THE IMPACT OF STAR PHYSICIANS ON DIFFUSION OF A MEDICAL TECHNOLOGY

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ABSTRACT

The Impact of Star Physicians on Diffusion of a Medical Technology

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This dissertation studies the effect of star power among physicians on the diffusion of a medical technology. Studies of the diffusion of medical technologies document institutional and market level factors influencing diffusion rates and patterns. The role of the physician in the diffusion of medical technology in hospitals is not widely studied. This dissertation seeks to fill this gap. Certain "star" physicians and hospitals are recognized as highly attractive to patients. A star physician is defined as a physician who meets any of the following criteria: (i) completed residency training at top 30 ranked hospital, (ii) graduated from a top 30 medical school or (iii) is included in Castle & Connolly's Top Docs publications. A star hospital is defined as a member of the American Association of Medical Colleges' Council of Teaching Hospitals.

Using quarterly data on all bariatric surgeries performed in the state of Pennsylvania from 1995 through 2007, I measure the effect of stars physicians and star hospitals on the diffusion of a surgical innovation in bariatric surgery called laparoscopic gastric bypass surgery. I use logistic and OLS regression to test for effects at both the hospital and physician level. At the hospital level, I find that having a star physician at a hospital raises the likelihood of that hospital diffusing laparoscopic gastric bypass from eleven percent to eighty-nine percent. I find that over the time period from first quarter 2000 to fourth quarter 2001, being a star hospital raises the likelihood of that hospital diffusing laparoscopic gastric bypass from thirteen percent to eighty-seven percent. At the physician level, the empirical results indicate that star physicians exert positive asymmetric influence on the adoption and utilization rates of non-stars at the same hospital. This dissertation supports earlier work in technology diffusion by finding a positive influence from key individuals. It adds to the literature on medical technology diffusion by testing a new data set for a chronic disease treatment.

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CHAPTER 1

INTRODUCTION

Over two thirds of U.S. adults are overweight or obese. Obesity is the second leading cause of death in the U.S. (Flegal, Graubard, Williamson & Gail, 2007; Mokdad et al 2004 & 2005). Obesity is a complex, chronic disease and has been associated with increased risk of several diseases including coronary artery disease, osteoarthritis, diabetes mellitus, gallbladder disease, sleep apnea and certain types of cancer (Centers for Disease Control and Prevention, 2009). The obesity rate has more than doubled over the period from 1980 to 2005 to about 33% of the adult population. Not only has the median obesity measure increased, but the heaviest adults, those who are classified as morbidly obese, have gotten heavier. Morbid obesity, sometimes called extreme obesity, accounts for 6% of the adult population in 2008 (NHANES 2007-2008).

In addition to its mortality and disease burdens, obesity imposes an economic burden on society in the form of decreased wages and productivity. Finkelstein, Trogdem, Cohen and Dietz (2009) have estimated the direct medical costs of obesity as 9% of health care spending in 2008, or almost $147 billion. Twenty-seven percent of the increase in per capita health care spending over the period from 1987 to 2001 can be accounted for by increases in obesity prevalence and increases in spending per capita on obese individuals (Thorpe, Curtis, Howard & Joski, 2004). Economic studies have shown a negative relationship between obesity, as measured by BMI, and wages and productivity (Han, Norton & Stearns, 2009; Wada & Tekin 2007; Conley & Glauber 2005 & 2007; Baum & Ford 2004).

A medical technology called bariatric surgery has been shown to effectively treat morbid obesity. Bariatric surgery is the general name for surgeries which alter the digestive tract to induce weight loss. Cost-benefit analysis has shown that bariatric surgery is an effective treatment for morbid obesity from the perspective of a third party payer and from the perspective of the patient (Martin and Lindstrom, 1998; Finkelstein and Brown, 2005). Bariatric surgery has been shown to be cost effective compared with non-surgical treatments for weight loss (Clegg, Colquitt, Sidhu, Royle & Walker, 2003; Craig & Teng, 2002). Since the late 1990s, the number of bariatric surgeries in the U.S. has increased more than twenty-fold, from 10,964 in 1995 to 220,000 in 2008. Data for the same time period show a dramatic increase in the number of bariatric surgeries performed in the state of Pennsylvania, from less than 100 in 1995 to over 7,500 in 2008. A specific innovation in bariatric surgery, laparoscopic gastric bypass surgery, is the subject of this study.

Technology is linked to productivity gains in the economic development literature. In health economics, productivity gains can mean increased life expectancy and enhanced quality of life. Technology diffusion, the adoption and increased usage of a technology, is a process. Studies of diffusion have focused on institutional and individual inputs associated with varying rates of diffusion. Recent studies of technology diffusion in the development literature have focused attention on asymmetric information and the role of key individuals. The agency role of the physician means that physician behavior has had a role in health economics diffusion literature unlike in other industries. Patients rely on physicians to recommend treatments because the cost of information acquisition is often beyond the patients' reasonable capability. Patients also rely on physicians for skill and technique in administering services. The behavior of individual physician's performance in learning the latest techniques is influential in the diffusion of those techniques to other physicians. Certain physicians are recognized as "stars," influential in their peer group.

Understanding the factors which influence diffusion has implications for policy and further research. Similar to intraocular lens implants to treat cataracts or coronary artery bypass surgery to treat coronary artery disease, bariatric surgery provides a treatment for a medical disease for which millions suffer and for which no previous treatment has been nearly as effective. The diffusion of bariatric surgery highlights the basic economic question of allocating scarce resources among unlimited human wants and needs. Technology sometimes increases life expectancy as well as health care expenditures. Diffusion of medical technology is considered a leading cause of increases in health care expenditures (Cutler and McClellan, 1996; Newhouse, 1992 and 2003; Chandra and Skinner, 2008). The increase in health care expenditures is an issue of national importance because almost half of all medical expenditures are funded by Medicare and Medicaid. Specific questions arise as to whether all hospitals should perform bariatric surgery or just certain hospitals. If surgical specialty hospitals exist, should they account for a larger share of bariatric procedures? Are hospitals which diffuse technology more quickly (slowly) than others efficient or are they imposing welfare losses on society? In what ways do star physicians contribute to the rate of bariatric surgery diffusion?

1.1 Motivation

Research in diffusion of medical technology among hospitals shows individual hospital and local market characteristics influence diffusion rates. The role of the physician in the diffusion of medical technology in hospitals is not widely studied. This dissertation seeks to fill that gap.

1.2 Background

Bariatric, or weight loss, surgery can be characterized as malabsorptive, restrictive or a combination of both. Malabsorptive surgeries reduce the body's absorption of nutrients. Restrictive surgeries reduce the body's ability to take in food. The first surgeries, performed in the 1950s were malabsorptive. The process changed very little until the 1980s. In 1991 the National Institutes of Health endorsed bariatric surgery as an effective treatment of morbid obesity. Since the late 1990s, the most prevalent type of bariatric surgery performed is Roux-en-Y ("RYGB") gastric bypass surgery. Gastric bypass surgery is a combination of malabsorptive and restrictive surgery. It chemically and mechanically alters the digestive system by reducing the size of the stomach and redirecting a piece of the digestive tract so that absorption of certain high fat foods is significantly reduced. Substitutes for surgery include dieting and drug treatments. Substitutes for gastric bypass surgery have low long term rates of success for weight loss. Surgical treatments for obesity are clinically proven to be the most effective long term method for resolving morbid obesity.

Open RYGB gastric bypass surgery was the most widely performed bariatric procedure until about 2004. An innovation in surgical technology provides an alternative to open surgery. Minimally invasive, or laparoscopic, surgery allows surgeons to operate using laparoscopes, instruments inserted through small openings in the abdominal cavity, while observing their actions on video screens. The appeal of minimally invasive surgery includes decreased recovery time for patients and decreased risk of hospital born infections. For abdominal surgery, 5 or 6 small, 0.5 cm to 1.0 cm incisions are made instead of one 10 cm long incision typical of traditional open surgery. Increased costs due to need for special surgical equipment are offset by improved outcomes. Nationwide, bariatric surgery shifted to predominantly laparoscopic technique between 2004 and 2006. Analysis of bariatric surgeries at academic medical centers show the shift from open to laparoscopic bariatric surgery is associated with lower post surgery morbidity rates.

In 2001, the FDA approved use of the laparoscopic restrictive device, also known as a lap band. The LAP-BAND® Adjustable Gastric Banding (LAGB®) System was approved by the FDA for use in severely obese adult patients. In 2007, the FDA approved the REALIZE™ system, introduced by Ethicon Endo-Surgery, Inc, a Johnson and Johnson Company. The bands, which are reversible as well as adjustable, mechanically restrict the digestive process by constricting the stomach opening. A study is needed to determine if the band is a complement or a substitute for RYGB surgery.

1.3 Objectives of the Dissertation

Hospital diffusion of technology is impacted by many factors: hospital level, market level, consumer level. This dissertation seeks to fill the gap in the lack of studies on physicians' impact on the rate of diffusion of gastric bypass surgery. The key research questions are as follows.

RESEARCH QUESTION 1: Does the presence of "star" physicians influence the diffusion rate of laparoscopic bariatric surgery technology?

RESEARCH QUESTION 2: Does the presence of "star" physicians at a hospital impact the diffusion rate of laparoscopic bariatric surgery technology to non-star physicians?

RESEARCH QUESTION 3: Do "star" hospitals, defined as those with higher level current technology relative to others in their market area, adopt and diffuse laparoscopic gastric bypass surgery more quickly than non-star hospitals.

1.4 Literature Review

Technology diffusion is the process by which technology is transferred from one economic agent to another. Neoclassical economic growth theory is rooted in

Joseph Shumpeter's (1942) theory of creative destruction. Entrepreneurs drive economic growth through adopting productivity enhancing technological changes. Propagated by the profit motive, waves of creative destruction carry in welfare improving innovations and carry out obsolete ideas, techniques, and technologies. Early empirical studies in agriculture and manufacturing (Griliches, 1957; Mansfield, 1961, 1963a, 1963b, 1963c) support the positive relationship between firm profit and technology diffusion. Evidence that diffusion occurs at varying rates in different contexts has focused academic studies on the causes and effects of such variations. Studies across industries highlight the role of technology spillovers and information asymmetries. See Griliches (1979) and Keller (1996, 2002a, 2002b and 2008) for a discussion.

Skinner and Staiger (2005), following the economic development literature, which has long accepted the link between technology adoption and diffusion, productivity and per capita income, link lower levels of medical technology diffusion to lower productivity of life saving technology in hospitals. Skinner and Staiger (2009) link characteristics of innovators to rates of diffusion over time and across the United States. In medical technology diffusion, health economists consider the characteristics of hospitals and doctors in technology diffusion. Ho (2007) and Burke, Fournier and Prasad (2007) consider the role of influential or "star" hospitals and doctors in the diffusion of medical technology. Since the diffusion of such life saving technology as beta blockers and cardiac surgery techniques has a direct impact on the productivity of life and health, lags in diffusion mean direct welfare implications and have a unique place in policy debates.

1.4.1 Griliches' and Mansfield's Work

Zvi Griliches' (1957) empirical work in the agricultural industry and Mansfield's (1961, 1963a, 1963b, 1963c) study of the manufacturing industry are seminal in the economic study of diffusion as profit driven. Griliches studied the diffusion of hybrid corn technology in all 31 corn growing U.S. states, from the 1930s through 1950 and concluded that profitability was the main driver in technology diffusion rates. Edwin Mansfield (1961, 1963a, 1963b, 1963c) found a positive relation between profit and the rate of diffusion of fourteen different manufacturing innovations in four industries: iron and steel, bituminous coal, railroad and brewing over a ten year period. He also found a negative relation between cost of an innovation and diffusion. Both find unequal levels of diffusion over time, which graph as an S-shaped curve with time on the horizontal axis and level of diffusion on vertical. Technology diffusion starts off at a slow pace, gains momentum, then levels off at some level, generally less than one hundred percent of the market.

Why are some firms early diffusers and some firms laggards? To answer this, both considered the environmental factors. Griliches (1957) controlled for geographic differences in the agricultural market regions by separating the state level data into nine subcategories or districts. He also considered the current level of technology diffusion in the market. Mansfield (1963b) found that diffusion is more rapid when markets are more competitive, rather than concentrated. Mansfield (1963c) found the size of a firm is positivity related to the rate of diffusion of an innovation. He provided the first empirical study of size of firms and technology diffusion rates. He studied 3 industries: bituminous coal, iron and steel, and petroleum refining. Using data from government sources, trade directories, and from firms, he documented the important process and product innovations from 1918 through 1958. He surveyed trade journals for identification and rankings of innovations. He also found that for some industries, such as petroleum and coal, the four largest firms diffused a disproportionately large fraction of the innovations. The largest firms diffused more innovations and diffused these innovations at a faster rate than other firms. If firm size is positively related to diffusion, then this suggests that diffusion may occur faster in the presence of possible economies of scale.

1.4.2 Early Debates

Though Neoclassical economic theory predicts profitability of the innovation as the primary factor influencing adoption of new technology and Griliches' and Mansfield's empirical data support the profit motive, debate over the human capital input to the diffusion process ensued. In Griliches' (1957) early work, he recognized the role of human capital inputs, but did not quantify them or attribute significant economic importance to them. This led to a response from the sociological scholars researching diffusion of hybrid corn and other agricultural innovations. In a series of articles in *Rural Sociology,* Bradner and Strauss (1959), Cleland (1960) and Rogers (1961) challenged Griliches on the role of profit, instead highlighting the role of the social structure in diffusion of agricultural technology. In 1962, Everett Rogers published the first edition of *Diffusion of Innovations*, in which he identifies five specific characteristic types of adopters of innovation: Innovators, Early Adopters, Early Majority, Late Majority and Laggards. Griliches (1960 and 1962) acknowledged a role for sociological factors in technology adoption. His response was that the sociological work could be interpreted economically and the economic work could be interpreted sociologically. Mansfield also acknowledged the role of human capital in his studies. He included educational background of firm managers to account for human capital. This laid the groundwork for future work to investigate the role of social interactions when information does not flow freely among agents.

1.4.3 Welfare Effects of Diffusion Lags

Observed laggards and non-adopters of technology advances do not benefit from the welfare enhancing technology diffusion in the same amount or at the same time as those who adopt or diffuse a technology at its earlier introduction. In agricultural technology diffusion, such as the Indian Green Revolution, laggards impose negative social welfare effects in the face of policy goals of agricultural self-sufficiency. In medical technology, negative welfare effects from lags in diffusion may mean that low cost, life extending treatments such as beta blockers for heart disease sufferers (Skinner & Staiger, 2009) may not diffuse widely. Skinner and Staiger (2009) classify hospitals as "tigers" and "tortoises," in relation to their adoption of technologies. They find wide variations in productivity, measured as survival rates, between the two classifications. They study 2.8 million Medicare patients who were treated for acute myocardial infarction (AMI or heart attack) over the time period from 1995-1996 and 2003-2004. Tigers are those hospitals in top quintile of effective technology diffusion. Tortoises are in the lowest quintile. The process innovation they study is the use of three life-saving treatments within twelve hours of an AMI, aspirin, beta blockers and reperfusion.

1.4.4 Social Learning and Social Network Theory

The idea that social learning occurs over time has been accepted in the economics literature as occurring when information flows are imperfect and returns to individuals are unequal (Jovanovic and Nyarko, 1995; Comin and Hobijn , 2004 and 2008). Banerjee (1992) offers a simple, game theoretic model in which the herd externality occurs during learning. The game results in ex ante negative welfare effects. Faced with imperfect information, an individual observes the actions of her neighbors and make decisions based on the observed outcomes of innovation to her neighbors. Empirical studies of social learning include studies from the Green Revolution in India and medical technology diffusion.

Foster and Rosenzweig (1995) and Munshi (2004) use farm level data over a three year period to study social learning in two crops, rice and wheat, at the onset of the Green Revolution in India, 1968-1970. High yield varieties of rice and wheat were imported to India. Diffusion is slower when individuals face heterogeneity in crop environmental characteristics. In this case, the high yield wheat technology differed from high yield rice technology. Farmers observed the results of neighbors who adopted the technologies and learned less from the high yield rice outcomes than from neighbors' outcomes with high yield wheat. Foster and Rosenzweig explain the slower relative diffusion of high yield rice compared with high yield wheat as attributable to social learning in the presence of imperfect information flows.

Munshi shows that the existence of heterogeneous returns to individuals, along with social learning, explain lags in technology diffusion. Munshi documents that, faced with uncertainty over returns, individual rice farmers rely on their own experience rather than social learning. Rice farmers experiment more than do wheat farmers with high yield innovations. Conley and Udry (2004) surveyed 450 farmers in Ghana over a 21 month period between 1996 and 1998 and report similar results when farmers face incomplete information and uncertain returns to switching crops from maize and cassava for local markets to pineapples for European markets.

Social learning is also evidenced by long term studies across several industries. Skinner and Staiger (2005 and 2007) find state level social capital factors associated with technology adoption across time and industries in all of the United States. Skinner and Staiger use data from all 50 U.S. states. Skinner and Staiger find states which are early adopters of hybrid corn in the 1920s are often early adopters of computers and cardiac drug treatments. Consistent with Comin and Hobijn (2004 and 2008), they find Learning By Doing or congruence, that is, states which adopt a previous technology are more likely to adopt a new technology than those which had not adopted the previous technology. Comin and Hobijn study 25 major technology adoptions in 23 industrialized countries over an extended time period, from 1880 to 1990.

1.4.5 Stars

Rogers (1962, 1995 and 2003) has recognized unequal influence by individuals through the diffusion process. "Opinion leaders" are those who are influential within an organization because of their particular social characteristics. Huckman (2003) finds opinion leaders recognized as having "technological status" influence the diffusion of cardiac procedures. He studied all cardiac procedures in New York state between 1993 and 1995 and created an index of hospital technology status using the number of publications of hospital staff to measure status. Berwick (2003) identifies opinion leaders as "change agents" in hospitals and traces their impact on hospital adoption of breast cancer screenings, flu shots and beta blocker usage. Certain hospitals identified as stars have been shown to be associated with early diffusion of technology. Ho (2006 and 2009) models consumer and producer surplus and finds that patients have preferences for certain hospitals she identifies as stars. Stars are identified as those hospitals with higher levels of technology.

Burke, Fournier and Prasad (2007) find diffusion of a medical innovation is positively related to the presence of opinion leaders they call "stars." They trace the diffusion over a five year period of coronary stents through the Florida hospital market. They include 148,174 quarterly observations of angioplasty patients between 1995 and 2001. They define a star as a physician who served a medical residency in one of the top 30 ranked hospitals in the U.S. They find star physicians influence non-star physicians through social interactions within local peer groups. Non-stars either imitate star physicians or learn directly from them.

This dissertation differs from previous studies in a few ways. Huckman (2003), Ho (2006 and 2009) and Burke, Fourner & Prasad (2007) study cardiac surgery, which treats an immediately life-threatening disease. This dissertation studies an elective abdominal surgery which treats a chronic disease. This dissertation presents a method for defining physician star status which includes peer and patient input. This differs from earlier studies which use hospital and physician group characteristics to define stars (Huckman, 2003 and Ho, 2006 and 2009). Following Burke, Fournier and Prasad (2007), this study defines the physician as a star based on characteristics of individual physicians. Unlike Burke, Fournier and Prasad (2007), this dissertation includes a measure of peer and patient review, Castle and Connolly's Top Docs publications. The data analyses in this dissertation are informed by personal interviews with hospital physicians and administrators.

1.5 Structure

This chapter introduced the research problem studied in this dissertation. Chapter 2 presents the theoretical model. Chapter 3 presents a discussion of the results of the interviews with Philadelphia area hospital administrators and physicians. Chapter 4 presents the data and methods used in this study. Chapter 5 presents the empirical models and results of the logistic regression analyses. Diffusion rates of laparoscopic gastric bypass surgery and individual market results are presented. Chapter 6 concludes with recommendations for further research.

CHAPTER 2

THEORETICAL MODEL

Sections 2.1 and Section 2.1.2 present a model for defining diffusion rates which can be used to classify adopting hospitals and physicians as Innovators, Early Adopters, Early Majority, Late Majority and Laggards following Rogers and Griliches. Section 2.1.3 presents the model from which the empirical model used in Chapter 5 is derived.

2.1 Models of Diffusion

An S-shaped pattern of diffusion is noted in the literature by Jerome (1931) and Ryan and Gross(1943), and empirically tested and modeled by Griliches (1957) and later Mansfield (1961 and 1963) and Mansfield et al (1968). Following Griliches, Mansfield and Romeo (1975), let us specify variables, using the proportional relationship between the number of adoptees at time period $t+1$ and the number that have already adopted at time t. Define the proportion of firms in industry *i* using innovation *j* at time *t* as $P_{ij}(t)$.

$P_{ij}\ (t) = m_t / n$

m_t = Number of adoptees at time t

m_{t+1} = Number of adoptees at time $t+1$

n = total population

$n - m_t$ = Number of potential adoptees who have *not* adopted at time t

b = the rate of growth coefficient

Following the logistic function, the number of firms adopting at time t is proportional to the number that have already adopted.

$m_{t+1} - m_t = b\ (n - m_t)\ m_t / n,\ \ where\ b>0$ [Equation 1]

Restated as a differential equation:

$- d\,m_t\ / dt\ \ x\ 1 / (n - m_t) = b\ m_t/n$ [Equation 2]

Which is solved as

$m_t / n = (1 + exp\ (- a - bt)\ )^{-1}$ [Equation 3]

where *a* is the constant of integration.

Taking the linear transform of Equation 3, which gives a form from which Ordinary Least Squares(OLS) regression analysis can easily be performed.

$log\ (\ m_t\ )\ / (\ n - m_t\ )) = a + bt$ [Equation 4]

Models of diffusion focus empirically on specifying a form for the expected value of *b*, the rate of diffusion or imitation as a function of the profitability and investment cost of the innovation and other unspecified variables. Following is a summary of Griliches' model.

2.1.1 Griliches' Model

Griliches' seminal empirical work on the diffusion of hybrid corn technology through the 31 "cornbelt" states of the United States (Econometrica 1957) uses data from 132 crop reporting districts over the period from 1940 to 1957. Griliches specifies the following variables in his model of the logistic curve:

K = the ceiling, or equilibrium value,

P_i = percentage of plants with hybrid seed,

a_i = constant of integration (positions curve on the time scale) and

b_i = the rate of growth coefficient

The logistic curve is denoted by Equation 5.

$$P_{it} = K_i /(1 + e-(a_i + b_{it}t)) \qquad \text{[Equation 5]}$$

The logistic form is asymptotic to its origin and to it ceiling, symmetric around its inflection point. Taking its first derivative gives the rate of growth which is proportional to the growth already achieved and to the distance to the ceiling value (Equation 6).

$dP/dt = -b/(P/K)$ [Equation 6]

Taking a log transform of Equation 6 gives Equation 7.

$ln\ (P_{it} /(K_i - P_{if})) = a_i + b_{it}t$ [Equation 7]

Griliches adds an error term and uses Equation 7 to estimate parameters of the diffusion curves for each state. The variables of interest are origins, slopes and ceilings. Griliches chooses a value of 10% of the ceiling as the origin. For the ceiling value, he uses a 90% value. The slopes are then estimated using Ordinary Least Squares regression.

2.1.2 Model of Diffusion Probability

The logistic, or logit model, is based on the cumulative logistic probability function. Logistic regression is appropriate when the dependent variable is a binary choice variable. In the case of diffusion, the dependent variable is 0= not diffused or 1= diffused. Assume there exists an underlying distribution Z_i which is determined by an explanatory variable X. Then,

$$Z_i = \alpha + \beta X_i \qquad \text{[Equation 8]}$$

The cumulative logistic probability distribution has the form

$$P_{i\,(Z)} = \frac{1}{1+e^{-Z}} \qquad \text{[Equation 9]}$$

Define the dependent variable Z as the log of the odds that an event happens.

$$Z_i = \log \frac{P_i}{1-P_i} \qquad \text{[Equation 10]}$$

Substituting Equation 1 into Equation 3 gives the form of the logistic regression model.

$$\log \frac{P_i}{1-P_i} = Z_i = \alpha + \beta X_i \qquad \text{[Equation 11]}$$

Adding an error term and designating the vector X_i variables provides the basis for the logistic regression analysis in Chapter 4.

