366,334	834,299	(1,790)	(834,493)	(32,045)
B$_3$L	LOS	(33,724)	(1,741)	(1,790)	3,518	1,496	(5,239)
B$_4$XS	Ownership x South	340,208	(1,277,125)	(834,493)	1,496	2,622,028	39,414
B$_6$V	Valve	(138,763)	10,030	(32,045)	(5,239)	39,414	705,934

* South = South Geographic Sector

Marginal Effects & Standard Errors for Geographic Location x Ownership

Ownership when South Geographic Sector = 1

Marginal Effect (B$_4$ when X = 1) = 47,505 + S(-8,529) = 38,976

$\sigma_{\partial Y/\partial S} = [var(B_1) + S^2 var(B_4) + 2Scov(B_1 B_4 X)]^{1/2}$

$= \sqrt{1,277,769 + S^2(2,622,028) - 2X(-1,277,125)} =$ 1,160

t = 38,976 / 1,160 = 33.60

Appendix 11
Part 2, Model 2-C - Collinearity Diagnostics (Intercept Adjusted)

Number	Eigen value	Condition Index	Proportion of Variation				
			Ownership	**LOS**	**South**	**Ownership x South**	**Valve**
1	2.82046	1	0.03122	0.03682	0.03676	0.0271	0.03104
2	0.99034	1.68759	0.05962	0.06172	0.00097473	0.09676	0.33767
3	0.55546	2.25338	0.19821	0.0213	0.40225	0.0004599	0.26779
4	0.45541	2.48863	0.06487	0.53462	0.07253	0.09636	0.36206
5	0.17834	3.97684	0.64609	0.34553	0.48748	0.77932	0.00145

Eigen values close to zero signify serious problems of multicollinearity. An example could be an Eigen value at 0.09 or below. None of the Eigen values in connection with Model 1-B were close to zero.

As a rule of thumb a condition index > 30 indicates serious problems of multicollinearity. None of the condition index values are even as high as 4.0.

About the Author

James Barrington holds Master of Public Administration (MPA) and Master of Public Health (MPH) degrees from the University of South Florida (USF). He also has bachelor degrees in sociology and accounting, as well as a fifth year in accounting. Mr. Barrington is also a Certified Public Accountant (CPA), Certified Business Manager (CBM), and a Certified Florida Family Court Mediator.

Mr. Barrington has worked for 26 years in local government and continued to work fulltime while matriculating through the Ph.D. program in USF's College of Public Health. Prior to entering the Ph.D. program he ran side businesses in accounting, tax return preparation, and grant writing.

Mr. Barrington has also assisted undocumented workers in obtaining individual tax identification numbers allowing them to file tax returns with the IRS and helped several of them establish their own limited liability companies.

A serious problem for undocumented workers is that they are often hired to perform physically strenuous jobs, but once the jobs are complete, employers either refuse to pay them or will remunerate to them only a small fraction of the agreed-upon amount. Employers are well-aware that undocumented workers have little or no legal recourse when they are underpaid or receive no payment at all. Over the years, Mr. Barrington has intervened on behalf of undocumented workers, challenging employers to fully pay their workers. This has often resulted in workers receiving a higher fraction of payment, and every now and then has resulted in a worker receiving full pay.

Mr. Barrington is also married, has two children and four grandchildren.