2.1.3 Diffusion of Medical Technologies

Models of medical technology diffusion concentrate on identifying statistically significant effects of particular market, hospital and physician characteristics through the β factor loadings. Burke, Fournier and Prasad (2007) add interaction terms identifying the impact on diffusion attributable to the influence from star to non-star physicians and from non-star to star physicians.

2.2 Hypotheses

HYPOTHESIS 1:   Controlling for market structure influences such as degree of competition in the market, market size, hospital size, and teaching status of the hospital, I consider the impact of physician's role in diffusion of a medical technology. I hypothesize that the presence of a "star" physician at a hospital impacts the diffusion rate of laparoscopic bariatric surgery technology.

HYPOTHESIS 2: Controlling for market structure influences such as degree of competition in the market, market size, hospital size, and teaching status of the hospital, I consider the impact of a star physician on non-star physicians. I hypothesize that the presence of "star" physicians at a hospital impacts the diffusion rate of laparoscopic bariatric surgery technology to non-star physicians.

HYPOTHESIS 3: "Star" hospitals cultivate a reputation as highly desirable among patients through the early adoption of technologies such as organ transplant surgery or robotic surgery. I hypothesize that the level of current technology in a hospital makes it more likely to adopt a technology than a non-star hospital.

CHAPTER 3

DISCUSSION OF INTERVIEWS

3.1 Introduction and Motivation

This chapter describes a limited qualitative analysis, in the form of personal interviews, conducted to gain background understanding of the economic decision-making process of hospital administrators and physicians in the adoption and diffusion of bariatric surgery. The purpose of the interviews is to substantiate or challenge assumptions made in the descriptive and quantitative analyses of chapters 4 and 5, in order to support possible explanations of observed diffusion patterns.

The chapter begins with a description of the interview methodology. Then it describes the findings of the interviews which were conducted among physicians and administrators at Philadelphia area hospitals. The findings may not be projectable to all hospitals, but certain findings support assumptions made about the hospital market definition used in this study, the importance of profit motive and the dominant role of hospital, not physicians, as decision maker in the adoption and diffusion of bariatric surgery. The findings of the interviews also suggest certain explanations for the observed patterns of diffusion. The key finding is that two distinct patterns can be found in the decision making process. The first pattern shows a physician led diffusion process. The second pattern is an administration led diffusion process.

3.2 Methodology

A total of nine interviews were conducted among physicians and hospital administrators at Philadelphia metropolitan area hospitals. The interviewees represent perspectives from more than nine hospitals because some physicians practiced at more than one hospital and one board member served at more than one hospital over the time period studied. Within a nineteen mile market (defined using the variable radius criteria as described in Chapter 4 Section 4.3.5), they represent twelve of twenty-four hospitals in the market. The respondents represent a variety of hospital characteristics: urban and suburban, teaching and non-teaching. Some hospitals had diffused bariatric surgery; some had not. Some hospitals had star physicians on their surgical staff, some did not. All respondents were from nonprofit hospitals. Though this is far from being a randomized sample or a complete survey, the data gathered are useful as background for the descriptive and statistical analysis of chapters 4 and 5.

Interviews were solicited through public information seminars and through professional and personal acquaintances. After an initial introduction, a follow-up letter of introduction (See Figure 1) and a List of Discussion Questions (See Figure 2) were sent via email. This follow-up sometimes involved fairly extensive explanation of purpose. I also agreed to provide respondents with a copy of my completed report, if they were interested. Each respondent was assured of confidentiality and that results would be presented carefully so that identities of individuals and individual hospitals would not be disclosed. Given that nine of the ten individuals contacted agreed to interviews, the response rate seemed to indicate that the introductions were adequate and assurances were credible. Six physicians and three administrators agreed to interviews. Each interview lasted from forty minutes to an hour. Most interviews were face-to-face at the hospital. Two interviews were by telephone.

3.2.1 Public Information Seminars

In the Spring of 2010, ten hospitals in the Philadelphia area held information seminars for prospective bariatric surgery patients. Dates, locations, times and instructions for registering for a seminar were posted on the hospital websites. These seminars were open to the public and generally lasted about two hours. Seminars consisted of an introduction of the hospital bariatric staff, usually a physician, the patient care coordinator, often a successful patient, and sometimes a nutritionist. A slideshow presentation gave a physical description of the types of bariatric surgeries available, both open and laparoscopic, required qualifying screenings and tests, expected results, including possible risks and complications, and some general insurance coverage information. A question and answer session followed. Then, attendees had an opportunity to speak with the staff one-on-one or register for an initial appointment with the bariatric surgery team.

Attendees were asked to register through a webpage, an email or by telephone. I registered and attended five sessions during the Spring of 2010. After registering, I telephoned and emailed the program administrator, introduced myself, gave a brief description of my dissertation work, and asked for permission to interview the doctor before or after his presentation. The administrator was usually the bariatric coordinator, the main administrator in the bariatric surgery center. Interviews took place at hospital conference rooms, bariatric suites within the hospital, or by telephone.

3.2.2 Other Interview Sources

Through some professional and personal contacts, I was introduced to a few hospital administrators who agreed to be interviewed. Consistent with the method of introduction of myself and the dissertation study used when attending the public information seminars, I sent a letter of introduction (See Figure 1), the List of Discussion Questions (See Figure 2), and provided any other explanation of purpose, as requested, for the respondent to review. Interviews took place at hospital administrators' offices and by telephone.

3.2.3 Format of the Interviews

The interviews are qualitative in nature. Because the interviews are designed to provide background for the descriptive and analytical analyses of the dissertation, the interviews did not follow a strict format. A list of basic questions was covered in each interview, but individual respondents elaborated on topics of their own choosing. While this provides a varied content of information, it presents some difficulty in quantification of the results. To insure against reporting idiosyncratic responses as findings, a statement is only considered a finding it is corroborated by at least three or more persons.

Figure 1

Introduction Letter

TEMPLE UNIVERSITY®

Dear Sir/Madam,

A research team at Temple University is conducting a study on how star physicians impact the diffusion of medical technology. We are requesting hospital administrators, board members and physicians to comment on the following survey questions in an interview. This survey has a total of 12 questions.

Your participation in this study is voluntary. You may choose not to participate and/or to withdraw from the study at any time. This survey is anonymous.

The overall results of the study may be published, but the research will be conducted with an assurance of confidentiality for you and your organization. Neither your name nor your individual answers will be known.

Participation in this interview will be considered your consent to participate.

If you have any questions concerning this interview, please contact Laura Shinn at (xxx) xxx-xxx, or by email, shinn@temple.edu.

Primary Investigator's Signature Date

Figure 2
List of Discussion Statements

		Agree Strongly		Neutral		Disagree Strongly
1	A single physician or group of physicians originates bariatric surgery at this hospital.	1	2	3	4	5
2	Administration or the board of directors originates bariatric surgery at this hospital.	1	2	3	4	5
3	One physician in the hospital is recognized by the other doctors as a Top Doc, or Star, or opinion leader in bariatric surgery.	1	2	3	4	5
4	A star brings status to other surgeons in the hospital.	1	2	3	4	5
5	Stars may generate a spillover effect to increase demand for the entire spectrum of services offered by the hospital.	1	2	3	4	5
6	Bariatric surgery is profitable for the hospital.	1	2	3	4	5
7	Bariatric surgery is *highly* profitable for the physician, that is, compared with other abdominal surgeries.	1	2	3	4	5
8	Laparoscopic surgery is a substitute for open surgery.	1	2	3	4	5
9	Patients prefer laparoscopic surgery over open surgery.	1	2	3	4	5
10	Laparoscopic restrictive devices are substitutes for gastric bypass surgery.	1	2	3	4	5
	Other questions: Which hospitals do you see as your main competitors in the market for bariatric surgery? Is my assumption of at least two surgeries per month for four consecutive quarters, that is, 24 surgeries per year, is indicative of a hospital having diffused bariatric surgery. What do you estimate as a minimum number of bariatric surgeries a hospital would need to do to achieve efficiency?					

3.3 The Findings

The findings from the interviews demonstrate agreement on several areas and lay a foundation for assumptions about the market for bariatric surgery which is consistent with patterns of diffusion described in chapters 4 and 5. The findings also suggest certain explanations for the observed patterns of diffusion. Four core areas were explored in all interviews with respect to adoption and diffusion of bariatric surgery:

1) the nature of the decision-making process, particularly, the role of individual physicians and administrators in a hospital's decision to adopt and diffuse bariatric surgery;
2) the role of profit motivation and non-price competition in both hospital and physician decisions to adopt and diffuse bariatric surgery;
3) the appropriateness of the nineteen mile variable radius hospital market definition used in this study (using the criteria described in Chapter 4 Section 4.3.5);
4) the characteristics of patient demand, including the role of laparoscopic gastric bypass as a substitute for open gastric bypass surgery.

Other areas of discussion include economies of scale and learning by doing, economies of scope, insurance coverage, and the definition of a star physician used in this study.

3.3.1 The Nature of the Decision Making Process

The nature of the decision-making process in the adoption of a bariatric surgery program at a hospital seems to lie with the important interaction between physician and hospital administration. For each of the hospitals with ongoing programs, there were two common patterns of adoption and diffusion which, for discussion, I call Pattern One and Pattern Two. In Pattern One, the physician seems to take the lead; however, since physicians and board members work so closely together in the early stages of new technology implementation, it is difficult to distinguish if physicians are indeed the initiators or this is a collaboration of professionals in an academic medical center setting. In Pattern Two, the administration decides that initiating a bariatric surgery program is consistent with the hospital's mission and then recruits physicians and staff and allocates other resources to the effort.

Pattern One. The first pattern describes the programs with the earliest adoption and diffusion dates. These hospitals and physicians might be called "Innovators" or "Early

Adopters" using the language of Rogers (See Chapter 1 Section 1.4.2). For this analysis, Innovators and Early Adopters are considered those who adopted gastric bypass in the eight quarters beginning with the first quarter of year 2000 (See Chapter 5 Section 5.1). In Pattern One, physicians seem to take the lead in adopting bariatric surgery; however, the physician is very conscious of the need to persuade the administration early to commit hospital resources to expand a general surgery office or to equip a bariatric office. This pattern is consistent with the role of the hospital as a teaching hospital, in which research and technological advances are valued as part of the hospital's mission and an active interchange exists between staff & administration. In this case, the administration, that is, the Board of Directors and the Trustees, is involved very early in the process, so that it may be impossible to distinguish who first decided to adopt bariatric surgery.

Pattern Two. The second pattern describes the hospitals which adopted and diffused gastric bypass at later dates than those described as Pattern One. Again using Rogers' well known descriptions, these latter hospitals and physicians might be called "Early Majority," "Late

Majority" or, possibly, "Laggards" (See chapter 1 Section 1.4.2). For this analysis, Early Majority, Late Majority and Laggards are considered those who adopted gastric bypass after the fourth quarter of the year 2000(See Chapter 5 Section 5.1). For Pattern Two hospitals, respondents consistently reported that a bariatric surgery center would further the hospital's mission, then hired physicians and allocated office space and support staff to the surgery center.

In reviewing the evidence, for both types of observed patterns, the Pauly-Redisch (1973) model of the physicians' cooperative is not substantiated. Other possible motives are discussed in Chapter 4 (Section 4.4.4.) and are considered in the following sections. Let us consider the profit motive and non-price competition.

3.3.2 Profit Motivation and Non-price Competition

No respondent claimed profit as the main motivation for a hospital's adoption and diffusion of gastric bypass surgery; however, each respondent communicated that positive expected profit plays an important central role in the adoption and diffusion decision-making process. Since each respondent represented a nonprofit hospital, this might be a reasonable response. It is consistent with each of the theories of nonprofit hospital behavior discussed in Section 4.4.4.

Expected return involves a tradeoff of risk and return. The perception of manageable and acceptable risk was acknowledged as a key determinant in the decision of the board to support adoption and diffusion of bariatric surgery. Physicians and administrators agreed that if the hospital has just a few, very complicated cases, the economic profit from the entire bariatric surgery center could become negative. Further, both parties were extremely sensitive to the possibility of patient lawsuits. Not only might the hospital suffer financial losses, damage to its reputation might cause it to lose patients in other areas of care. One board member commented that one wrongful death suit can cost her hospital $1 million. She further noted that Philadelphia juries are well known for their high damage awards to plaintiffs in medical malpractice and wrongful death cases. Understandably, the board and the CEO will be very cautious when adopting a new medical technology.

In the case of adoption and diffusion as described as Pattern One (Section 3.3.1), a typical case might develop as follows. A surgeon performs gastric bypass, developing a track record for performing bariatric surgery with acceptable risk. Acceptable risk means complication rates are around the average expected rates for this surgery and lawsuits are minimal. Hospital administrators recognize that the surgeon can perform the surgery and the hospital can make a profit or perhaps that the addition of the surgery is consistent with the hospital's mission as a research hospital. Then administrators provide more staff and hospital resources to support expansion of the practice at the hospital. As one physician noted,

> …I haven't killed anyone yet. Once the board and the CEO see that I can do this surgery, people do not die, and the hospital can make money, then they are convinced they want to support it.

From his perspective, as a self-identified early adopter, his role was to perform a few of these surgeries until the administration was won over and provided more support staff, dedicated office area in the hospital, advertising and other support. This perspective was reinforced by an administrator who remarked that he would be willing to support a new surgery at his hospital if one of his trusted physicians were to come to him and lobby for board support to perform bariatric surgery. The administrator said he would initially provide limited support, incrementally increasing his support as he became comfortable with the physician's demonstrated experience. He cited the need for an accumulation of surgical experience with a new technique before he or the board would support allocating significant hospital resources to it.

Market Competition Characteristics

The hospital regions with the highest market capacity, as measured by hospital beds per thousand, seem to adopt gastric bypass earlier and at faster rates do than other regions of Pennsylvania (See Chapter 4 Section 4.2.5, Table 5 and Table 12). Higher number of hospital beds per thousand population may mean that hospitals compete for physicians (See Chapter 4 Section 4.4.5). Hospitals compete for physicians through financial and non-price competition. Non-price competition is involved in the case of technologically advanced medical treatments because the treatments enable physicians to fulfill their role as teachers, innovators, leaders in research and caring healers. Non-price competition also means that offering this technology advances the institutional goals of university and teaching hospitals. Hospitals attract physicians to their bariatric centers because, in addition to the financial rewards physicians gain when they are granted privileges, the hospital provides staff and equipment which enable the physician to engage in a practice which appeals to one of the altruistic goals for which many physicians entered medicine, the ability to provide a service to patients which dramatically transforms their health, both their outward appearance and overall health. Physicians can offer a treatment which is more effective than any nonsurgical treatments for morbid obesity. Providers in the field of bariatric medicine are very enthusiastic about the transformational effects of the surgery. Administrators and physicians note that the role of the physician in bariatric surgery is different from the interaction between physicians and patients for other surgeries. One respondent called bariatric surgery a "tool" which facilitates patients' ability to take control of a lifelong health issue. This was echoed by a physician in his presentation to potential patients, "This surgery changes the relationship between you and food forever." Since the induced weight loss will only be maintained if patients change their lifestyles and eating habits after surgery, physicians must make professional assessments of a patient’s eligibility for surgery which involve processing results from physical as well as psychological screening tests.

One encounter between a potential patient and physician illustrates the unique relationship between physician and bariatric patient. During his slideshow presentation, a physician explained the physical difficulties in performing laparoscopic surgery in morbidly obese men who exceed a certain weight. After the presentation, a prospective patient approached the physician, asking if the doctor would consider him a candidate for laparoscopic surgery. The physician reminded him of the criteria he had outlined in his presentation. The man’s current weight put him over the size limit the physician had recommended. He told the prospective patient that if he lost thirty pounds, the doctor would consider performing the surgery laparoscopically. After the exchange, the physician remarked,

> …You see what I did? I challenged him. This is about control. You have to get in here (and he pointed to his own head). He’s a man. I challenged him where he lives. If he loses the weight, I’ll do the surgery.

In the case of adoption and diffusion described as Pattern Two (Section 3.3.1), it is hospital administrators, comfortable with the risks of bariatric surgery, who initiate bariatric surgery centers. These administrators rely on the profit motive as well as non-price competition to attract physicians to their hospitals. Non-price competition again plays a role. Administrators can offer physicians a title and hospital resources to grow their own bariatric surgery team along with appealing to physicians' patient care goals.

One physician had left a successful practice in another area, outside Pennsylvania, to head a new bariatric center. When asked why he stopped doing other types of gastrointestinal surgery to concentrate on bariatric surgery, he replied that he was tired of a career where today's surgery was "gall bladder #xxx." With bariatric surgery, he is able to treat the whole patient. Patients can only fully realize the most potential weight loss if they change their lifestyles and eating habits after surgery. Since the process of pre-surgery screenings and post surgery checkups is lengthier for bariatric patients than for other surgery patients, the physician has an opportunity to really get to know his patients. Several of the seminars included patients and physicians giving testimony to their mutual excitement over the patient's post surgery weight loss and other life accomplishments. One respondent showed me a thank you letter from a group of his successful patients who had completed a fitness run. In it, they expressed their gratitude to the doctor and told of their desire to have t-shirts printed which proudly proclaimed, "Body by Dr. (Respondent's name here)."

Other examples of non-price competition include support services the hospital offers to the physician. The hospital can offer bariatric surgery patients a state of the art nutrition counseling center specifically tailored for the bariatric patient, meeting places for monthly patient support groups, website support, as well as access to ancillary services in a convenient one stop shop. For instance, some hospitals offer all the pre-screening tests in their facilities. The pre-screening tests include blood tests, gastrointestinal screenings, cardiac and pulmonary tests, routine gynecological exam, and psychological tests. Finally, hospitals offer name recognition to their surgeons. Expensive hospital advertisement for wide ranges of services might benefit the bariatric surgeon because potential patients associate the hospital name with the physician.

3.3.3 Market Definition

The variable radius definition of hospital market used in this study (See Chapter 4 Section 4.3.5) area appears to describe the market for the Philadelphia area as recognized by the respondents. There was unanimous corroboration of a market radius of less than or equal to 19 miles. Respondents were asked which hospitals they consider competitors. In each case they named hospitals in the market as defined by the methodology of this study. Since respondents tended to name about three or four hospitals as direct competitors, I asked about hospitals identified within this study's market definition but not named by the respondents. There was general consensus that those hospitals also were competitors. The degree of agreement might sometimes be qualified with phrases like "to a lesser extent" as competitor hospitals became 10 miles or more distant from the respondent's hospital. One respondent at a university hospital noted that the university hospital would like to have patients come to the main hospital campus, yet, given the choice, patients seem to prefer to go to suburban satellite facilities closer to their homes.

This is the case, even with distances from the academic center less than 19 miles.

It appears that the variable radius market definition method used to define the hospital market in which the respondents operate provides a reasonably close approximation of the hospital market. Whether or not this is an appropriate approximation for all hospitals used in the study depends on other characteristics of the market. The respondents in this survey were all in the urban and suburban Philadelphia area. Other hospitals in the survey may have wider market radii, especially rural hospitals. This study is also limited because it did not consider hospitals which might be within the geographic radius, but were outside Pennsylvania.

3.3.4 Patient Characteristics & Demand

Patient Characteristics

Physicians and administrators are knowledgeable about the demographic characteristics of their patients. Bariatric patients are informed consumers. Prospective patients are media savvy. They use print, television and internet to obtain information about bariatric surgery, hospitals and physicians. Prospective patients use websites which have ratings of physicians and hospitals on which patients share detailed reviews of individual physicians. One physician, noting in his presentation, "You may have learned this on the internet or perhaps at another seminar at another hospital."

Along with finding a competent surgeon, they seek an accessible relationship with their potential health care provider. The staff members are very conscientious of being courteous and promptly following up on patient questions or concerns. Word of mouth matters a lot.

Demand

Never underestimate the power of one influential patient. The same physician cited the internet video posting of singer Carne Wilson's gastric bypass surgery in 1999 and the very visible, post gastric bypass weight loss of morning television weatherman Al Roker in 2002. He also mentioned the spread of information necessary and how much easier his job of educating his patients becomes when a well known personality has bariatric surgery. He said that it is easier for potential patients to learn about and consider bariatric surgery when, along with learning about the media star who had the surgery, the patient has a family member or friend or neighbor who has had the surgery. That kind of networking effect has done much to improve the visibility of bariatric surgery and increase the demand for bariatric surgery.

One respondent noted that his practice benefits from marketing by other hospitals. He told of a patient who told him she had learned a certain fact from the hospital's video. He knew his hospital produced no such video, but he benefited from the patient's knowledge.

Usually, the physician hired to be director of the bariatric center had experience at another early adopting facility. At least two physicians interviewed relocated over one hundred miles to head new programs. I did not observe business stealing within the Philadelphia market, such as physicians moving within the 19 mile radius. The physicians were from many miles outside the market radius, some from outside Pennsylvania.

3.3.5 Star Definition

Star Physicians

Research Question 1 in this dissertation asks, "Does the presence of "star" physicians influence the diffusion rate of laparoscopic bariatric surgery technology?"

Research Question 2 asks, “Does the presence of “star” physicians at a hospital impact the diffusion rate of laparoscopic bariatric surgery technology to non-star physicians?” (See Chapter 1 Section 1.3) To address both questions, stars are defined as physicians who influence others via social interactions. Consistent with Burke, Fournier and Prasad (2007), this study uses a proxy for social influence: physician medical school or residency training at a top institution or physician inclusion in a patient and peer rating publication, Top Docs.

The academic training criteria defining “star” used in this study was considered too simplistic by many of the respondents; however, several of the respondents were stars by the criteria used in this study. These star physicians not only met the criteria I used as a proxy for star power, they exhibited some of the characteristics for which the academic criteria are assumed to proxy. Each one was actively leading in the medical field through published research, held an active presentation schedule at scholarly conferences, and was very knowledgeable about the current academic literature. Each was characterized by lifestyles of hard work, long hours, and great personal investment in his patients. Several stars had presentation skills which easily engaged others in an enthusiasm for the work of the hospital’s bariatric team.

One administrator dismissed the proxy criteria used in this study. He noted that key individuals who will notice influential physicians, or stars, are (i) other physicians; (ii) nursing and support staff; and (iii) patients. He said physicians self-promote through speaking, attending lots of community events, holding and hosting educational seminars. He gave an example of a well-known area physician who

> …has average surgical skills, but self-promotes very effectively. She is no better than others, but she is able to generate that opinion among peers, patients. For example, she is like (1980s pop singer) Madonna. She’s an average singer, but a brilliant marketer. Marketing perception matters.

Though the proxy for star criteria was definitely viewed as inadequate by the respondents, the number and consistency of comments on characteristics which make particular physicians influential seem to support the proxy used in this study. Of the physicians surveyed who met the star proxy criteria, they also exhibited other, less easily quantifiable characteristics, acknowledged by other respondents as characteristics of influential or star physicians.

3.3.6 Substitutes

Open gastric bypass is a substitute for laparoscopic gastric bypass. Respondents agree that patients prefer laparoscopic surgery to open surgery and view laparoscopic gastric bypass as a substitute for open gastric bypass. Physicians view open and laparoscopic gastric bypass as substitutes. If a physician is performing a laparoscopic surgery and she runs into complications, it may become necessary to convert the laparoscopic surgery to open surgery. This is mentioned as a possibility in each of the information seminar presentations.

3.3.7 Economies of Scale & Learning-By-Doing

Economies of scale mean that as production increases, operating cost per surgery decreases. It is difficult to empirically test for economies of scale in bariatric surgery. Prices, which might be an indicator of changes in cost, are not transparent. It is hard to tell if prices decrease because third party insurers are powerful negotiators or if suppliers have experienced decreased costs or if both events are occurring simultaneously. Learning-By-Doing is the concept that productivity increases due to worker skill improving with repetition. Bariatric surgery is a surgical subspecialty which requires a particular skill. Several respondents agreed that an initial time to perform the surgery is about six hours. With experience, the time decreases. Many now have an average surgical time of one to two hours. Each of these respondents had performed several hundred surgeries; however, it was not evident from their interviews how long it took to achieve this Learning-By-Doing. Several respondents quickly cited the 100 per year rule of thumb for proficiency in a surgery. Experience may also improve quality, which may mean decreased complications from surgery as well as decreased operation performance time. Whether increasing number of surgeries at a facility means lower prices, lower costs or higher quality is unclear; however, positive correlation between procedure volumes and hospital size may be an indirect indicator of economies of scale (See Chapter 4 Section 4.4.5 and Table 10).

3.3.8 Economies of Scope

Economies of Scope mean production costs decrease as a firm produces more than one product using some of the same inputs to production. Applying this to bariatric surgery, both the physical labor of surgical team and the physical inputs can be used to produce multiple outputs. The same surgeon who performs a laparoscopic gastric bypass often has experience performing laparoscopic gall bladder removal, a common procedure for many bariatric patients. Since bariatric surgeries are scheduled along with other general surgeries, hospitals are sometimes using the same equipment for a knee replacement as for gastric bypass. For example, physical inputs such as supplies which support the extra weight of the morbidly obese such as wheelchairs, operating tables, chairs, scales and beds may be used for morbidly obese patients undergoing other services in the hospital. Some surgical imaging equipment used for laparoscopic gastric bypass may be used for other types of surgery.

3.3.9 Halo Effect and Demand Complementarities

For bariatric surgery, demand complementarities may be generated for pre-surgical and post-surgical services. If patients perceive the surgeon, the practice or the hospital to have a certain skill or prestige, the hospital can gain revenue from providing other services to the patient. Pre-surgical demand complementarities exist in the demand for laboratory tests of blood and urine and for cancer screenings, cardiac exams and gynecological exams (the majority of bariatric patients are women). Such exams are required for surgery. Demand for diet and nutrition counseling services may also be generated at the hospital before and after patients undergo surgery. Candidates for bariatric surgery must demonstrate failed non-surgical attempts to lose weight for a length of time in order to qualify for many third party reimbursements. After surgery, bariatric patients must modify their eating habits to safely maintain their modified digestive system and sustain weight loss. This includes vitamin and mineral supplements as well as training in nutritionally appropriate diets. Successful weight loss patients may have excess skin tissue that can be surgically removed. If they perceive the bariatric surgeon has special skills due to the original surgery, they may return to the same surgeon or surgeon group at the hospital for additional surgery. Gall bladder removal surgery is also often required by patients who are candidates for bariatric surgery. This may be done pre or post-bariatric surgery.

According to one administrator, referring to the pre-admissions testing,

> …The hospital wants this downstream income. Patients are free to go to other providers, but if the hospital gets the tests, it can mean about $10,000 in revenue per patient.

It appears from the respondent’s comments that demand complementaries are perceived as a possible positive benefit from the decision to adopt laparoscopic bariatric surgery. Additionally, a halo effect may be generated because of a hospital’s reputation as a star provider of bariatric services. A halo effect means that demand for all hospital services may increase.

3.3.10 Insurance Coverage

Hospital administrators and physicians appeared to be mindful of reimbursement levels and practices by third party insurers and their impact on patient behavior. One Medicaid provider had begun denying pre-approval for gastric bypass, an administrator noted that patients just switched coverage to the provider which did provide coverage. A respondent commented that insurers require six months diet counseling and some weight loss prior to surgery, yet there exists no empirical evidence to support that such actions improve surgical outcomes. The move is meant to limit coverage. Another respondent commented on what he observed as a practice by insurers

> …There’s prejudice. Patients have contracts which restrict their use of bariatric surgery to one surgery per lifetime. Can you imagine telling a heart patient that they could only

> have one angioplasty because they didn’t follow the diet they were supposed to?

Using Getzen’s (2010) terminology, it appears these observations lend support to the premise that bariatric surgery has entered the third stage, bordering on the fourth stage of the Financial Reimbursement Cycle, in which a system of administered prices prevails and insurers work to enforce global budgets (See Chapter 4 Section 4.4.4 Profitability).

3.4 Summary of the Interviews

The interviews provide a limited qualitative analysis of the decision-making process of hospitals and physicians in adoption and diffusion of bariatric surgery. The key finding regards the decision making process. Two discernible patterns emerge. In some cases, diffusion is initiated by a physician. In other cases, diffusion is led by administration. Findings support the central role of the profit motive in adoption and diffusion of a technology. The findings also support the assumptions used in the descriptive and statistical analyses of chapters 4 and 5. The findings may not be applicable to all hospitals, but they suggest certain explanations for observed diffusion patterns.

CHAPTER 4

METHODOLOGY

This chapter describes patterns of diffusion of bariatric surgery in the U.S., the state of Pennsylvania and within smaller geographic regions within Pennsylvania. This chapter discusses the available data, characteristics and patterns observed in the market for bariatric surgery, some of which are quantified and considered in the empirical analysis of chapter 5.

This chapter is organized as follows. Section 4.1 describes the data and data sources. Section 4.2 describes the observed diffusion patterns. Section 4.3 describes the methodology for defining the relevant geographic market. Section 4.4 presents alternate variables which might serve as explanations of the observed diffusion patterns. Combined with the interviews of Chapter 3, this chapter serves as a background for the empirical analysis presented in Chapter 5. The chapter ends with a summary of the findings.

4.1 Data and Data Sources

Data are collected from a variety of sources. Publicly available data are obtained from the U.S. Bureau of the Census, the Centers for Disease Control and Prevention, the Pennsylvania Department of State, American Association of Medical Colleges' Council of Teaching Hospitals and Health Systems, and individual hospitals. Proprietary and publicly available data are collected by the Pennsylvania Health Care Cost Containment Council (the PHC4).

4.1.1 Demographic Data

Publicly available information from the U.S. Bureau of the Census and the Centers for Disease Control and Prevention include data used to calculate state and county level population, obesity rates, and income.

4.1.2 Bariatric Surgery Data

Proprietary data from the PHC4 include data from each hospital in the state of Pennsylvania from fourth quarter 1995 through second quarter 2007. The data include 39,918 patient level observations. Patient information includes patient diagnoses, hospital length of stay, age, race, gender, county and ZIP code of residence. Diagnoses data include up to eight Diagnostically Related Group (DRG) procedure codes. Procedure data for each surgery are classified according to U.S. Department of Health and Human Services *International Classification of Diseases, 9th Revision, Clinical Modification* (ICD-9-CM)procedure codes: 44.31, the code for open gastric bypass surgery; 44.38, the code for laparoscopic gastric bypass; or 44.95, the code for adjustable gastric restrictive band and port insertion.

4.1.3 Hospital Data

Publicly available data from the Pennsylvania Health Care Cost Containment Council are used to track individual and aggregated hospital characteristics. The series of annual financial reports published by the PHC4 list all hospitals in Pennsylvania. The reports include hospital size (measured in beds), hospital closures, openings, mergers and name changes. The data include all short term, general, acute care hospitals. Short term means patient's length of stay is 30 days or less. Outpatient data are excluded. Data are also obtained from the American Hospital Association (AHA), from the Council of Teaching Hospitals and from individual hospitals.

4.1.4 Physician Data

The PHC4 proprietary data include the Pennsylvania medical license number of the operating physician, attending physician and referring physician for each entry. Each license number is matched with physician name and address from the Pennsylvania Department of State database. There are two hundred ninety-seven operating physicians. Residency, special training, medical school graduation date and school are matched from the American Medical Association physician database. Further information is obtained from individual hospital websites and from phone calls to individual physician offices.

4.2 Observed Diffusion Patterns

Diffusion patterns in the U.S. and in Pennsylvania follow a similar pattern. There is a very large increase in the early years, followed by smaller increases over time. Following Tian (2006), a hospital is considered to have diffused laparoscopic gastric bypass surgery if an average of two surgeries per month is performed for four consecutive quarters, that is, one year.

4.2.1 Total Surgeries in U.S.

Since the 1950s, surgeons have performed bariatric procedures; however, the number of surgeries never exceed more than a few hundred per year. These surgeries were mostly malabsorptive in nature. In 1991, the National Institute of Health issued a consensus statement which formally set standards for bariatric surgery candidates. By the end of the decade, the total number of bariatric procedures in the U.S. for one year, 1998, exceeded the number of procedures in the previous eight years. Most of these surgeries were gastric bypass surgery. In 1993, Dr. Alan Wittgrove performed the first laparoscopic gastric bypass surgery. Following Dr. Wittgrove's pioneering work in California, Dr. Philip Schauer performed the earliest laparoscopic gastric bypass in the state of Pennsylvania in 1997 in Pittsburgh. In 1999, Wittgrove & Clark published results and follow-up on five hundred patients (Wittgrove & Clark, 1999) from his California center. In 2000, Schauer & associates published results and follow-up on two hundred seventy-five patients (Schauer, Ikramuddin, Gourash, Ramanathan, & Luketich, 2000). By 2004-2005, laparoscopic gastric bypass surgery became the dominant type of gastric bypass surgery and some procedures could be done on an outpatient basis. Table 1 shows the number of in-patient surgeries performed in the U.S. and the annual percentage change. Data on outpatient surgeries are not available.

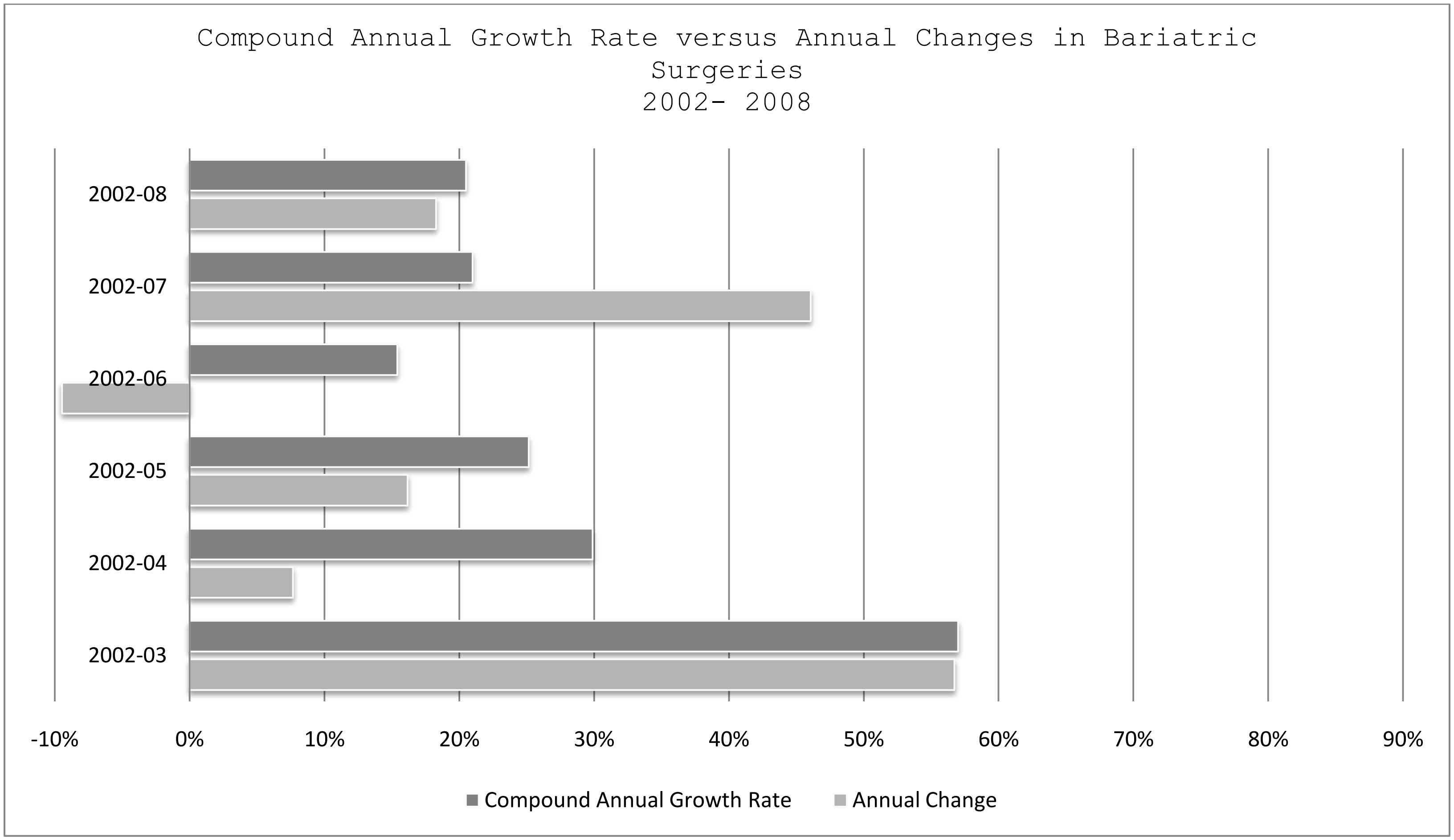
Table 1
U.S. Bariatric Surgeries and Percentage Change

Year	Total	Annual % Change
1990-1997	12,203	
1998	13,386	
2002	71,733	436%
2003	101,144	41%
2004	121,055	20%
2005	140,640	16%
2006	127,335	-9%
2007	186,000	46%
2008	220,000	18%

Note. Data are from The Agency for Healthcare Research and Quality and The Annual HealthGrades Bariatric Trends in American Hospitals Study (2006, 2007, 2008, 2009 and 2010).

Annual Growth Rates. Annual estimates for individual years 1999 through 2001 are not available. The increase from 1998 through 2002 is very large, estimated at over 430%. Annual increases after 2002 are less dramatic, yet average twenty-one percent per year from 2002 through 2008, the last year for which data are available. Between 2002 and 2005, the annual percentage change averages twenty-five percent. The annual percentage change for 2006 is remarkable because it is negative. Bariatric surgeries performed in general acute care hospitals decrease nine percent in 2006, perhaps due to an increase in the number of outpatient surgeries (Health Grades Inc., 2008). The trend is not sustained in 2007 when the annual growth rate increases to forty-six percent. In 2008, an estimated 220,000 bariatric surgeries were performed in general acute care hospitals in the U.S., an annual increase of eighteen percent over 2007. Figure 3 shows annual percentage changes in bariatric surgeries and compound annual percentage growth in bariatric surgeries from 2002 through 2008.

Figure 3
Compound Annual Growth Rate versus Annual Changes in Bariatric Surgeries in the U.S. 2002-2008



4.2.2 Total Bariatric Surgeries in Pennsylvania

Table 2 shows the number of bariatric surgeries per year in Pennsylvania. The number of surgeries increased more than ten-fold from 1996 through 2004. The highest number of surgeries occurred in 2004, perhaps reflecting the policy changes by the Department of Health and Human Services in July of that year. The policy change rescinded earlier Medicare policy statements and formally recognized obesity as a disease for the first time. Later in the year, Medicare coverage of bariatric surgery began. In 2005 and 2006, a slight decrease follows the national trend, perhaps suggestive of the entry into the market for outpatient surgery. This is reflective of a nationwide trend in which the number of outpatient bariatric surgeries increased from 2004 through 2006. It may also be due to a 2006 Medicare ruling that bariatric surgery reimbursed under Medicare must be performed at a CMS designated Center of Excellence. Moreover, the nationwide recession may have decreased the demand for surgery if patients found copayments and the lost time from work to be obstacles to surgery. Demand may also have fallen as in the number of persons with health insurance decreased. In 2007, the level of surgeries rises again. Figure 4 shows the total bariatric surgeries in Pennsylvania from 1995 through 2007.

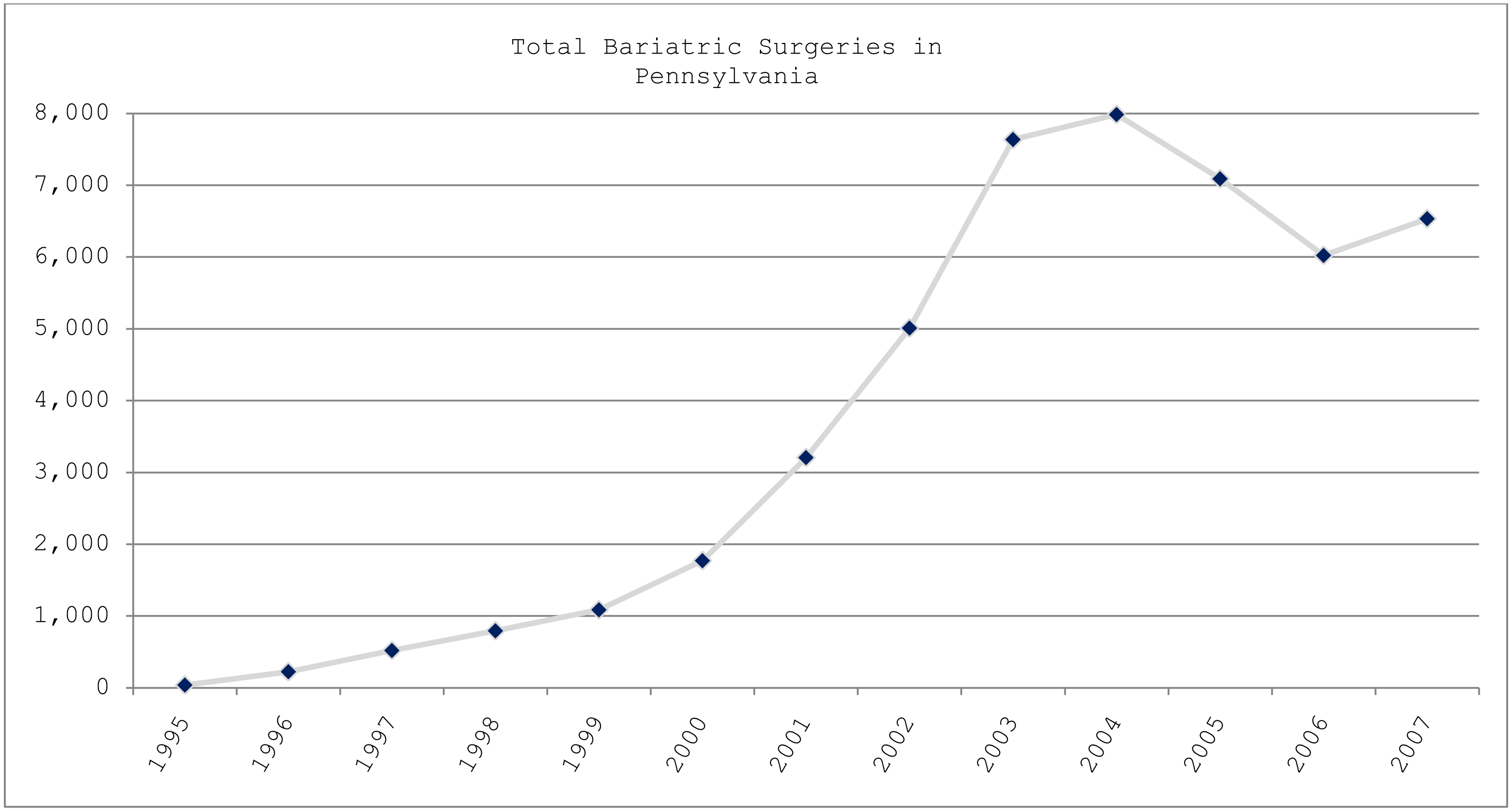
Table 2
Pennsylvania Bariatric Surgeries

Year	Total	% Change
1996	70	
1997	198	183%
1998	362	83%
1999	674	86%
2000	1315	95%
2001	2684	104%
2002	4128	54%
2003	6215	51%
2004	7119	15%
2005	6724	-6%
2006	5746	-15%
2007	6471	13%

Note. Data are from the Pennsylvania Health Care Cost Containment Council and The Annual HealthGrades Bariatric Trends in American Hospitals Study (2006, 2007, 2008 and 2009).

Figure 4

Total Bariatric Surgeries in Pennsylvania

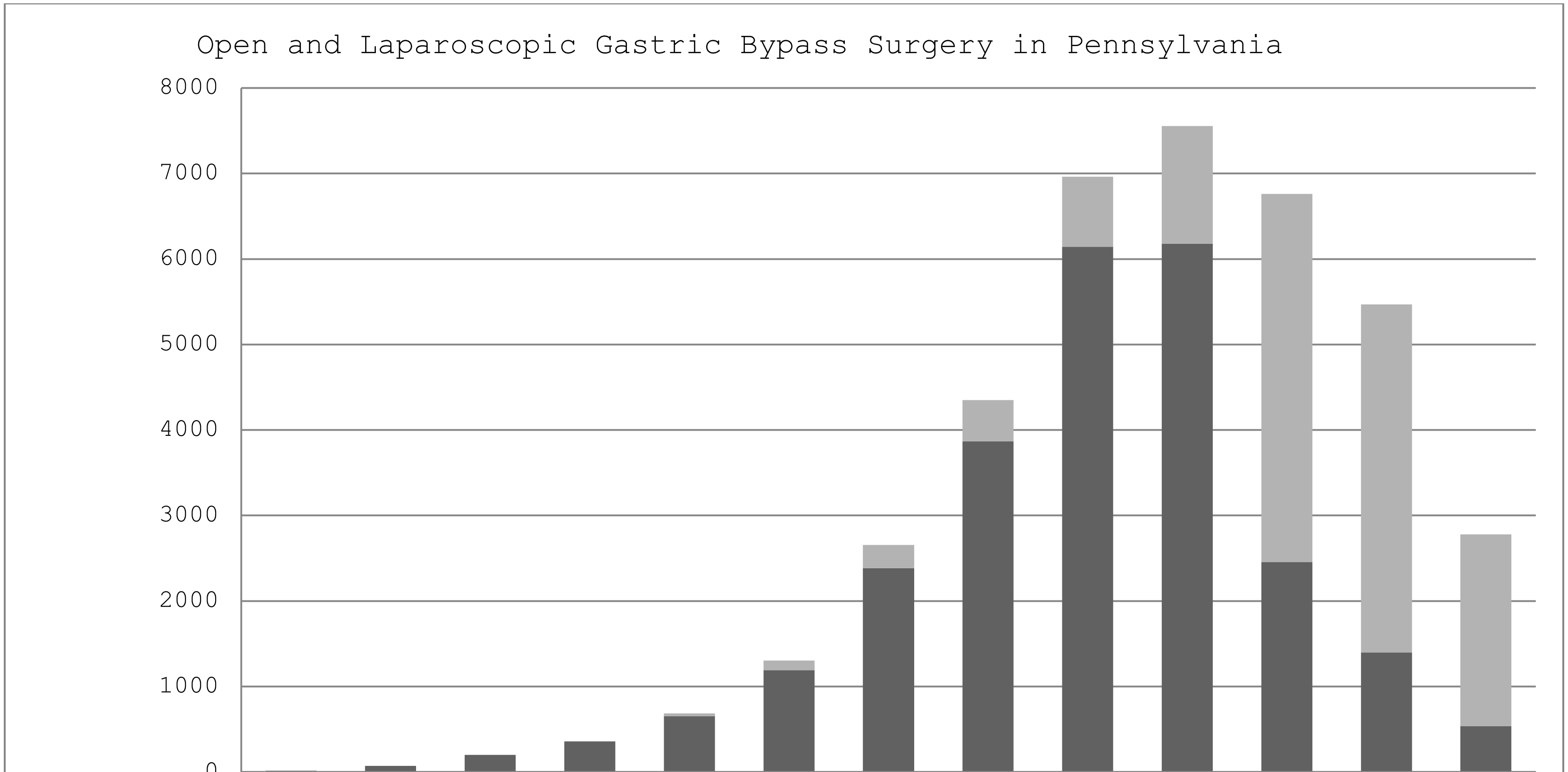


Note. Total surgery data are from the Pennsylvania Health Care Cost Containment Council, HealthGrades Bariatric Trends in American Hospitals Study (2006, 2007, 2008, 2009), and the U.S. Census Bureau. Total data include laparoscopic and gastric bypass, laparoscopic adjustable bands and other types of bariatric surgery.

In 1997, Dr. Philip R. Schauer and a group of physicians from Pittsburgh introduced laparoscopic gastric bypass surgery. The percentage of laparoscopic surgeries remained in the 10 to 12 percent range through 2003. In 2005, laparoscopic surgeries exceeded open surgery for the first time, accounting for 64 percent of the Pennsylvania gastric bypass market. By 2007, the percentage of surgeries performed laparoscopically accounted for 81 percent of all bariatric surgeries in Pennsylvania. Figure 5 shows the number of laparoscopic and open surgeries from 1995 through 2007 in Pennsylvania.

Figure 5

Open and Laparoscopic Surgeries 1995-2007



	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007
Laparoscopic	0	0	1	4	34	114	269	484	820	1377	4309	4071	2242
Open	14	70	197	358	653	1190	2385	3867	6143	6177	2453	1399	538

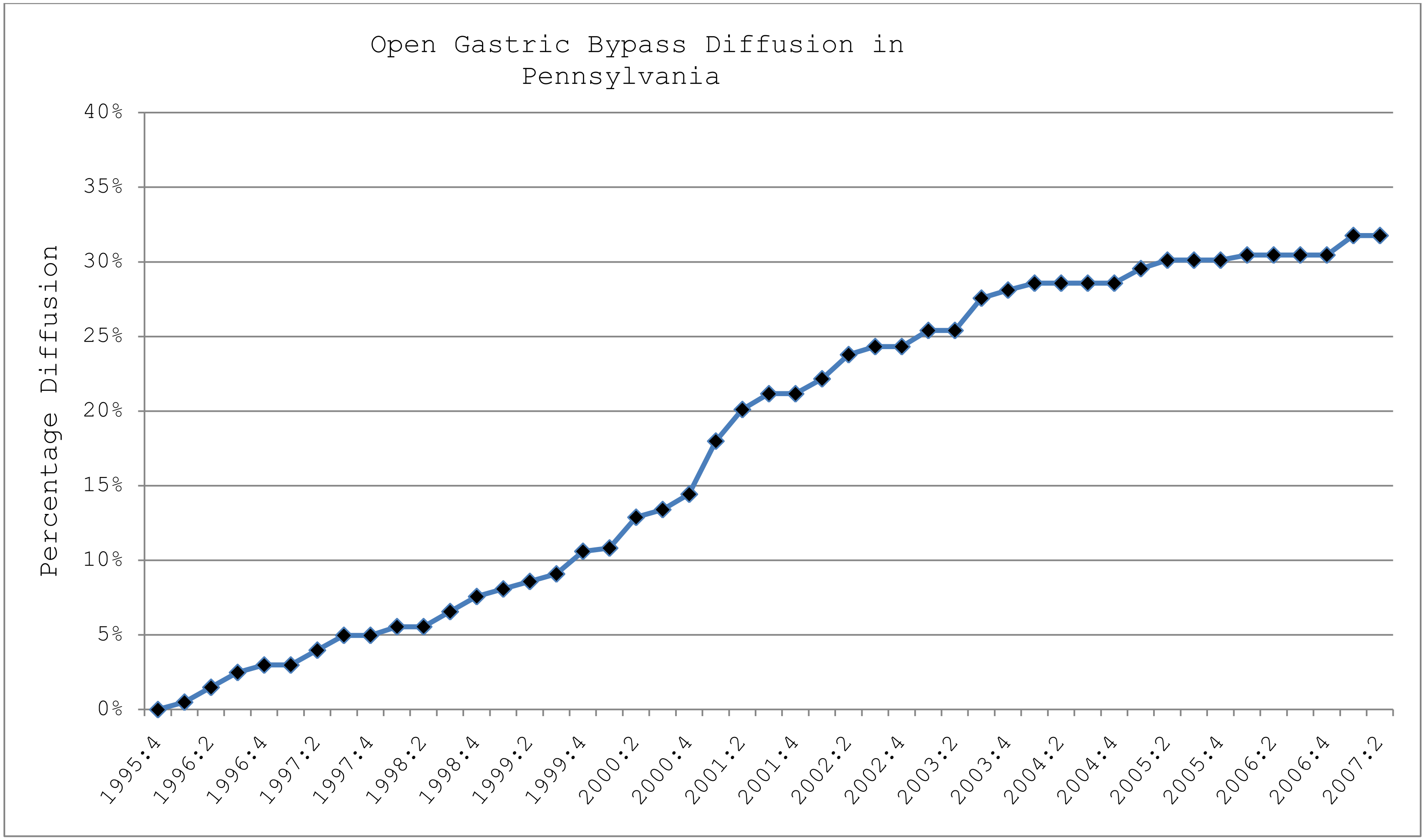
Note. 2007 represents only half-year of data. 1995 represents one quarter year of data.

4.2.3 Open Gastric Bypass Surgery in Pennsylvania

The diffusion pattern of open bariatric surgery in Pennsylvania follows a sigmoid or S-shaped pattern. The significance of this pattern in the diffusion literature is discussed in chapter 1. The S-shape evolves because the rate of diffusion is very slow until it hits a lower threshold, about 10% "saturation level," the percentage of potential adopters who diffuse the surgery. Then, diffusion rates increase more quickly until they reach an inflection point and the rate of diffusion decreases as a maximum market saturation level is reached. An upper bound is then reached at the slower rate of diffusion and the S-shape is traced out. Upper bounds for some surgical procedures may reach eighty percent or more, as is the case for stents in cardiac surgery. Burke, Fournier & Prasad (2007) find stent usage reaches eighty percent of all short term, general acute care hospitals in Florida within five years of its introduction. For an abdominal surgery, an upper bound of thirty percent may be appropriate. For bariatric surgery, Tian (2006) finds an upper bound of thirty percent of all short term, general acute care hospitals in nine states reached after five years. Abdominal surgeries account for a much smaller fraction of hospital revenue than cardiac surgery. In Pennsylvania, while digestive system surgery accounts for about eight percent of hospital revenues, cardiac surgery accounts for almost twenty percent of revenues (PHC4 Reports County Profiles, 2010). It took 4.5 years for the saturation level to increase from ten to thirty percent. In 1999, ten percent of hospitals in the state have diffused open gastric bypass surgery. By 2003, the state's saturation level was about thirty percent for open gastric bypass surgery. Figure 6 shows the diffusion pattern for open gastric bypass surgery among Pennsylvania hospitals.

Figure 6

Open Gastric Bypass Diffusion in Pennsylvania



Note. Data are from the PHC4.

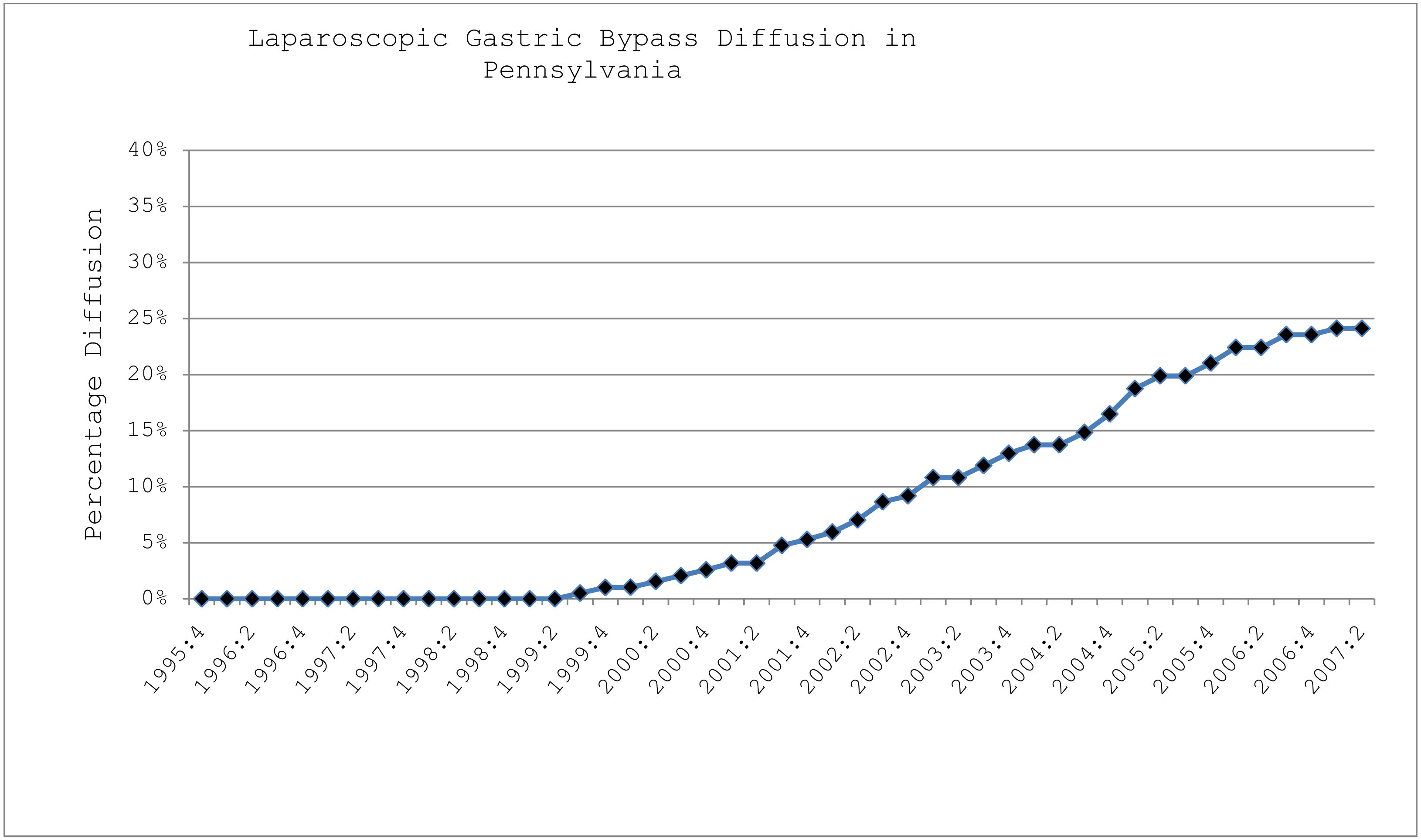
4.2.4 Laparoscopic Gastric Bypass Surgery in Pennsylvania

Similar to the diffusion pattern followed by open gastric bypass surgery, laparoscopic gastric bypass surgery in Pennsylvania also follows a sigmoid or S-shaped pattern. The time between reaching a lower bound of ten percent and its maximum rate, twenty-five percent, in this case, is four years. It may be that if two additional quarters of data were available for Pennsylvania and Pennsylvania's growth rate of surgeries for the year followed the national trend upward, then the thirty percent threshold may be reached by the end of 2007. That would mean the diffusion patterns of open and laparoscopic gastric bypass were very similar.

Figure 7 shows the diffusion pattern of laparoscopic bariatric surgery in Pennsylvania.

Figure 7

Laparoscopic Gastric Bypass Diffusion in Pennsylvania



Note. Data are from the PHC4.

4.2.5 Diffusion Patterns among Hospital Regions

PHC4 aggregates hospital data into nine geographic regions. Figure 4.1 maps the hospital regions in Pennsylvania and includes data on population and counties included in each region. Table 19 lists the hospitals in each region. The number of hospitals in each region varies from 11 to 31, with an average of 14. The mean number of hospital beds per thousand population is 3.58 (standard deviation .73), varying from a minimum of 2.4 to maximum of 4.5 hospital beds per thousand population. Table 3 presents the annual number of bariatric surgeries in each hospital region.

Table 3
Bariatric Surgeries by Hospital Region

	HR1	HR2	HR3	HR4	HR5	HR6	HR7	HR8	HR9
1995	4	2	1	0	2	0	2	0	3
1996	23	18	1	0	3	0	9	0	16
1997	91	11	4	0	10	3	33	0	46
1998	216	21	5	0	23	2	44	3	48
1999	387	22	8	0	42	15	109	4	100
2000	681	20	14	0	121	36	199	16	217
2001	1066	28	54	26	321	104	466	67	522
2002	1635	221	119	92	509	134	671	115	855
2003	2572	486	195	224	875	207	969	317	1118
2004	2637	453	144	294	1130	168	967	541	1220
2005	2105	369	177	338	1003	181	729	826	1034
2006	1690	325	138	362	705	145	643	641	821
2007*	892	180	67	220	348	44	283	332	414

Note. Data are from the Pennsylvania Health Care Cost Containment Council and The Annual HealthGrades Bariatric Trends in American Hospitals Studies.
*2007 includes first two quarters of data.

Figure 8

Pennsylvania Hospital Regions, Counties and Populations

Region 1

Allegheny, Armstrong, Beaver, Fayette, Greene, Washington, and Westmoreland.
Population: 2,297,676

Region 2

Butler, Cameron, Clarion, Clearfield, Crawford, Elk, Erie, Forest, Jefferson, Lawrence, McKean, Mercer, Potter, Venango, and Warren.
Population: 1,142,783

Region 3

Bedford, Blair, Cambria, Indiana, and Somerset.
Population: 637,688

Region 4

Centre, Clinton, Columbia, Lycoming, Mifflin, Montour, Northumberland, Snyder, Tioga, and Union.
Population: 501,354

Region 5

Adams, Cumberland, Dauphin, Franklin, Fulton, Huntingdon, Juniata, Lancaster, Lebanon, Perry, and York.
Population: 1,785,083

Region 6

Bradford, Lackawanna, Luzerne, Monroe, Pike, Sullivan, Susquehanna, Wayne, and Wyoming.
Population: 904,891

Region 7

Berks, Carbon, Lehigh, Northampton, and Schuylkill.
Population: 1,161,932

Region 8

Bucks, Chester, Delaware, and Montgomery.
Population: 2,332,097

Region 9

Philadelphia
Population: 1,517,550

FIGURE 8. Hospital Regions, Counties & Population. Total Pennsylvania Population 12,281,054 (in the Year 2000).

Diffusion Index

Tables 4 and 5 represent my attempt to summarize the diffusion patterns in each Hospital Region by creating an index. This is a primitive approximation at best, based on arbitrarily chosen geographic markets; however it can serve as a monotonically consistent indicator across broad areas. Table 4 and Table 5 provide an index (Slow, Medium, Fast) of diffusion and summarize diffusion characteristics: year of adoption, speed of adoption, final saturation rate and procedures per 1,000 for the last year of the study, 2006 quarter 4 through 2007 quarter 2.

HR1 and HR9. The most striking feature in the data is the dominance in adoption and diffusion of Hospital Regions 1 and 9, both of which include major research hospitals. HR1 is dominated by the University of Pittsburgh's hospital system (UPMC HS) and West Penn Allegheny Health Systems. UMPC accounts for over thirty-five percent of hospital beds with eight hospitals in the system. West Penn Allegheny's five hospitals mean the two largest hospital systems in HR1 account for almost sixty percent of the approximately 8,200 beds in the region. In contrast to HR1, HR9 is made of up several research hospitals, including University of Pennsylvania Hospital System, Temple University Hospital System, Albert Einstein, Thomas Jefferson University

Hospital and Hahnemann University. Both regions appear to have a number of firms seeking a first mover advantage. That is, firms which enter a market first expect to capture and maintain a large share of the market (Markides, Constantides & Geroski, 2005). They take high risks in the hopes of earning large returns. Both hospital regions are early adopters and rapid diffusers of both open and laparoscopic surgery, reaching saturation rates of 45% in HR1 and 59% in HR9. Figure 10 and Figure 11 show the diffusion patterns for HR1 and HR9 for open and laparoscopic gastric bypass surgery.

HR2, HR3 and HR8. HR2, HR3 and HR8 might be classified as second movers. Second movers are unwilling to take the risks that first movers take, but are willing to wait for the market for a product to emerge and then compete by producing a "me-too" product (Markides, Constantides & Geroski, 2005). HR2 and HR8 are both slow to adopt and slow to diffuse laparoscopic gastric bypass. In contrast to HR1 and HR9, HR2, HR3 & HR8 are characterized by the absence of major university teaching hospitals. HR2 & HR3 geographically border HR1; HR8 geographically borders HR9. For open gastric bypass, both HR2 and HR8 eventually reach market saturation rates of 27%. For laparoscopic surgery, the saturation rate in both is very close to 10%. HR3 adopts both laparoscopic and open surgery later than HR2 & HR8; however, like HR2 and HR8, HR3 diffuses slowly.

HR5 and HR6. Hospital diffusion patterns in both HR5 and HR6 are might be classified as following "fast second" strategy. A fast second strategy means firms monitor the actions of first movers and hold off entry. These firms are slow to adopt the technology, but once in the market, they are fast diffusers because they capitalize on firm strengths such as institutional structure which might be conducive to exploiting economies of scale(Waldman & Jensen, 2000; Markides, Constantides & Geroski, 2005). Both HR5 and HR6 have academic medical centers which could account for their ability to quickly diffuse the new surgery. Milton Hershey Medical Center is in HR5 and Geisinger Medical Center is in HR6. Both hospital regions reach saturation points of 24% by the end of the study.

HR7. HR7 can be distinguished from the other hospital regions by its lack of large research hospital or large hospital system. Diffusion of both open and laparoscopic surgery is classified as "Medium." By the end of the study, HR7 reaches 50% saturation rate for open surgery and 46% saturation rate for laparoscopic surgery.

Figure 9 shows the diffusion pattern of bariatric surgery in PA and in each Hospital Region. Tables 4 and 5 shows saturation rates for each Hospital Region. HR1 and HR9 contain major teaching hospitals and lead in the intensity and speed of diffusion. Both are the first to adopt both open and laparoscopic gastric bypass. HR1 and HR9 dominate the number of surgeries performed, accounting for almost half of all gastric bypass surgeries in Pennsylvania over the time period studied.

Table 4
Open Gastric Bypass Diffusion by Hospital Region

Region	Diffusion Description	Year of Adoption	Speed of Adoption	Final Saturation Rate	2006-2007 Procedures Per 1000 Population
HR1	Fast	1995:4	Fast	.45	.06
HR2	Slow	1995:4	Fast	.27	.05
HR3	Slow	1997:4	Medium	.18	.01
HR4	Slow	2001:2	Slow	.07	.01
HR5	Medium	1998:1	Medium	.31	.12
HR6	Slow	1999:1	Medium	.18	.02
HR7	Medium	1996:2	Medium	.50	.04
HR8	Slow	2001:1	Slow	.27	.09
HR9	Fast	1995:4	Fast	.59	.15

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

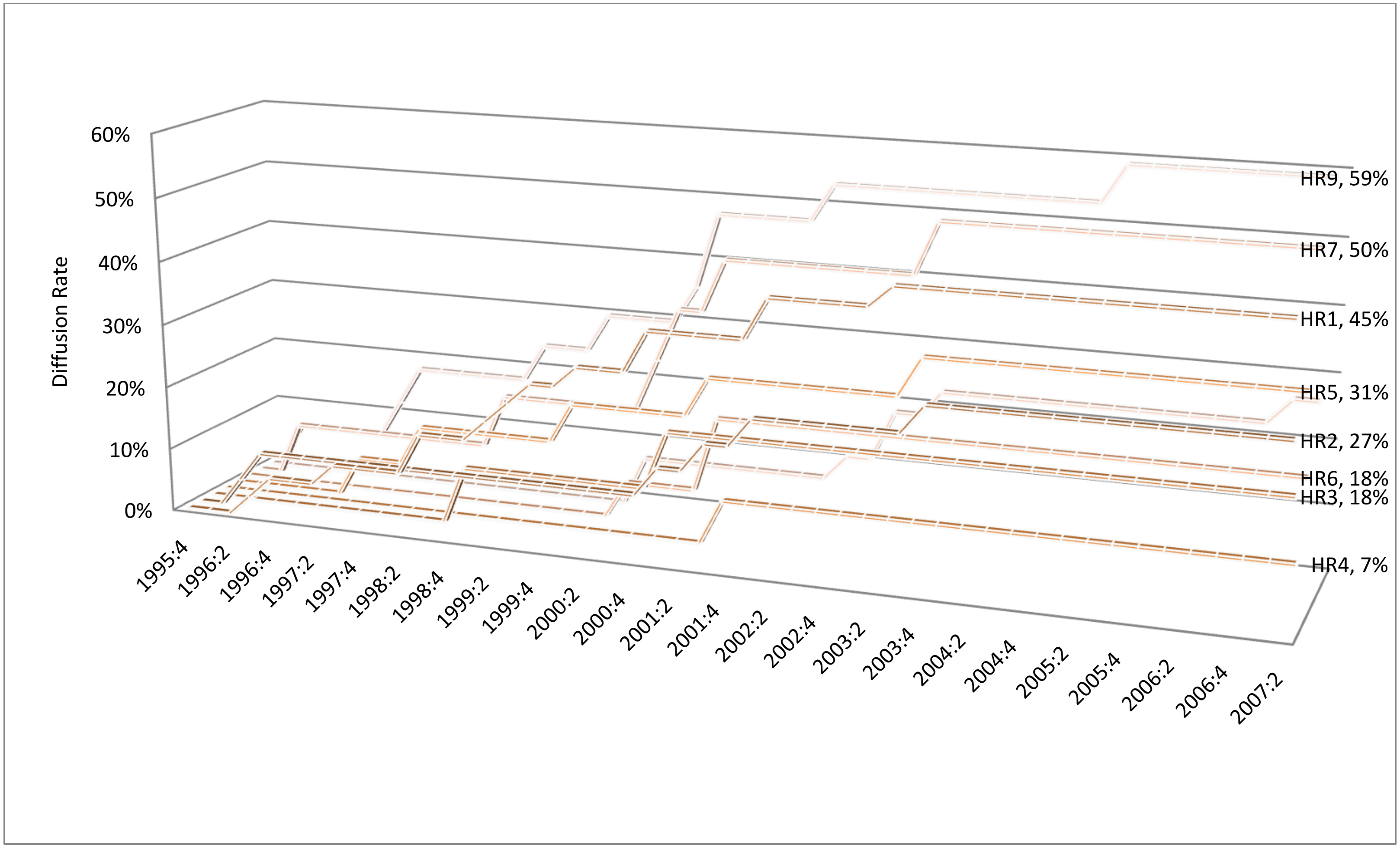
Table 5
Laparoscopic Gastric Bypass Diffusion by Hospital Region

Region	Diffusion Description	Year of Adoption	Speed of Adoption	Final Saturation Rate	2006-2007 Procedures Per 1000 Population
HR1	Fast	1999:2	Fast	.42	.68
HR2	Slow	2004:4	Slow	.09	.24
HR3	Slow	2002:4	Medium	.20	.19
HR4	Slow	2002:2	Fast	.07	.29
HR5	Fast	2004:1	Slow	.24	.27
HR6	Fast	2003:1	Slow	.24	.10
HR7	Medium	2001:1	Fast	.46	.45
HR8	Slow	2004:3	Slow	.13	.18
HR9	Fast	2001:1	Fast	.29	.43

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Figure 9

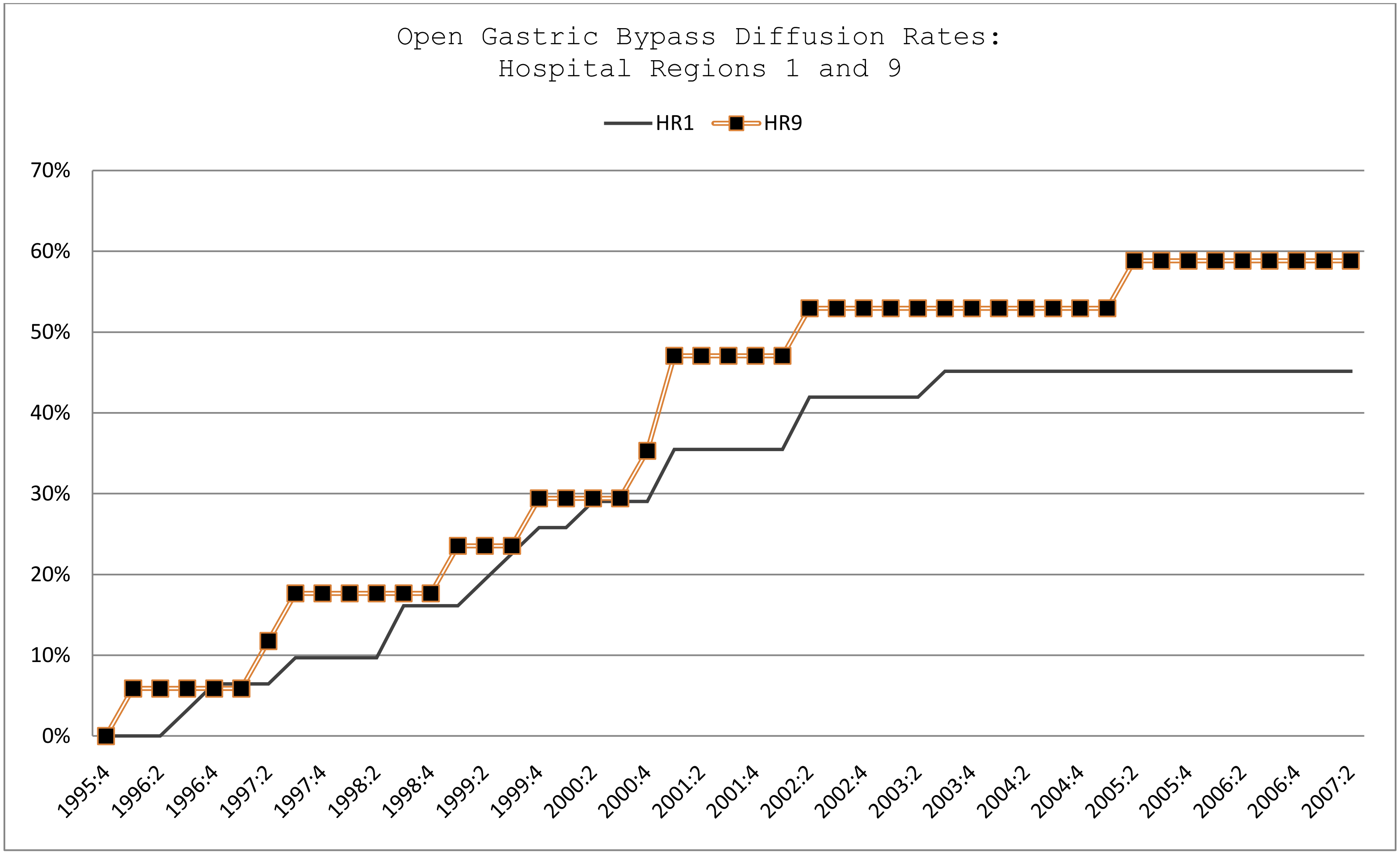
Diffusion by Hospital Region: Open Surgery



Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Figure 10

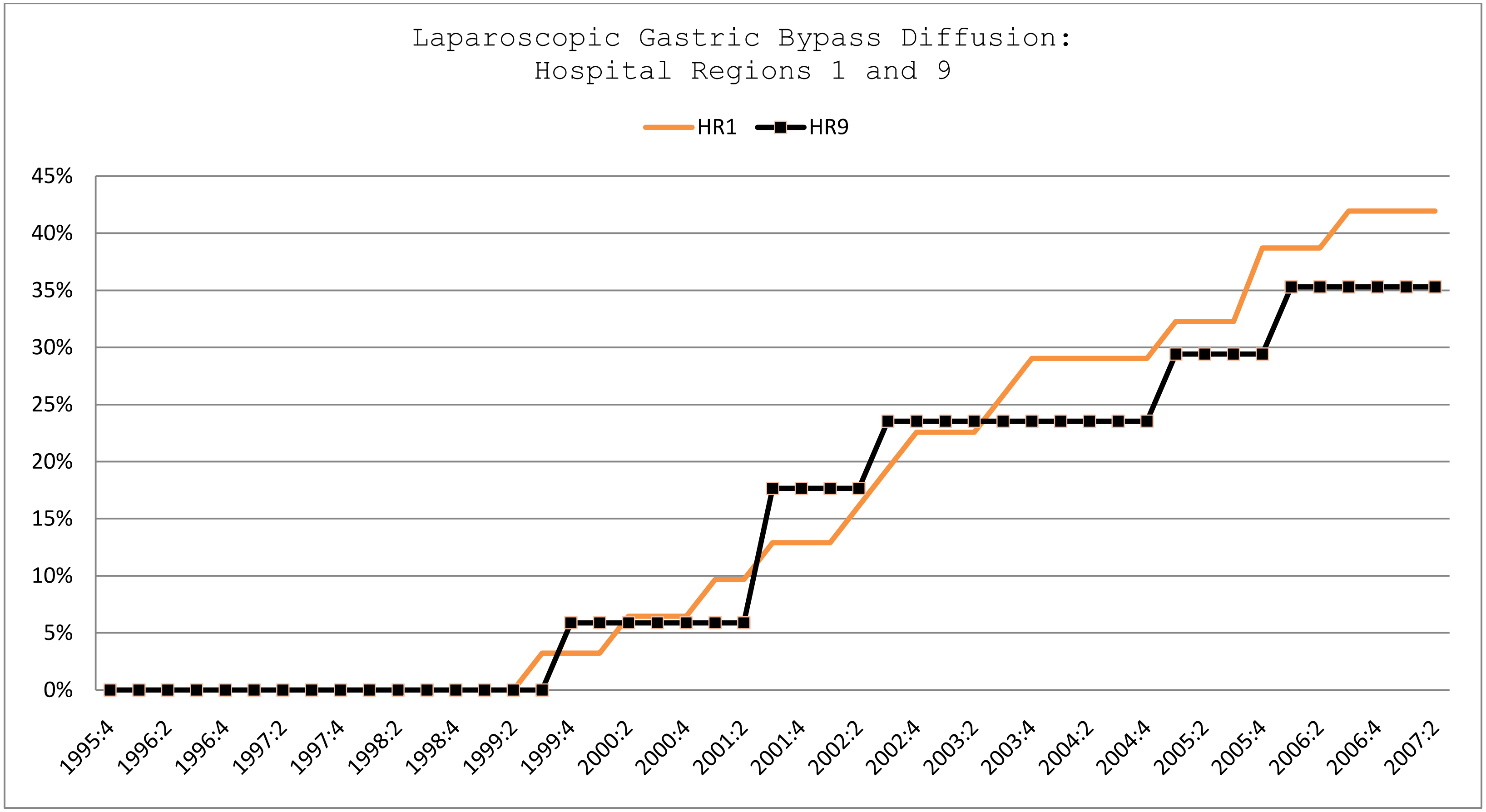
Open Gastric Bypass Diffusion for HR1 and HR9



Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Figure 11

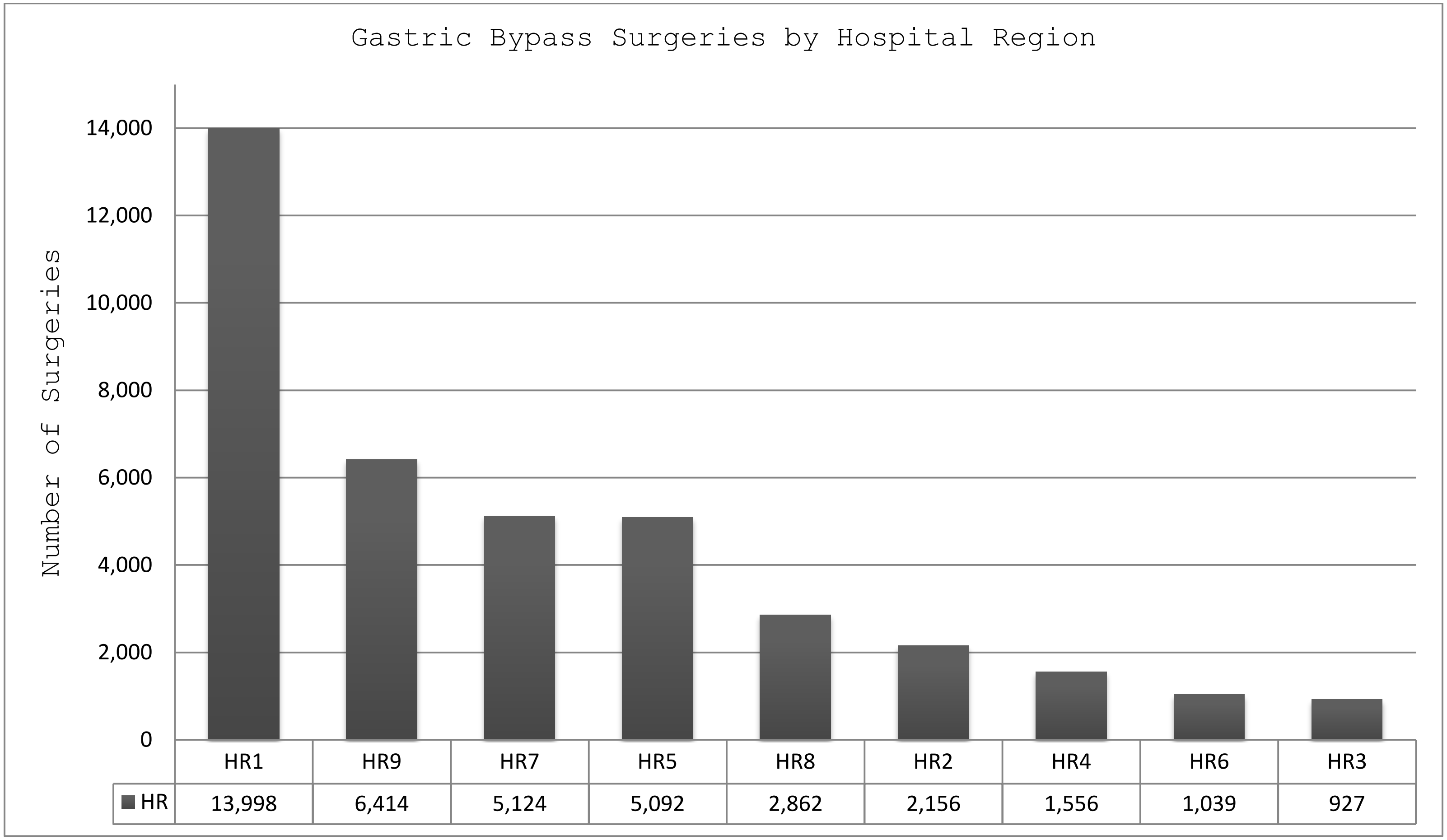
Laparoscopic Gastric Bypass Diffusion for HR1 and HR9



Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Figure 12

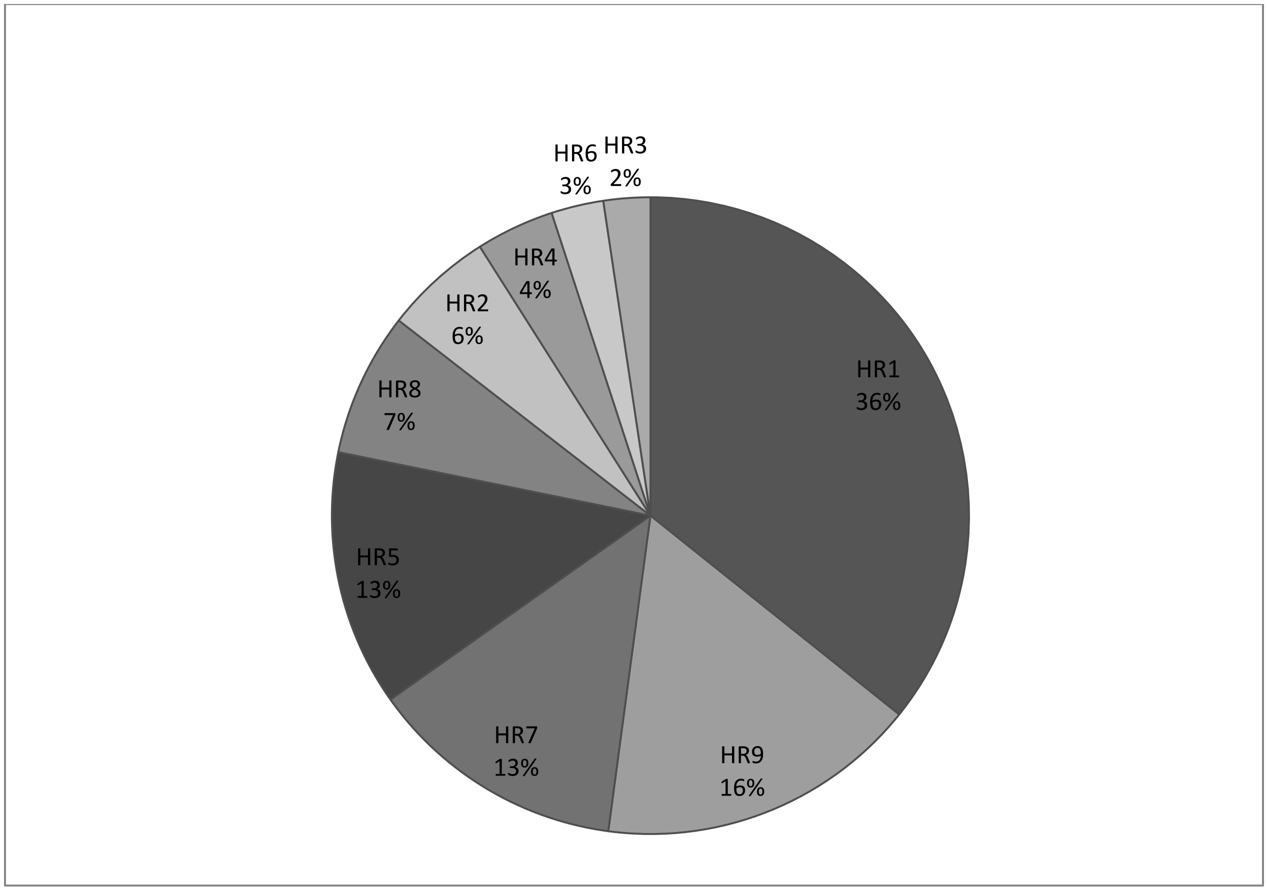
Total Gastric Bypass Surgeries by Hospital Region



Note. Data are from the Pennsylvania Health Care Cost Containment Council and include gastric bypass surgeries from 1995:4 to 2007:2.

Figure 13

Percentage Gastric Bypass Surgery by Hospital Region



Note. Data are from the Pennsylvania Health Care Cost Containment Council and include gastric bypass surgeries from 1995:4 to 2007:2.

4.3 Defining the Relevant Geographic Market

This section describes the theoretical basis for defining a geographically relevant hospital market and explains the rationale for possible empirical applications for defining hospital markets: socio-politically definitions, Elzinga-Hogarty definitions, fixed radius market definitions, and variable radius market definitions. Section 4.3.1 explains the theoretical bases for market definition. Section 4.3.2 describes the socio-politically defined regions. These include the PHC4 hospital regions, HR1 through HR9, which have conveniently been used thus far in describing the hospital data. Section 4.3.3 describes the Elzinga-Hogarty test. Section 4.3.4 describes the fixed radius approach to market definition. Section 4.3.5 describes the variable radius approach to market definition. The use of a variable radius market definition in this dissertation allows for the incorporation of actual patient flow data and results in much smaller markets within the PHC4 defined hospital regions.

4.3.1 Economic Theory & Market Definition

Economic theory defines the relevant geographic market using the hypothetical monopolist test. The relevant geographic market is defined by the smallest group of firms which, if acting collusively as a hypothetical monopolist, could profitably raise prices a significant amount over a sustained time period. The lack of transparent price information for hospital services makes implementing the hypothetical monopolist test challenging. The Department of Justice and the Federal Trade Commission make recommendations for implementing geographic market definitions when assessing the impact of proposed hospital mergers on local markets. See Section 4.3.3 and 4.3.5. Other approaches focus on use of readily available measures of social or political boundaries.

4.3.2 Socio-politically Defined Market Regions

Social and political bounds are sometimes used to define hospital markets. This can include or be limited to a city, county, Metropolitan Statistical Area (MSAs) and urban areas (Lynk, 1995a; Dranove, 1992). The PHC4 aggregates hospital data into nine geographical regions. The PHC4 assigns each of the sixty-seven Pennsylvania counties to one of nine geographic markets, or hospital regions. Figure 1 maps the hospital regions in Pennsylvania and includes data on population and counties included in each region. Table 10 lists the hospitals in each region. The number of hospitals in each region varies from 11 to 31, with an average of 14. The mean number of hospital beds per thousand population is 3.58 (standard deviation .73), varying from a minimum of 2.4 to maximum of 4.5 hospital beds per thousand population. The number of hospitals in each region declined over the time period studied. The total number of hospitals in Pennsylvania declined from 191 hospitals in 1995 to 166 in 2007. Thirty-seven hospitals closed or merged with another hospital. Two hospitals entered the market. This study excludes those hospitals which closed during the time period studied. Data from merged hospitals are included as one hospital.

4.3.3 Market Definition Using Elzinga-Hogarty Test

The Department of Justice and the Federal Trade Commission use the Elzinga-Hogarty criteria as a geographic market definition starting point when assessing the impact of a proposed hospital merger on local markets (Elzinga and Hogarty, 1973). According to Department of Justice and Federal Trade Commission (1996), the hypothetical monopolist could increase price by five percent for one year and maintain monopoly profits. Hospital markets are characterized by great variability and lack of easy access to information about prices. Absent transparent price information, the focus of development of criteria for defining a relevant geographic market for hospitals has been patient flows. The Elzinga-Hogarty test is a two part test which measures patient flows by import and export of hospital services: LIFO is a measure of services imported and LOFI a measure of services exported. The LIFO (Little In From Outside) calculation measures the percentage of patients who live in the geographically defined market area and travel outside the geographically defined market area for services. The LOFI (Little Out From Inside) measures the percentage of patients who live outside the geographically defined market area who travel to the geographically defined market area for services. If ninety percent of patients who live in the area obtain services in the area, then the geographic market satisfies the "strong" Elzinga-Hogarty test. If seventy-five percent of the patients who live in the area obtain services in the area, then the geographic market satisfies the "weak" Elzinga-Hogarty test.

Criticisms of the Elzinga-Hogarty Test. Early criticism of the Elzinga-Hogarty test (E-H Test) measure is that it may measure markets too broadly (Werden, 1981 & 1990; Capps, Dranove, Greenstein, & Satterthwaite, 2001; Tenn, 2008). Elzinga and Hogarty concur that the seventy-five percent criteria is arbitrary. They suggest increasing the criteria to ninety percent (Elzinga and Hogarty, 1978;

Elzinga, 1981). Another criticism is that the E-H test is designed to measure markets in which firms sell homogeneous products, but hospitals are multiproduct firms which sell differentiated products (Possai and Goetz, 1994). Finally, the E-H tests do not account for observed one way flow of patients from rural to urban centers (Blackstone and Fuhr, 1998). The FTC/DOJ suggest that the hypothetical monopolist test should be implemented, but used along with additional evidence of market definition such as hospital's strategic planning documents, which might identify potential competitors.

PHC4 Hospital Regions and the Elzinga-Hogarty Test. Of the nine hospital regions, only HR5 satisfies the E-H criteria. HR5 captures seventy-five percent of patient flows, satisfying the weak E-H market criteria. Since the defined hospital regions include several counties, market definitions which include smaller areas are considered.

4.3.4 Fixed Radius Criteria

Fixed radius criteria reflect the idea that patients seem to prefer to patronize hospitals within a relatively short distance from their homes. In the case of emergency medical situations, ambulances are often required by law to take a patient to the nearest hospital. Using fixed radius criteria, a radius is drawn from a hospital's address to the desired distance, with fifteen miles being a frequent cut off (Robinson and Luft, 1985; Gruber, 1994; and Shen, 2002). Sometimes, the distance is calculated from the exact longitude and latitude of the hospital to the area extending to and including the ZIP codes within the chosen cutoff point. The entire ZIP code reached is included in the relevant geographic market. Other times, the centroid of the ZIP code which includes the hospital is used and extended to the chosen cutoff point. The U.S. Bureau of the Census calculates the centroid for each ZIP code location as the latitude and longitude point determined as the mean population center within a ZIP code region. The fixed radius criteria are convenient and relatively easy to apply; however, a fixed market definition does not account for demographic or hospital characteristics which might result in differences in hospital market size.

4.3.5 Variable Radius Criteria

Variable radius market definitions capture the seventy-five and ninety percent patient flows of the Elzing-Hogarty criteria by finding the length of radius which reflects hospital and demographic characteristics and satisfies the seventy-five and ninety percent patient flow requirements. Phibbs and Robinson (1993) use hospital admission data from the state of California to empirically test for geographic bounds corresponding to seventy-five percent and ninety percent patient flows. Gresenz, Rogowski and Escarce (2004) use hospital admission data from nine states to define hospital markets which capture seventy five and ninety percent of patient flows. Both calculate median and mean radii which are less than the fifteen miles often used as an ad hoc cut off in fixed radius models.

4.3.6 Variable Radius Test for Bariatric Surgery Markets

Following Gresenz, Rogowski and Escarce (2004) and Phibbs and Robinson (1993), this study calculates the radii which capture seventy-five percent and ninety percent of all patient discharges as seventeen and nineteen miles respectively. The distance between the centroid of the patient's ZIP code and the centroid of the ZIP code of the hospital is used as the proxy for the exact distance between patient's home and the hospital. The nineteen mile market radius used in the strong market definition in this study is consistent with the work of Gresenz, Rogowski and Escarce (2004) and Phibbs and Robinson (1993). Hospital characteristics which are statistically significant (p<=.05) include the following: population density, number of hospitals within fifteen miles, average patient length of stay, log of total charges, and hospital teaching status. Table 6 shows a comparison of the variables used in this study and the variables used by Phibbs and Robinson and Gresenz, Rogowski and Escarce for the ninety percent market definition. Ordinary Least Squares Regressions are used to calculate the ninety percent patient flows.

Table 7 shows a comparison of the radii used in this study and the radii calculated by Phibbs and Robinson and Gresenz, Rogowski and Escarce for the ninety percent market definition. The radii for bariatric surgery in Pennsylvania compare favorably with the previous work. The 19.2 miles actually is the mean patient distance to hospital which captures ninety percent of patients. The regression is then used to predict market radii. The radii predicted is 18.7 miles. I then use 19.0 miles to calculate the radius of a hospital's market for each hospital in the sample.

Table 6

Variables Used in Market Radius Calculations: Comparison with Previous Research

	Phibbs & Robinson		Gresenz, Rogowski & Escarce		Shinn	
Hospital Characteristics						
Population density	√	***	√	***	√	***
Number of hospitals within 15 miles	√		√		√	***
COTH hospital	√		√	**	√	***
Urban code	√		√		√	***
Hospital system member					√	***
Average length of stay (days)	√		√		√	***
Log of total charges	√	***			√	***
Patient sex					√	***
Patient race					√	***
Adjusted R-squared		.35		.44		.20

Note. *p<=0.10; **p<=0.05; ***p<=0.01. Gresenz, Rogowski& Escarce test for burn unit, trauma center, geriatric services, reproductive services, post acute care services, specialized imaging services, disease specific care and other medical services a find no statistical significance.

Table 7
Comparison of Market Radii with Earlier Studies: 90% of Patient Discharges

	Mean	Median	Standard deviation	Minimum	Maximum
Actual radius(miles)					
Phibbs & Robinson	17.8	14.0	12.7	0.6	124.4
Gresenz, Rogowski & Escarce	21.5	15.7	19.7	0.4	179.0
Shinn	19.2	13.4	18.5	0.1	97.8
Predicted radius(miles)					
Phibbs & Robinson	17.8	17.2	7.9	4.7	42.6
Gresenz, Rogowski & Escarce	22.8	21.0	12.2	0.2	105.1
Shinn	18.7	17.6	8.1	0.0	45.6

Note. Phibbs & Robinson, 1983, California, 355 hospitals. Gresenz, Rogowski & Escarce, 1997 data, 9 states, 1,246 hospitals. Shinn, 1995 through 2007, Pennsylvania, 166 hospitals. Gresenz, Rogowski & Escarce calculate slightly large radii for rural areas. Urban area data are shown above.

This study extends the work of Gresenz, Rogowski and Escarce (2004) and Phibbs and Robinson (1993) by including discharge data restricted to a specific surgery. This early work in market definition includes all types of hospital discharges. This study is consistent with the work of Huckman (2006) and Burke, Fournier & Prasad (2007), both of which use a variable radius test. Both use data which include a cross section of patients undergoing surgery for acute myocardial infarction. Lack of information about contiguous areas in neighboring states may limit the analysis of market definition in those markets in which patients cross state lines.

Payer Testimony. The FTC/DOJ suggests that the hypothetical monopolist test should be implemented as a starting point for defining a relevant market. Additional evidence such as strategic planning documents of merging hospitals, payer testimony, and customer testimony should be used next. Strategic planning documents could show which hospitals the merging hospitals consider as competitors. Payer testimony is important in hospital cases because of the existence of third party payers. Patient testimony could contribute information on willingness to travel which could be used in defining relevant geographic markets. Interviews with physicians and hospital administrators in one market are used to ask which hospitals they consider competitors. See Chapter 3. This information provides some support for the market definitions.

PHC4 Hospital Regions and the Variable Radius Criteria. Using the variable radius criteria, I estimate the market for each of the hospitals in Pennsylvania. This helps show variations in markets within the PHC4 defined hospital regions. For instance, using a variable radius market definition for a hospital in HR9 means some hospitals in HR8 are included in the market definition. HR9 includes the city of Philadelphia, a major teaching center. HR8 includes suburban areas surrounding Philadelphia. The variable radius measure captures the observed one way flow of patients from outside urban areas to urban centers (Blackstone & Fuhr, 1998). A limitation of the variable radius criteria is that the market defined for a hospital in HR8 may include the HR9 hospitals within its nineteen mile radius, despite the limited draw of patients to the suburbs from the city.

In theory, the variable radius method could result in one hundred sixty-six different values of market concentration, a distinct value for each geographic location. Empirically, measuring a Herfindahl-Hirshman Index (HHI) sometimes results in measures which are consistent with the PHC4 calculation. The calculated HHI for HR9 is 1081. Using the variable radius criteria, the range of HHIs calculated for the each of the 17 hospitals in HR9 is 604 to 734. This is explained easily because HR9 includes the county and city of Philadelphia, which is densely populated within a small radius.

Empirically, measuring a Herfindahl-Hirshman Index (HHI) sometimes results in measures which are vary widely from the PHC4 calculation. The HHI for HR8 is 1179. Using the variable radius criteria, the range of HHI calculated for the 26 hospitals in HR8 is 620 to 4009. HR8 contains the counties just outside Philadelphia. It is reasonable that hospitals bordering Philadelphia would have HHIs close to those observed in HR9, in the competitive range. Those further away from the city are in the concentrated range for HHI, over 2,500 (Federal Trade Commission/Department of Justice, 2010).

Defining the relevant market using the variable radius method provides more precise measures of market competition than using the PHC4 defined hospital regions in HR1, the region in which the highest levels of diffusion occur. This is helpful in teasing out the different market characteristics in and around the Pittsburgh area, which is included in HR1. The calculation of HHI for the PHC4 defined HR1 results in a measure of market competition that is moderately concentrated, a value of 1638. Using the variable radius criteria to define a nineteen mile market radius for each of the 31 hospitals within HR1 reveals several concentrated markets. HHI calculations for each of the hospital markets range from 2,458 to 10,000, all of which are in the highly concentrated range for HHI. The Appendix shows each hospital and hospital HHI.

4.4 Explanatory Variables

4.4.1 Demographic Patterns

Incidence of Obesity and Diffusion within the United States

There is little evidence of a relationship between the number of hospitals diffusing bariatric surgery in an area and the rate of obesity in an area. The National Health and Nutrition Examination Survey (NHANES) estimates obesity levels in the U.S. population and in individual states. The NHANES takes a telephone sample of all U.S. households and follows up with actual visits during which NHANES representatives take height and weight measurements to calculate participants' BMI. States with the highest levels of obesity, all over thirty percent of the population aged twenty to seventy-four, are centered in the south: Alabama, Mississippi, Oklahoma, South Carolina, Tennessee, and West Virginia. State level data on number of bariatric surgeries is available for seventeen U.S. states. The data show that there is a concentration of the number of bariatric surgeries in a handful of states (Healthgrades, 2009). California, New York, Pennsylvania and Texas account for over half of all the surgeries among the seventeen states. The data show little correlation between states in which the most bariatric surgeries are performed and states in which the highest rates of obesity are observed.

National Trends in Morbid Obesity

The NHANES data for 2005 through 2007 which show that the levels of obesity in the U.S. show no statistically different trend from 2004, when overweight and obesity accounted for two-thirds of the adult population. County level rates of obesity are available from the U.S. Census American Community survey beginning in 2004; however, data on morbid obesity rates are not readily available. Though the population obesity rates overall have stabilized, the rates of morbid obesity (BMI greater than or equal to 40.0) continue to increase. In addition, the total bariatric eligible population increases from eleven million to over twenty two million if one includes those with BMI greater than 35 and comorbidity such as type II diabetes(Martin, Beekly, Kjorstad and Sebesta, 2010). Using the criteria outlined by Martin, Beekly, Kjorstad and Sebesta (2010), the number of bariatric surgeries in 2006 accounted for less than one half of one percent of those eligible.

Table 8
Population of Morbidly Obese

	Morbidly Obese	Percent change
1971-1974 NHANES I	1.3	
1976-1980 NHANES II	1.4	7.7
1988-1994 NHANES III	3.0	114.3
1999-2000 NHANES	5.0	66.7
2005-2006 NHANES	6.2	24.0

Note. NHANES data include adults aged twenty to seventy-four.

Incidence of Obesity and Diffusion within Pennsylvania

Beginning in 2005, the CDC estimates annual obesity rates at the county level for each of the 3,141 counties in the U.S. Within Pennsylvania, the counties with the highest rates of diffusion seem to bear no relationship to the counties with relatively higher rates of obesity. Table 9 shows the 2007 rate of obesity and the 2007 saturation rates for laparoscopic gastric bypass surgery for each of the PHC4 defined hospital regions in Pennsylvania.

Table 9

2007 Obesity Rates, Market Saturation Rates and Diffusion Speed by Hospital Region

Hospital Region	Obesity Rate	Market Saturation Rate	Speed of Diffusion
HR1	28.8	0.42	Fast
HR2	28.2	0.09	Slow
HR3	28.9	0.18	Slow
HR4	27.8	0.07	Slow
HR5	28.2	0.25	Fast
HR6	27.6	0.24	Fast
HR7	28.9	0.50	Medium
HR8	23.7	0.12	Slow
HR9	29.1	0.35	Fast

Note. County level obesity rates are from the Behavioral Risk Surveillance Survey and the CDC.

Income Changes 1996 - 2007

Changes in income do not seem to explain the patterns of diffusion. Table 20 shows median household income, and change in bariatric surgeries from 1995 through 2007. Getzen (2000) and Fogel (1999) calculate a long run income elasticity of demand for health care services equal to 1.6

at the national level. Using the 1.6 elasticity estimate, the 3.6 percent income growth in Pennsylvania over the time 1997 through 2006, would account for an increase in demand for bariatric surgery of just 5.7 percent.

Table 10
Income and Bariatric Surgery

Year	PA median household income(2000 dollars)	Percentage Change in Income	Percentage Change in Bariatric surgeries	Surgeries per 1000 population
1995	48,248			.001
1996	47,507			.01
1997	49,991	-1.54%	183%	.02
1998	51,466	2.95%	83%	.03
1999	48,790	-5.20%	86%	.06
2000	52,732	8.08%	95%	.11
2001	52,901	.032%	104%	.22
2002	50,862	-3.85%	54%	.35
2003	50,260	-1.18%	51%	.57
2004	50,275	.03%	15%	.62
2005	51,064	1.57%	-6%	.55
2006	51,767	1.38%	-15%	.45
2007	50,298	-2.84%	13%	.46

Note. Data are from the Pennsylvania Health Care Cost Containment Council, HealthGrades Bariatric Trends in American Hospitals Study (2006, 2007, 2008, 2009), and the U.S. Census Bureau. Income is reported in 2000 dollars.

4.4.2 Substitutability of Open and Laparoscopic Surgery

The number of substitutes for a technology affects its diffusion. Bariatric surgery has been shown to effectively treat morbid obesity. Substitutes for surgical treatment of obesity are behavior modification through dieting and exercise alone or pharmacological treatment. None approach the long term success of bariatric surgery (Sjöström L. et al, 2007). Bariatric surgery has been shown to be cost effective compared with non-surgical treatments for weight loss (Clegg, Colquitt, Sidhu et al, 2003; Craig & Teng, 2002; Keating, Dixon, Moodie et al, 2009). Surgical substitutes for open or laparoscopic gastric bypass include sleeve gastrectomy, duodenal switch, and laparoscopic gastric banding. Expected weight loss with gastric bypass surgery, whether open or laparoscopic, is about fifty to seventy percent of excess weight, with maximum weight loss occurring within eighteen months. Expected weight loss with gastric banding and other bariatric surgeries is about forty percent of excess weight, with maximum weight loss occurring over two years. During the time period covered in this study, gastric bypass accounts for over ninety percent of all procedures in Pennsylvania.

Laparoscopic gastric bypass surgery is a substitute for open gastric bypass surgery. Open surgery uses a traditional surgical opening to access the abdominal cavity. With laparoscopic surgery, five or six small incisions are made and cameras are inserted into the abdominal cavity so that the surgeon views the abdominal cavity indirectly on a video screen. Laparoscopic surgery is also called minimally invasive surgery. The main advantage of laparoscopic surgery over open surgery is faster recovery time. Risks of hospital borne infections and incisional hernia are also reduced with laparoscopic surgery (Jones Jr, et al., 2006).

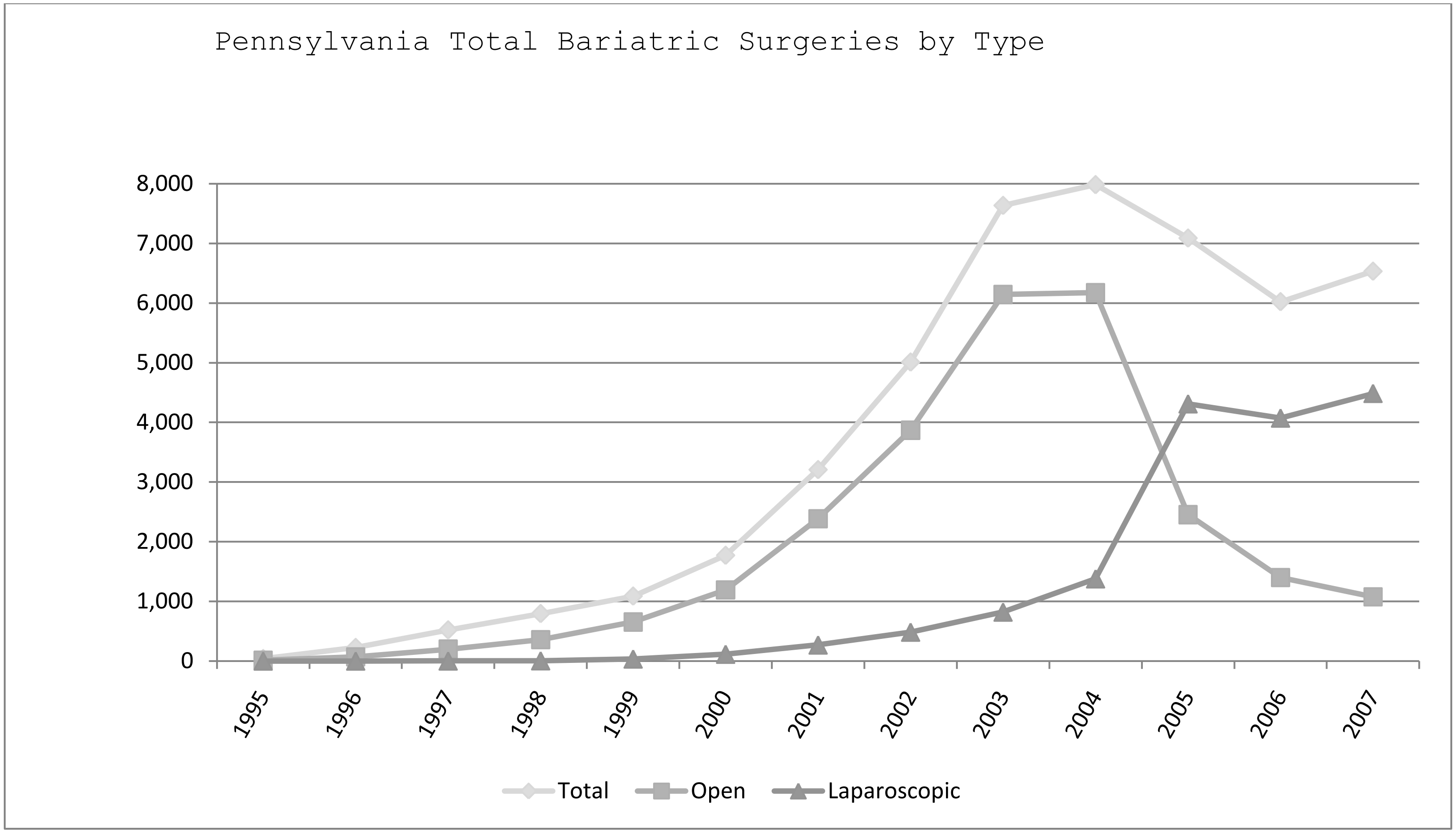
Since morbidly obese patients present unique difficulties in surgery, it may be difficult to assess the ability to complete successfully a laparoscopic gastric bypass on a patient. Some patients may have scar tissue from previous abdominal surgeries which may preclude laparoscopic surgery. Others may have too much fat tissue surrounding the organs for a successful laparoscopic procedure. Surgeons rely on the ability to convert a laparoscopic surgery to an open surgery if it is medically necessary.

In most cases, diffusion of laparoscopic gastric bypass occurs at surgery centers in which open gastric bypass has already diffused; however, it is not a necessary condition for diffusion of laparoscopic gastric bypass surgery. A hospital may offer minimally invasive surgery for gallbladder and other abdominal surgeries and extend its offerings to gastric bypass.

Surgeon training has changed over the time period studied. From 1998 through 2002, there was rapid growth in the number of open gastric bypass surgeries being performed. Surgeons learned the gastric bypass operation in a general surgery or specialized residency program or individualized training after they were already in practice. Laparoscopic techniques were being perfected in several areas during the 1990s. Very few surgeons had mastered both gastric bypass and laparoscopic surgery. By the end of the study, students graduating medical school Residency programs will have had training in laparoscopic techniques. A resident may not know how to perform gastric bypass, but she will have had some experience with laparoscopic techniques. Training in laparoscopic bariatric surgery, including gastric bypass, will come through residency or fellowship training.

Figure 11 shows the distribution of open and laparoscopic surgeries in Pennsylvania from 1995 through 2007.

Figure 14
Total Bariatric Surgeries by Type



Note. Data are from the Pennsylvania Health Care Cost Containment Council.
*2007 includes first two quarters of data.

4.4.3 Supply Regulation: Center of Excellence Designation

Surgical procedures are sometimes subject to direct governmental regulation of supply such as when certificate of need (CON) legislation limits the number of specific surgical centers which may be built within a geographic area. This is not the case for bariatric surgery; however, restrictions on subsidies also serve to restrict supply. Government directly pays for almost half of all medical expenditures through Medicare and Medicaid, yet the influence of Medicare payment guidelines extends to all hospitals since private insurers often follow Medicare guidelines. In February 2006, the Centers for Medicare and Medicaid Services (CMS) issued a ruling that Medicare and Medicaid will cover bariatric surgical procedures only at facilities certified either by the American College of Surgeons (ACS) or the American Society for Metabolic & Bariatric Surgery (ASMBS). Designation of surgery centers as Centers of Excellence (COE) may restrict the ability of low volume hospitals to offer gastric bypass surgery. Third party insurers, which accounted for over ninety-three percent of all surgeries in 2007, may choose to reimburse only for procedures at certified centers of excellence.

The certification programs of the ASMBS and the ACS share many similarities. Both ASMBS and ACS have multilevel certifications. Both certifications track in-hospital morbidity and mortality and 30 day readmission rates and require on site facility inspections. Both require the surgery center to perform 125 surgeries per year. The ACS's A-1 certification requires the surgery center to have two surgeons, each of whom has performed at least 100 surgeries in the past twenty-four months. ACS's Level 2 certifications require an inpatient center to perform a minimum of 25 surgeries annually and have at least one surgeon who has performed at least 50 surgeries in the past 24 months. Medicare and Medicaid provide reimbursement for ASMBS full and provisional status hospitals and ACS's A-1 certified hospitals. Some commercial insurers reimburse for Level 2 facilities for certain low-risk patients.

The ASBMS Surgery Center of Excellence (BSCOE) designation differs from the ACS certification in a few ways. The ASMBS certifies facilities and surgeons. The ACS certifies the facility level and requires the facility to certify surgeons. The ASMBS designation requires follow up data on patients and certification of other process of care features such as the existence of a follow-up program, presence of a medical director, a nutritionist and other support staff.

Bariatric surgery is similar to other abdominal surgeries which require a specialized skill in that as surgeons perform more operations, learning-by-doing occurs. Decreases in mortality, surgical complications and cost are realized as surgeons perform a certain number of surgeries. Measuring volume by hospital and by surgeon has been used as criteria for determining learning. Defining surgery centers which perform over 100 surgeries annually as high volume, Nguyen et al(2004) find an inverse relationship between volume and cost and between volume and mortality at academic medical centers over a three year time period.

ACS certification began in 2003. ASMBS certification began in 2005. Requirements by Medicare for COE certification began in 2006. This study includes forty-seven quarters of data, five of which occur after the Medicare ruling. It is possible that hospitals may discontinue services if they did not meet the COE minimum requirements. No such behavior is evident in the data. It is also possible that hospitals may decide not to enter the market because of the requirements; however, it is impossible to observe this from the data available.

4.4.4 Profitability

Among for profit firms, the role of profitability has been central to economic research in technology diffusion; however, the hospital industry is comprised of nonprofit, for profit, and government hospitals. If most hospitals are nonprofit organizations, what is the role of profit in hospital diffusion of technology? The issue of whether nonprofit hospital behavior is the same as for profit hospital behavior is highly contested. To account for the varied findings on statistical significance of hospital's profit status, an independent variable "for_profit" is included as a control variable in the empirical analysis. See Section 5.1.2.

This section contains a brief discussion of the theory and findings in the literature on nonprofit hospital behavior, including the role of nonprice competition. Then, it provides estimates of costs and reimbursements to hospitals and physicians. An explanation of the tradeoff between risks and returns to hospitals and physicians from the adoption of bariatric surgery results in an expectation of a positive operating margin. The section concludes with a discussion of the Financial Reimbursement Cycle.

Theories of Nonprofit Hospital Behavior

Economists have proposed several theories of nonprofit hospital behavior. Each involves an objective function with a different maximand. Testing the objective function of nonprofit firms is difficult and may lead to the same result being interpretable by more than one theory. This categorization follows Horwitz (2007). Either (1)firms maximize output; (2)markets maximize output; (3)firms maximize profit; or (4)a combination of the previous objectives describes firm behavior. Let us consider each in turn with respect to technology diffusion.

1. Firms maximize output (Newhouse, 1970 and Rose-Ackerman, 1996). This is consistent with altruistic goals of the firm. Nonprofit firms might adopt a technology because providing this technology is consistent with the goal of fulfilling the hospital's mission to provide the best quality care to the community, where best means the latest, best quality technology available. In this case, pricing behavior might mean nonprofit hospitals compete on price to obtain high prices for one service to subsidize a service for which they have little or no profit.

2. Markets maximize output (Weisbrod, 1988 and Frank and Salkever, 1991). According to this theory, the entire

hospital market provides some goods or services which, absent the presence of nonprofits, would not be provided by for profit or government hospitals. It is the mix of hospital types, nonprofit, for profit and government, which results in a maximizing of market output. Nonprofits not only provide profitable services, but they respond to the overall market mix of services provided. For instance, nonprofit hospital may offer less profitable services such as psychological services, in an attempt to compete with for profit hospitals which concentrate on more profitable services. In this way, market output is maximized.

3. Nonprofit hospitals maximize profit, or firms act as for-profits in disguise. The Pauly-Redisch (1973) theory of the hospital as the physicians' cooperative falls under this category. According to Pauly-Redisch, nonprofit hospitals might adopt new technologies because it fits physicians' objectives. A variation on the physicians' cooperative is that nonprofit hospitals adopt new technologies and capture the profits for management.

4. Mixed Objectives Theories. Hirth (1997 and 1999). Firms maximize output and firms act as For-Profits in Disguise. According to this theory, hospitals which are nonprofit have motivations which may be either to maximize

output or to maximize profit. Both types of firms exist in the hospital market.

Common to each of the four theories is the idea that nonprofit hospitals may compete for profit in one area in order to subsidize other services which may not be profitable. Each of the theories support nonprice competition in terms of quality or prestige through learning and research.

The Role of Nonprice Competition. Whether or not the profitability of bariatric surgery is central to the decision making process of the hospital, the additional goals of the nonprofit hospital support the idea that hospitals have an expectation of profitability along with an expectation that diffusion of bariatric surgery may support some of the firm's other goals such as advancement of research and learning, prestige, and improvements to patient care and quality of life. These other goals may be achieved through nonprice competition. Nonprice competition means firms compete for physicians and patients on the basis of technology, quality and other characteristics.

The Literature. The lack of transparency in hospital pricing limits empirical tests of nonprofit and for profit hospital exercise of market power through pricing behavior. Despite that, several anti-trust cases lend support to arguments that nonprofit hospitals act like for profit hospitals and raise prices after merging with other hospitals.

Lower prices. Lynk (1995) and Lynk and Neuman (1999) find that nonprofit hospitals respond differently to incentives than do for profit hospitals. They find hospital mergers between nonprofit firms may lead to lower market prices (Lynk 1995). This behavior would be consistent with the theory that firms maximize output (Newhouse, 1970 and Rose-Ackerman, 1996) or the mixed objectives theories (Hirth, 1997 and 1999).

Higher Prices. Dranove and Ludwig (1998); Keeler, Melninick & Zwanziger (1998); Lynk and Neuman (1999) find hospital mergers between nonprofit firms lead to higher market prices. Brickley and Van Horn (2002) find CEO compensation and turnover are significantly related to return on assets. They find no evidence that hospitals provide incentives for management to focus on non-financial or altruistic goals. If prices are higher, is it because nonprofit hospitals compete on non-price bases? If so, should there be evidence of higher quality at nonprofit hospitals? Vita and Sacher (2001) test the competitive effects of non-profit hospital mergers and find no evidence of higher quality accompanying higher prices. This pricing behavior would be consistent with the theory that firms maximize profit (Pauly-Redisch 1973) or the mixed objectives theories (Hirth, 1997 and 1999).

Market Mix of Nonprofit, For Profit and Government Hospitals. Nonprofit, for profit and government hospitals interact in markets in ways which may impact market efficiency. If this competition is wasteful, then it may that policy changes should result in revoking or restricting the tax exempt status of nonprofit hospitals (Kessler and McClellan, 1999). Blackstone and Fuhr (2000 and 2003) argue that the exercise of monopoly power by nonprofit hospitals (post merger) casts doubt on the desirability of stronger state utility regulation of merged nonprofit hospitals. Horowitz (2007) and Schlesinger and Gray (2006) argue that the interaction between non-profit and for-profit hospitals results in variation in services offered within markets. They argue against legal and political challenges to the tax exempt status of non-profit hospitals, citing unintended consequences in product offering by hospitals. Blackstone and Fuhr (2007) argue that for profit surgical specialty hospitals may improve overall market efficiency.

The presence of for profit general hospitals and surgical specialty hospital raises questions about their impact on the behavior of the entire market in diffusing technology. HR8 contains the only surgical specialty hospital in Pennsylvania. Table 13 presents the distribution of hospitals by profit status and number of beds.

Operating Margin

The contribution of a bariatric program to a hospital's operating margin, or profit, is determined by the reimbursements hospitals receive from patients and third party insurers less the costs of offering bariatric surgery. For a physician, the return from performing bariatric surgery is determined by reimbursements from patients and third party insurers less the costs of performing bariatric surgery.

Reimbursements to Hospitals. Reimbursements, or payments, to hospitals from patients and third party insurers vary. Medicare payments are accessible, but private insurance payments vary according to agreements hospitals may have negotiated with individual insurers. Schoenthal and Getzen (2005) cite hospital reimbursement from Medicare at $10,000 per surgery and from private insurers in the range of $13,000 to $15,500. Hospital charges, but not payments or reimbursements, are available from the PHC4 data set. Table 11 presents the average hospital charge for bariatric surgeries in Pennsylvania by year.

Hospital Costs. Encinosa (2005) uses national data to estimate an average hospital cost per gastric bypass surgery at $ 13,500. Angus (2001) uses data from one surgery center in New York for one year and estimates costs at approximately $ 8,200 per surgery. Schoenthal and Getzen estimate direct costs in the range of $6,500 to $11,200. Surgical complications can add a lot to costs and result in losses to hospitals. Encinosa (2005), Angus (2001) and Shoenthal and Getzen (2005) note that large variances in cost estimates are due to the cost of the few cases in which complications arise.

Table 11

Total Hospital Charges for Bariatric Surgery

Year	Total Hospital Charges	% Change
1996	22,964	-
1997	29,167	27%
1998	32,338	11%
1999	35,067	8%
2000	37,055	6%
2001	36,314	-2%
2002	36,924	2%
2003	34,479	-7%
2004	38,536	12%
2005	39,769	3%
2006	42,797	8%
2007	44,464	4%

Note. Data are from Pennsylvania Health Care Cost Containment Council. Hospital charges are different from hospital revenues. Charges are average charges.

Reimbursement to Physicians. Physicians are paid a standard rate per procedure. This rate includes pre-surgery consultations, post-surgery follow-up visits as well as payment for the surgery itself. This is consistent with payment practices for other surgeries. There appears to be variability in rates among physicians. For the few self-pay patients, physicians' charges are set in the open market. (No market regulatory body interferes with the transaction.) Payments from Medicare and Medicaid are set by the individual agencies. Payments by private insurance companies are often based on a markup over the Medicare rate. Schoenthal and Getzen (2005) use MedStat data and estimate payments to physicians as follows: Private insurer pays $1,400. Medicare pays $1,300 to $1,900. Medicaid pays $ 600 to $700. Angus et al (2003) uses annual data on a small sample in New York and give range of reimbursements to physicians similar to Schoenthal and Getzen. They highlight the lower Medicaid payment to physicians along with the higher Medicaid payment to hospitals.

Physician Practice Costs. Champion and Williams (2005) estimate the costs to a general surgery practice of adding a bariatric surgery team. They note the large potential variability in the cost of medical malpractice insurance. After a comprehensive estimate of practice costs, they leave open a salary of about $70,000 per year for a physician director.

Optimizing Operating Margin

Synergies in the strengths of hospitals and surgeons may mean that the salaried physician as bariatric surgery director working along with a comprehensive bariatric team in a hospital or outpatient setting are the models for a profitable surgery center. On the revenue side, bigger programs and hospitals may negotiate more effectively with private insurers for higher reimbursements. On the cost side, risk management is very important. Physicians' expertise in managing patient risk is important. The risk of a potential lawsuit will be borne by both the hospital and the physician. Being able to shift the costs of practice insurance to a hospital may be optimal to a surgeon. Moreover, there is a subsidy between Medicaid patient revenue and private insurer revenue to physicians and there is a subsidy between private insurer revenue to hospitals and Medicaid revenue to hospitals. Angus (2001) highlights the lower Medicaid payment to physicians along with the higher Medicaid payment to hospitals. Finally, meeting Center of Excellence requirements may mean that the model for a profitable surgery center is a salaried physician as bariatric surgery director working along with a comprehensive bariatric team in a hospital setting.

The Financial Reimbursement Cycle

Getzen (2010) describes the observed cycle of financial reimbursement in medical care as having four stages. In stages one and two, providers are paid at rates higher than their costs. Payments to providers in stage one may seem excessive; however, a certain amount of payment over cost is necessary to generate initial investments in technology. Payments in stage two reflect efforts to somehow associate payments to providers with costs. The existence of third party payers, private and government insurers, generates a certain amount of differentiation in reimbursement rates. Stage three is when the imposition of a system of administered prices, such as the prospective payment system is the norm. Payment to physicians by RBRVs and to hospitals under DRGs is characteristic of stage three. The final stage occurs when strict budget limits are imposed through global budgets. An example of a strict budgets imposition is when insurance company denies or delays eligibility or suspends coverage for a service. In 2005, Schoenthal and Getzen identify the market for bariatric surgery to be in stage three and bordering on stage four. Anecdotal evidence of this is found during the interviews discussed in Chapter 3. Physicians and administrators note the changing insurance company requirements for coverage of bariatric surgery. Some insurance companies require six months of diet counseling prior to bariatric surgery. Others restrict a patient's lifetime number of bariatric surgeries to one. See Chapter 3 Section 3.3.9.

The Role of Expected Profitability

The role of profit maximization may or may not be the primary goal of hospital administrators and physicians; however, the expectation that diffusing a surgery will be profitable to hospital and physician is central to the diffusion decision. Along with the expectation that adopting bariatric surgery will contribute to the operating margin of the hospital, adoption affords hospitals the opportunity to achieve other goals through nonprice competition.

4.4.5 Market Competition Characteristics

Market Saturation Rate. An independent variable is included as a lagged measure of the cumulative market saturation rate of bariatric surgery. The variable is included in the multivariate analysis. Following Tian (2006), a hospital is considered to have diffused open gastric bypass surgery when it has an average of 2 surgeries per month over 4 consecutive quarters. This level is consistent with a Level 2 ACS Center of Excellence rating. The saturation rate is calculated as the number of hospitals in a market which have diffused the surgery divided by the total number of hospitals in the market. Saturation rates are calculated for each market as well as for the state as a whole. Please see Section 5.2.3 for further discussion.

Herfindahl-Hirschman Index. Market competition level is measured using the hospital market Herfindahl-Hirschman Index. The Herfindahl-Hirshman Index (HHI) is the sum of the squared market shares of all firms in the market. Calculation of HHI

Let n_i = number of hospital beds at hospital i

N = total number of hospital beds in market

For each hospital i, let s_i equal market share.

$$s_i = \frac{n}{N}$$

Then, $HHI = \sum_i (s_i)^2$.

Measures under 1500 are considered competitive. Measures greater than 1500 and less than 2500 are considered moderately concentrated and measures greater than 2500 are considered concentrated.

Level of Market Capacity. Market capacity is a measure of available hospital beds per 1000 population in the hospital region. Population data are from the 2000 U.S. Census. For each hospital, the number of beds is the average reported by Pennsylvania Health Care Cost Containment Council over the time 1995 – 2007. The average number of general acute care beds per 1,000 population in Pennsylvania is 3.48; the median is 3.60 and the maximum is 4.46. Table 12 shows the number of hospital beds per thousand population for the nine PHC4 hospital regions. Blackstone & Fuhr argue that the number of hospital beds in a market may be a measure of market power if excess capacity acts as a deterrent to market entry (Blackstone & Fuhr, 1989). Higher levels of available hospital beds per population may be also be an indicator of hospital competition for physicians if diffusion is higher in markets with higher number of available hospital beds.

Table 12
Hospitals Beds Per Thousand Population by Hospital Region

	HR1	HR2	HR3	HR4	HR5	HR6	HR7	HR8	HR9
Hospitals in Data	30	23	10	14	17	17	13	24	19
Beds per 1,000 population	4.46	3.60	3.48	4.03	2.39	3.60	3.37	2.38	3.99

Note: Population data are from U.S. Census 2000. For each hospital, the number of beds is the average reported by Pennsylvania Health Care Cost Containment Council over the time 1995 – 2007.

Hospital Specific Indicators of Profitability

Evidence of Economies of Scale. Based on procedure volumes, there is some evidence of economies of scale in the provision of gastric bypass surgery. Procedure volumes which correlate positively with hospital size may indirectly indicate that larger hospitals have lower average cost per surgery; however, limited availability of data on hospital costs at the procedure level means that empirical support is lacking. Table 10 shows each hospital in Pennsylvania, the number of gastric bypass surgeries for the last year of the data collected (third quarter 2006 through second quarter 2007) and the size of the hospital measured in beds. From the interviews (Chapter 3), there is acknowledgement that bigger hospitals may have greater bargaining power than smaller hospitals have with third party insurers. That might meant that bigger hospitals, assuming costs are at least at the same level as small hospitals, might have higher operating margin. Hospital size is used as a control variable in the empirical analysis (See Chapter 5 Section 5.2.3).

Patient Demand

Laparoscopic surgery may cost more than open surgery (Jones Jr, et al., 2006). Patient demand for laparoscopic surgery across the body systems is evidenced by the variety of laparoscopic surgeries now offered by hospitals. In addition to laparoscopic cholecystectomy, and other surgeries of the abdominal cavity such as myomectomy and hysterectomy, laparoscopic surgery is now offered for hip and knee replacement surgery. Minimally invasive surgery and the search for other substitutes such as surgery through mouth or vagina which involve no surgical incisions are in the developmental/experimental stages.

The total bariatric eligible population increases from eleven million to over twenty two million if one includes those with BMI greater than 35 and comorbidity such as type II diabetes (Martin, Beekly, Kjorstad and Sebesta, 2010).

The number of bariatric surgeries in 2006 accounted for less than one half of one percent of those eligible for surgery.

4.4.6 Hospital Characteristics

Hospital Size. Certain stylized facts emerge from the research. Mansfield (1963)finds that firm size is positively related to diffusion. He also finds that for certain industries, the largest firms diffuse a disproportionately large share of innovations. Table 13 shows the number of hospitals and average size of the hospitals, measured as number of beds.

Congruence, Tigers and Tortoises: Has the Hospital Diffused Open Gastric Bypass Surgery? Whether or not a hospital has diffused open gastric bypass surgery seems to be highly correlated with whether a hospital adopts and diffuses laparoscopic gastric bypass surgery. Skinner and Staiger (2007) find congruence in technology adoption and diffusion over long time periods, across states and across a variety of technologies from tractors to heart medicine. That is, previous adopters of new technology are more likely to be early adopters of other new technology. They name early adopters and diffusers of technology "tigers," and identify late adopters and diffusers as "tortoises."

Consistent with Tian (2006) and with the definition of diffusion used in the independent variable, a hospital is considered to have diffused open gastric bypass surgery if an average of two surgeries per month is performed for one year. Table 19 shows the number of hospitals in each hospital region diffusing open surgery and the number diffusing laparoscopic surgery.

Table 13
Hospital Size and Profit Status by Region

Hospital Region	Number of Non-profit Hospitals	Number of For Profit Hospitals	Average Size of Non-profit Hospitals	Average Size of For profit Hospitals
1	26	5	244	388
2	22	0	144	N/A
3	11	0	136	N/A
4	14	0	125	N/A
5	15	1	231	211
6	17	0	175	N/A
7	12	0	281	N/A
8	24	1	190	47
9	16	1	341	390

Note. Data are from Pennsylvania Health Care Cost Containment Council. For each hospital, size is measured as the average number of hospital beds reported over the time 1995-2007.

Table 14
Hospital Size and Diffusion

Hospital Bed Size Group	Number of Hospitals	Average Beds in Hospital	Number of Hospitals Diffused Laparoscopic Surgery
0 to 100	47	62	1
101 to 200	45	150	2
201 to 300	27	244	7
301 to 400	15	339	5
401 to 499	7	452	4
over 500	25	648	22

Note. Data are from Pennsylvania Health Care Cost Containment Council. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Hospital Star Quality. Certain features of hospitals make them highly attractive to patients. Four hundred Association of American Medical Colleges Council of

Teaching Hospitals (COTH) account for less than six percent of all hospitals in the U.S., yet COTH hospitals operate more than forty percent of technology intensive services such as neonatal and pediatric ICUs, surgical transplants, Level 1 trauma centers, and burn care centers. Since COTH hospitals provide surgeries on the frontier of medical technology, COTH hospitals can be expected to account for a large percentage of bariatric surgeries in the early years of the study. Twenty six hospitals, almost sixteen percent of the hospitals in this study, are COTH member hospitals; however, COTH members account for more than fifty percent of hospitals diffusing surgery in the sample. Huckman (2006) and Ho (2008) account for hospital star quality and analyze the welfare effects of hospital market power in the market for cardiac surgery. Huckman constructs an index as a control variable. Ho controls for hospital star quality by counting the number of high technology services offered by hospitals in her calculation of consumer and producer surplus. Table 13 shows the COTH members in this sample.

Table 15
Star Hospitals (member Council of Teaching Hospitals)

Hospital Name	Region
Albert Einstein Medical Center	9
Allegheny General Hospital	1
Children's Hospital of Philadelphia	9
Crozer-Chester Medical Center	8
Fox Chase Hospital	9
Frankford Hospital	9
Geisinger Med Ctr/Danville	4
Gettysburg Hospital	5
Hahnemann University Hospital	9
Hamot Medical Center	3
Hospital of the University of Pennsylvania	9
Lehigh Valley Hospital	7
Magee-Womens Hosp of UPMC	1

Note. Hospitals are defined as stars if they are members of the Association of American Medical Schools' Council of Teaching Hospitals and Systems

Table 15 (continued)
Star Hospitals (member Council of Teaching Hospitals)

Hospital Name	Region
Main Line Hospital Lankenau	8
Mercy Hosp of Pittsburgh	1
Pennsylvania Hospital/U PA HS	9
PA State/Milton S Hershey Medical Center	7
Penn Presbyterian Medical Center	9
Pinnacle Health Hospital	5
Reading Hospital and Medical Center	7
St Lukes Bethlehem	7
Thomas Jefferson University Hospital	9
Temple University Hospital	9
UPMC Bedford	3
UPMC Shadyside Hospital	1
Western PA Hosp/Forbes Regional Hospital	1

Note. Hospitals are defined as stars if they are members of the Association of American Medical Schools' Council of Teaching Hospitals and Systems

Table 16
Hospitals Diffusing Open and Laparoscopic Surgery

Hospital Region	Number of Open Surgeries	Number of Laparo-scopic Surgeries	Number of Hospitals Diffusing Open Surgery	Number of Hospitals Diffusing Laparoscopic Surgery
1	8,398	5,600	14	13
2	1,648	508	6	2
3	587	340	2	2
4	1,166	390	1	1
5	3,572	1,520	5	4
6	668	371	3	4
7	3,303	1,821	6	6
8	2,038	824	7	3
9	4,064	2,350	10	6

Note. Average size is measured in hospital beds. A hospital is considered to have diffused open gastric bypass surgery when it has an average of 2 surgeries per month over 4 consecutive quarters.

4.4.7 Physician Characteristics

The PHC4 proprietary data set includes the Pennsylvania medical license number of the operating physician, attending physician and referring physician for each entry. Each license number is matched with physician name and address from the Pennsylvania Department of State database. There are two hundred ninety-seven operating physicians. Residency, special training, medical school graduation date and school are matched from the American Medical Association physician database. Further information is obtained from individual hospital websites and from phone calls to individual physician offices. Thirty-nine of the operating physicians are graduates of Top 30 medical schools. Forty-five of the operating physicians completed residency training at one of U.S. News & World Report's annual ranking of Top 20 Hospitals. The total number of stars sums to seventy-one because there are thirteen physicians who meet both criteria for star. Table 17 summarizes the star characteristics of operating physicians.

Table 17
Star Characteristics of Operating Physicians

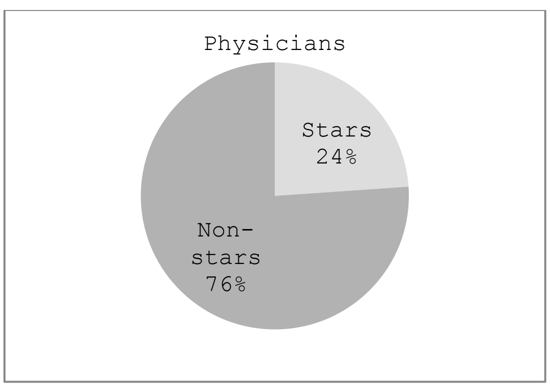
	Top 30 Medical School Graduate	Residency at Top 20 Hospital	Classified as Star Physicians
Number of physicians	39	45	71
Percent of physicians	13.1%	15.2%	23.9%

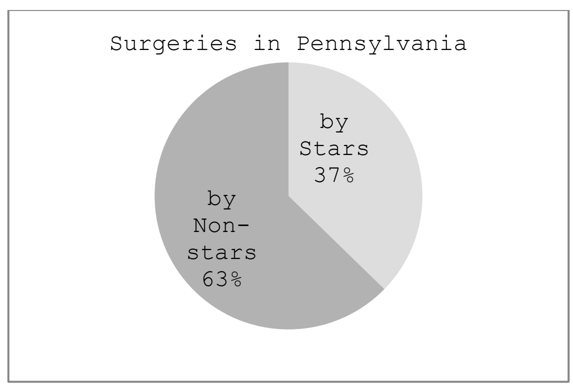
Note. 71 physicians classified as stars represents 23.9% of the total 297 physicians in the sample.

Star physicians account for less than twenty-four percent of all surgeons performing bariatric surgery; however, they perform over one-third of all bariatric surgeries. Table 18 shows the allocation of surgeries by star and non-star physicians.

Table 18
Surgeries by Physician Type

	Stars	Non-stars	Total
Open Surgeries			
Total	9,207	15,947	25,154
Percent of total	36.6%	63.4%	
Laparoscopic Surgeries			
Total	5,258	8,356	13,614
Percent of total	38.6%	61.4%	
Total surgeries	14,465	24,303	38,768
Percent of total	37.3%	62.7%	





Star Physician. A physician counts as a star if a physician meets any of the following criteria: (i) graduated from a top 30 medical school (ii) completed residency training at one of the U.S. News & World Report's top 20 ranked hospitals, or (iii) is included in Castle & Connolly's Top Docs publications during the period. These measures are intended to capture unobserved behavior and influence of individual physicians. Use of the U.S. News & World Report rankings is consistent with Burke, Fournier and Prasad (2007). While these measures can be observed, they can only approximate a measure of social interactions of individuals which might enhance social influence. Certain influential physicians may not be captured by this measure.

Table 19
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 1				
ACMH Hospital	0	0	0	170
Allegheny General Hospital	25	156	181	814
Alle-Kiski Medical Center	0	0	0	211
Butler Memorial Hospital	1	38	39	251
Canonsburg General Hospital	0	0	0	89
Excela Frick Hospital	1	0	1	153
Excela/Latrobe Area Hospital	0	0	0	230
Excela/Westmoreland Hospital	0	27	27	298
Heritage/Medical Center Beaver	0	0	0	585
Heritage/Sewickley Valley Hospital	7	173	180	197

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 1 (continued)				
Highlands Hospital	2	0	2	77
Jefferson Regional Medical Center	0	0	0	324
Mercy Hospital Pittsburgh	0	0	0	481
Mercy Jeannette Hospital	1	46	47	181
Monongahela Valley Hospital	0	0	0	292
Ohio Valley General Hospital	0	0	0	109
Southwest Regional Medical Center	0	0	0	38
St Francis Medical Center	0	0	0	270
St. Clair Memorial Hospital	0	23	23	334
Uniontown Hospital	0	0	0	229

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 – 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 1				
UPMC Braddock Hospital	0	0	0	123
UPMC Children's Hospital Pittsburgh	0	0	0	235
UPMC Magee Women’s Hospital	3	504	507	301
UPMC McKeesport	0	0	0	305
UPMC Passavant	0	0	0	192
UPMC Shadyside	8	159	167	572
UPMC St Margaret	15	243	258	259
Western Pennsylvania Hospital	74	182	256	507
Western PA/Forbes Regional Hospital	0	10	10	317
Washington Hospital	0	0	0	239

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 – 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 2				
Bradford Regional Hospital	0	0	0	112
Brookville Hospital	0	0	0	60
Charles Cole Memorial Hospital	0	0	0	49
Clarion Hospital	0	0	0	43
Clearfield Hospital	0	0	0	81
Corry Memorial Hospital	0	0	0	49
DuBois Regional Medical Center	0	0	0	191
Elk Regional Health System	0	0	0	57
Ellwood City Hospital	0	0	0	77
Grove City Medical Cener	0	0	0	95

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 – 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 2 (continued)				
Hamot Medical Center	22	215	237	399
Jameson Memorial Hospital	0	0	0	123
Kane Community Center	28	0	28	53
Meadville Medical Center	1	0	1	245
Millcreek Community Hospital	0	0	0	101
Punxsutawney Area Hospital	0	0	0	30
Sharon Regional Hospital	0	0	0	144
St Vincent Health System	0	0	0	466
Titusville Area Hospital	0	0	0	80
UPMC Horizon Hospital	6	64	70	201

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 – 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 2 (cont)				
UPMC Northwest	0	0	0	373
Warren General Hospital	0	0	0	124
Hospital Region 3				
Altoona Reg Health Sys/Altoona Hospital	6	71	77	123
Altoona Reg Health Sys/Bon Secours	0	0	0	53
Conemaugh Valley Memorial Hospital	2	47	49	245
Indiana Regional Medical Center	0	0	0	101
Meyersdale Community Hospital	0	0	0	30
Miners Medical Center	0	0	0	144

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 3 (continued)				
Nason Hospital	0	0	0	466
Somerset Hospital	0	0	0	80
Tyrone Hospital	0	0	0	201
UPMC Bedford	0	0	0	373
Windber Hospital	0	0	0	124
Hospital Region 4				
Berwick Hospital Center	0	0	0	123
Bloomsburg Hospital	0	0	0	53
Bucktail Medical Center	0	0	0	245
Evangelical Community Hospital	21	0	21	101

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 4 (continued)				
Geisinger Medical Center/Danville	251	146	397	30
Jersey Shore Hospital	0	0	0	144
Lewistown Hospital	0	0	0	466
Lock Haven Hospital	0	0	0	80
Mount Nittany Medical Center	0	0	0	201
Shamokin Area Community Hospital	0	0	0	373
Soldiers & Sailors Memorial Hospital	0	0	0	124
Sunbury Community Hospital	0	0	0	123
Susquehanna Health/Muncy Valley Hospital	0	0	0	53
Susquehanna Health/Williamsport Hospital	0	0	0	245

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 – 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 5				
Carlisle Regional Medical Center	0	0	0	30
Chambersburg Hospital	8	28	36	144
Ephrata Community Hospital	0	0	0	466
Fulton County Medical Center	0	0	0	80
Gettysburg Hospital	0	0	0	201
Good Samaritan Hospital/Lebanon	0	0	0	373
Hanover Hospital	0	0	0	140
Heart of Lancaster Regional Medical Center	31	0	31	136
Holy Spirit Hospital	0	0	0	320

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 5 (continued)				
Lancaster Regional Medical Center	0	0	0	235
Memorial Hospital York	0	0	0	150
Milton S. Hershey Medical Center	67	125	192	437
Pinnacle Health Hospital	31	193	224	731
Waynesboro Hospital	0	0	0	62
York Hospital	85	129	214	470

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 – 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 6				
Barnes-Kasson Hospital	0	0	0	58
Community Medical Center/Scranton	9	0	9	356
Geisinger South/Wilkes Barre	0	0	0	193
Geisinger Wyoming Valley Medical Center	2	10	12	144
Hazleton General Hospital	4	76	80	160
Marion Community Hospital	0	0	0	121
Memorial Hospital/Towanda	0	0	0	39
Mercy Hospital/Scranton	0	0	0	306
Mid-Valley Hospital	0	0	0	51

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 6 (continued)				
Montrose General Hospital	0	0	0	34
Moses Taylor Hospital	0	0	0	257
Pocono Medical Center	0	0	0	197
Robert Packer Hospital	0	0	0	273
Troy Community Hospital	0	0	0	25
Tyler Memorial Hospital	0	0	0	58
Wayne Memorial Hospital	0	0	0	98
WVHCS Hospital	0	0	0	606

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 7				
Blue Mountain Health System/Gnaden Huetten Memorial Hospital	0	0	0	28
Blue Mountain Health System/Palmerton Hospital	0	0	0	70
Easton Hospital	1	102	103	369
Lehigh Valley HN/Lehigh Valley Hospital	26	76	102	661
Lehigh Valley HN/Muhlenberg	0	0	0	148
Reading Hospital & Medical Center	3	149	152	594
Sacred Heart Hospital	0	187	187	287

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 7 (continued)				
Schuylkill Med Ctr/Good Samaritan Reg	0	0	0	159
Schuylkill Med Ctr/Pottsville	0	0	0	153
St Joseph Med Ctr/Reading	0	0	0	248
St Lukes Hosp & H S/Bethlehem	20	7	27	556
St Lukes Hosp & H S/St Lukes Miners	0	0	0	93

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 8				
Abington Memorial Hospital	7	42	49	662
Barix Clinics of Pennsylvania	196	354	550	47
Brandywine Hospital	0	0	0	168
Chester County Hospital	0	0	0	220
Crozer-Chester Medical Center	1	17	18	320
Delaware County Memorial Hospital	0	0	0	247
Doylestown Hospital	0	0	0	196
Elkins Park Hospital	0	0	0	60
Grand View Hospital	0	0	0	199
Holy Redeemer Hospital	0	0	0	227

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 8 (continued)				
Jennersville Regional Hospital	0	0	0	59
Lansdale/Central Montgomery Hospital	0	0	0	125
Lower Bucks Hospital	0	0	0	163
Main Line Health/Bryn Mawr Hospital	0	0	0	307
Main Line Health/Lankenau Hospital	0	0	0	331
Main Line Health/Paoli Hospital	0	0	0	157
Mercy Fitzgerald Hospital	0	0	0	239
Mercy Suburban Hospital	0	0	0	130

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)
Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 8 (continued)				
Phoenixville Hospital	0	0	0	136
Pottstown Memorial Hospital	0	0	0	227
Riddle Memorial Hospital	0	0	0	225
Springfield Hospital	0	0	0	33
St Lukes Hospital & HS/Quakertown	0	0	0	57
St Mary Medical Center	0	0	0	270
Taylor Hospital	0	0	0	135
Warminster Hospital	0	0	0	125

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 9				
Albert Einstein Medical Center	1	191	192	514
Chestnut Hill Hospital	0	0	0	137
Children's Hospital of Philadelphia	0	0	0	430
Hahnemann Hospital	6	38	44	618
Hospital of Fox Chase Cancer Center	0	0	0	100
Hospital of the University of PA (HUP)	69	201	270	631
Jeanes Hospital	0	1	1	148
Jefferson University Hospital	0	0	0	701

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

Table 19 (continued)

Gastric Bypass Surgery and Hospital Size (Number of Beds)

Hospital	Open	Laparoscopic	Total	Size (Number of Beds)
Hospital Region 9 (continued)				
Mercy Philadelphia Hospital	0	0	0	214
Nazareth Hospital	0	0	0	308
Penn Presbyterian Hospital	3	40	43	282
Pennsylvania Hospital	118	86	204	433
Roxborough Memorial Hospital	0	0	0	122
St Christopher's Hospital	0	0	0	161
St Joseph Hospital	0	0	0	152
Temple University Hospital	27	98	125	450

Note. Data are from the Pennsylvania Health Care Cost Containment Council. Open, laparoscopic and total surgeries are over the time 1995:4 - 2007:2. Hospital size is measured as the average number of beds reported over the time 1995-2007.

4.5 Summary

Role of expected profitability.

Given difficulty of knowing hospital's profit to each surgery center or physician practice profit at the hospital level, it may be useful to discuss expected profitability and the proxy variables such as charges, volume, diffusion rates over time. Interviews also help to inform the discussion.

Expected revenue from charges will vary according to adjustments to DRG for teaching hospital and other hospital characteristics. Bargaining power between hospitals and private insurers will play a role in hospital's returns to investment. Expected costs include any additional cost for malpractice insurance charges. Risk is spread to the hospital from the physician practice. It could be that the physician negotiates so that the hospital pays the malpractice insurance for the physician.

For smaller city hospitals, the cost of one wrongful death lawsuit can be prohibitive and the hospital or hospital board may decide to delay or to forgo adoption of the surgery.

CHAPTER 5

RESULTS

This chapter presents the empirical models and the results of the empirical analysis of observed diffusion patterns at the market, hospital and physician levels. Section 5.1 presents Empirical Model 1 and Section 5.2 reports the results of the statistical analysis at the hospital market levels. Having a star physician raises the likelihood of diffusing laparoscopic gastric bypass from 12% to 88%. Sections 5.3 and 5.4 present the physician level empirical model and results. The presence of star physicians raises the likelihood of a non-star physician adopting laparoscopic gastric bypass surgery from 5% to 95%. Utilization rates by non-star physicians increase 4.88% for every one co-located star physician over the time period studied.

5.1 Empirical Model 1

Recall Equation 11 from the theoretical model in Chapter 2 where the probability that a given hospital has diffused laparoscopic gastric bypass at time *t* is given by

$\log\frac{P_i}{1-P_i} = Z_i = \alpha + \beta X_i$ [Equation 11]

Let $\widehat{z_i}$ = the log odds of hospital *i* diffusing laparoscopic surgery.

Let $\boldsymbol{X_i}$ = a vector of physician, hospital, and market variables. $\boldsymbol{X_i}$ = { X_1 , X_2 , X_3 , X_4 , X_5 , X_6 , X_7 , X_8 , X_9}. Then, adding an error term to Equation 11, using carrots above the betas and lower case x_i to denote parameter estimates yields the following:

$$\hat{z}_i = \widehat{\alpha_i} + \widehat{\beta_1}x_1 + \widehat{\beta_2}x_2 + \widehat{\beta_3}x_3 + \widehat{\beta_4}x_4 + \widehat{\beta_5}x_5 + \widehat{\beta_6}x_6 + \widehat{\beta_7}x_7 + \widehat{\beta_8}x_8 + \widehat{\beta_9}x_9 + e_i$$

[Equation 12]

5.1.1 Hypotheses Tested by Model 1

Research Question 1 and Research Question 3 are addressed in Model 1.

Research Question 1: Does the presence of star physician(s) influence a hospital's diffusion rate of laparoscopic bariatric surgery technology? For Research Question 1, let H_0: $\beta_1 = 0$. The null hypothesis is that physician star status has no statistical relation to hospital's diffusion of laparoscopic gastric bypass surgery.

Research Question 3: Do star hospitals adopt and diffuse laparoscopic gastric bypass surgery more quickly than non-star hospitals? For Research Question 3, let H_0: $\beta_2 = 0$. The null hypothesis is that hospital star status has no statistical relation to a hospital's diffusion of laparoscopic gastric bypass surgery.

5.1.2 Descriptive Statistics

Table 20 presents a summary of the variables used in Model 1. Variable X_1 describes the star quality of physicians. There are 297 physicians in the sample, 71 of whom are classified as star physicians. See Section 4.4.7 and Table 17. Variable X_2 describes the star quality of hospitals. Star hospitals account for about sixteen percent of the 166 hospitals in the sample. See Section 4.4.6 and Table 16. Variables X_3, X_4 *and* X_7 describe hospital characteristics. Variables X_3 *and* X_4 describe the hospital size and whether or not a hospital has diffused open gastric bypass surgery. See Sections 4.3.5 and 4.4.6.

Variable X_7 is dichotomous variable which is 0 if the hospital is not for profit and 1 if the hospital is for profit. See Section 4.4.4. Variables X_5, X_6 *and* X_8 describe market competition. Variable X_5 measures each hospital's market saturation rate, lagged one quarter. Variable X_6 measures market competition. Sixty-eight percent of hospitals are in markets categorized as "concentrated"; fourteen percent are in markets categorized as "moderately concentrated"; and eighteen percent are in markets categorized as "competitive." See Section 4.4.5 and Table 12. Variables X_8 measure of the number of beds per thousand population in the hospital region.

5.2 Empirical Model 1 Results

The empirical analysis of Model 1 supports the hypothesis that there is a positive relationship between hospital's diffusion of laparoscopic gastric bypass surgery and the presence of a star physician (Research Question 1). Having a star physician raises the likelihood of diffusing laparoscopic gastric bypass from 11% to 89%. The empirical analysis provides limited statistical support for a relationship between star hospitals and diffusion of laparoscopic surgery (Research Question 3). Over the years 2000 through 2002, being a star hospital, that is, having a

Council of Teaching Hospital certification, increases the probability of diffusing laparoscopic gastric bypass surgery from 13% to 87%.

5.2.1 Star Physicians

Variable: X_1 doc_star

Having a star physician raises the probability of the hospital diffusing laparoscopic gastric bypass from 11% to 89%. See Tables 22 and 23. The result seems reasonable if the variable doc_star is capturing the qualities of influential individuals (See Chapter 1 Section 1.4.5). Star physicians in hospitals are identified by this study as agents who influence the diffusion of laparoscopic gastric bypass surgery within and among hospitals. From the interviews, it appears that the criteria used in this study are a reasonable proxy for star power (See Chapter 3 Section 3.3.6). Stars can be compared with "opinion leader" physicians in the diffusion of cardiac procedures (Huckman, 2003) and "change agent" physicians in the diffusion of breast cancer screenings, flu shots and beta blocker usage (Berwick, 2003).

A shortcoming of the data is that the data include only physicians who ultimately perform bariatric surgery over the time period. Some physicians who perform general surgery learn and specialize in bariatric surgery during the study time period. Many general surgeons with the characteristics choose not to learn or specialize in bariatric surgery. Some physicians, especially by the end of the study time period, are specifically trained in bariatric surgery and make the decision to adopt bariatric surgery before they join a hospital. In this study, general surgeons who do not adopt bariatric surgery are not included. A study which includes all physicians who perform general or abdominal surgery during the time period, but who do *not* adopt bariatric surgery would likely produce less striking results.

If a hospital has a star physician, the odds of that hospital diffusing laparoscopic gastric bypass surgery are 7.8 times greater than the odds of a hospital without a star physician diffusing the technology. Sections 5.2.1 through 5.2.3 present the results of each of the variables in Model 1.

5.2.2 Star Hospitals

Variable: X_2 coth

The empirical analysis supports only a qualified statistical relationship between star hospitals and diffusion of laparoscopic surgery. This statistical outcome appears counterfactual, since COTH hospitals have been shown to account for a disproportionate share of technology intensive hospital services (See Chapter 4 Section 4.4.6 Hospital Characteristics). It may be that the data include a long enough time frame, that by the end of the time period, laparoscopic gastric bypass is no longer considered a high technology or technology intensive service. Then, other factors, such as whether or not a hospital has star physicians, might become more important factors in hospital's decision to adopt and diffuse a technology.

The result is statistically significant if a shorter time frame is considered. If the statistical analysis is limited to the years 2000 through 2002, then being designated a Council of Teaching Hospital (COTH) increases the likelihood of a hospital diffusing laparoscopic gastric bypass surgery from 13% to 87%. It appears that, in the case of laparoscopic gastric bypass surgery, the strongest statistical impact from teaching hospital status occurs in the earliest phases of use of a new technology. This is consistent with the work of Burke, Fournier and Prasad (2007).

5.2.3 Hospital Characteristics

Hospital Size

Variable: X_3 beds_201

Holding all other variables constant, the likelihood of a hospital diffusing laparoscopic gastric bypass increases from 4% to 96% when a hospital is large, that is, it has more than 200 beds. It is possible that economies of scale are realized when a hospital exceeds 200 beds.

Procedure volumes which correlate positively with hospital size may indicate that larger hospitals have lower average cost per surgery; however, data on hospital costs across hospitals are unavailable. Though it may be impossible to discern economies of scale from the available data, it may be true, assuming costs are at least at the same level as small hospitals, that differences in hospital reimbursements could mean larger hospitals realize higher margins than smaller hospitals (See Chapter 4 Section 4.4.5). From the interviews (Chapter 3), there is acknowledgement that bigger hospitals may have greater bargaining power than smaller hospitals have with third party insurers. That might mean that bigger hospitals might have higher operating margins. See Tables 22 and 23.

Diffused Open Gastric Bypass Surgery

Variable: X_4 dif_op

The majority of hospitals which adopt laparoscopic gastric bypass surgery have previously adopted open gastric bypass surgery. The variable dif_op is used to control for this effect. A hospital which has diffused open gastric bypass surgery has 97% probability of diffusing laparoscopic gastric bypass compared with a 3% probability for a hospital which has not diffused open gastric bypass surgery. At the beginning of the study period, each hospital which adopted laparoscopic gastric bypass surgery already had an open surgery bariatric program in place. By the end of the study period, a few hospitals might adopt laparoscopic gastric bypass and open surgery concurrently, because open surgery might be necessary as a backup to laparoscopic surgery.

See Tables 22 and 23.

Profit Status

Variable: X_7 for profit

Hospital diffusion of laparoscopic gastric bypass surgery is statistically positively related to a hospital's profit status. Holding all other variables constant, the probability of a for-profit hospital diffusing laparoscopic surgery is 85% compared with a 15% probability for a non-profit hospital. See Tables 22 and 23. Only eight of the one hundred sixty-six hospitals in the data set are for profit hospitals. Over half of for- profit hospitals are located in HR1, an area with the highest rates of diffusion. For-profit hospitals represent about twenty percent of all hospitals in HR1, but represent less than five percent of all hospitals in each of the other hospital regions. See Table 13. This may provide support to Horowitz (2007) and Schlesinger and Gray (2006) arguments that interactions between non-profit and for-profit hospitals results in variation in services offered within markets. In this case, the variation may result in improvements in consumer welfare as diffusion occurs more quickly.

5.2.4 Market Variables

Market Saturation Rate

Variable: X_5 *lag_sat*

The saturation rate is calculated as the number of hospitals in a market which have diffused the surgery divided by the total number of hospitals in the market. For every one percentage point increase in lagged market saturation, the probability of a hospital diffusing laparoscopic surgery increases 13.1%. See Tables 22 and 23. In this study, saturation rates range from less than ten percent to forty-two percent. See Figures 7 and 8. It may be that this is consistent with the hospital competition on non-price basis. See Section 4.4.5. As a hospital competes with other hospitals for patients and for physicians, offering a new technology, such as laparoscopic gastric bypass, is a way to compete.

Market Competition Measures

Variable: X_6 hhi_type

Category type 1 is competitive. Category type 2 is moderately concentrated. Category 3 is highly concentrated. The sign is negative. Increasing levels of market concentration, or market power, mean diffusion is less likely. The coefficient is not statistically significant. See Tables 22 and 23.

Market Capacity Measure

Variable: X_8 beds_per1000 population

The probability of a hospital diffusing laparoscopic gastric bypass surgery decreases 46.2% for every one unit increase in market capacity, measured by the number of hospital beds per 1000 population. See Tables 22 and 23. This could be consistent with hospitals using non-price competition to compete for physicians and patients. Hospitals could be adopting technology as a way to attract physicians and patients.

Interaction Term

Variable: X_9 d_op_star

The variable d_op_star represents the interaction between a hospital having diffused open surgery and hospital having a star physician. Since doc_star and dif_op are highly correlated, the interaction term is estimated by orthogonalization technique. The variable doc_star is regressed on dif_op and the error terms are stored and used as "d_op_star." The interaction term improves the overall model fit, but is not statistically significant on its own. Several other interaction terms were tested, using Wald tests and Hosmer and Lemeshow tests of significance. Only d_op_star improved the overall statistical mode. See Tables 22 and 23.

Table 20
Model 1 Variables and Descriptions

x_n	Variable Name	Description
	dif_lap	Diffused laparoscopic surgery. dif_lap = 0 if hospital has not diffused laparoscopic gastric bypass; dif_lap = 1 if hospital has diffused laparoscopic gastric bypass. Diffusion is assumed if a hospital performs average of 6 surgeries per quarter for four consecutive quarters (Tian 2006).
X_1	doc_star	Physician star characteristic. doc_star = 0 if physician is not star; doc_star = 1 if physician is a star.
X_2	coth	Hospital star characteristic. coth = 0 if hospital is not COTH member; coth = 1 if hospital is a COTH member.
X_3	beds_201	Hospital size variable. beds_201 = 0 if hospital has <= 200 beds; beds_201 = 1 if hospital has > 200 beds.
X_4	dif_op	Diffused open surgery. dif_op = 0 if hospital has not diffused open gastric bypass; dif_op = 1 if hospital has diffused open gastric bypass.

Table 20 *(continued)*
Model 1 Variables and Descriptions

x_n	Variable Name	Description
X_5	lag_ sat	Market competition measure. Continuous variable of each hospital's market saturation rate, lagged one quarter.
X_6	hhi_type	Market competition measure. hhi_type = 1 if HHI < 1500, market is competitive; hhi_type = 2 if 1500 < HHI ≤ 2500, market is moderately concentrated; hhi_type = 3 if HHI > 2500, market is highly concentrated.
X_7	for_profit	Hospital profit status for_profit = 0 if hospital is not for profit institution; for_profit = 1 if hospital is a for profit institution.
X_8	Beds_per_1000	Market competition measure. Continuous variable equals number of hospital beds per thousand population in the hospital's market.
X_9	d_op_star	d_op_star, interaction term = doc_star * dif_op

Note: N = 5984. Mean HHI is 3,753, standard deviation 2556, minimum 462 and maximum 10,000. Mean number of beds is 219, standard deviation 176, minimum 25, and maximum 814.

Table 21
Model 1 Means and Standard Deviations

x_n	Variable	Mean	Minimum	Maximum
	dif_lap	0.102 (.303)	0	1.00
X_1	doc_star	0.059 (.235)	0	1.00
X_2	coth	0.187 (.390)	0	1.00
X_3	beds_201	0.751 (.432)	0	1.00
X_4	dif_op	0.211 (.408)	0	1.00
X_5	lag_sat	8.934 (16.426)	0	100
X_6	hhi_type	2.48 (.778)	1	3.00
X_7	for_profit	0.054 (.227)	0	1.00
X_8	beds_per_1000	3.578 (.730)	2.380	4.46
X_9	d_op_star	3.65e-11 (.067)	-.917	.083

Note: N = 5984. Mean HHI is 3,753, standard deviation 2556, minimum 462 and maximum 10,000. Mean number of beds is 219, standard deviation 176, minimum 25, and maximum 814.

Table 22
Model 1 Variables and Expected Signs

x_n	Variable Name	Variable Description	Expected Sign	Results
	dif_lap	Diffused laparoscopic surgery		
X_1	doc_star	Star physician	+	+
X_2	coth	Star hospital	+	+
X_3	beds_201	Hospital has > 200 beds	+	+
X_4	dif_op	Diffused open surgery	+	+
X_5	lag_sat	Lagged market saturation rate	+	+
X_6	hhi_ type	Level of market competition	-	-
X_7	for_profit	Profit status	+	+
X_8	beds_per1000	Beds per 1000 population	-	-
X_9	d_op_star	d_op_star, interaction term	-	-

Note: N = 5984.

Table 23
Model 1: Results of Logistic Regression

x_n	Variable Name	Coefficient (Robust Std Err)	z	P>|z|	Odds Ratio
x_1	doc_star	2.051 (.488)	4.20	0.000*	7.776
x_2	coth	0.753 (.642)	1.17	0.241	2.120
x_3	beds_201	3.225 (.792)	4.07	0.000*	25.156
x_4	dif_op	3.351 (.941)	3.56	0.000*	28.545
x_5	lag_sat	0.123 (.015)	8.23	0.000*	1.131
x_6	hhi_ type	-0.256 (.305)	-.84	0.402	0.774
x_7	for_profit	1.693 (.599)	2.82	0.005*	5.433
x_8	beds_per1000	-0.620 (.343)	-1.81	0.070**	0.537
x_9	d_op_star	-1.510 (.913)	-1.65	0.098**	0.221

Note: N = 5984. McFadden's R2 = .724. Wald chi(9) =103.13. Hosmer-Lemeshow chi2(7) = 8.34. Prob > chi2 = .3039. *p =.05, **p=.10

Table 24
Pearson Correlation Matrix

			X_1 doc_ star	X_2 Coth	X_3 beds_ 201	X_4 dif_ op	X_5 lag_ sat	X_6 hhi_ type	X_7 for_ profit	X_8 beds_ per_1000	X_9 d_ op_star
	dif_lap	1									
X_1	doc_star	.486*	1								
X_2	coth	.299*	.359*	1							
X_3	beds_201	.292*	.231*	.315*	1						
X_4	dif_op	.577*	.435*	.377*	.334*	1					
X_5	lag_sat	.605*	.254*	.099*	.250*	.381*	1				
X_6	hhi_type	-.030	-.155*	-.293**	-.149**	-.055**	-.027	1			
X_7	for_profit	.151*	.149*	.118*	.175*	.138*	.020*	-.033	1		
X_8	beds_per_1000	.078*	.109*	.047*	.208*	.045*	.088*	.152*	.168*	1	
X_9	d_op_star	.130*	.000	.058*	-.006	.165*	.082*	.010*	.062*	.011	1

Note. N = 5984. *p =.05, **p=.10

Table 25
Summary of ANOVA

		Sum of Squares	Df	Mean Square	F	Prob > F
	Model	353.225	81	4.361	119.61	.000
x_1	doc_star	17.206	1	17.206	471.93	.000
x_2	coth	1.445	1	1.445	39.64	.000
x_3	beds_201	.520	1	.520	14.27	.002
x_4	dif_op	17.286	1	17.286	474.13	.000
x_5	lag_sat	106.154	66	1.608	44.12	.000
x_6	hhi_type	.596	2	.298	8.17	.003
x_7	for_profit	2.362	1	2.362	64.78	.000
x_8	beds_per1000	4.365	7	.626	17.10	.000
x_9	d_op_star	1.097	1	1.097	30.09	.000
	Residual	215.178	5902	.0364		.000
	Total	568.404	5983	.0950		

Note. N = 5984; R2 = .6214; Root MSE = .1909; Adjusted R2=.6162.

Summary of Results for Model 1

Controlling for hospital and market characteristics, having a star physician on staff (Research Question #1) means a hospital with a star physician has an 89% probability of diffusing laparoscopic gastric bypass surgery, compared with a hospital without a star physician on staff which has an 11% probability. The model provides limited support for the hypothesis that hospitals which are star hospitals are more likely to diffuse laparoscopic gastric bypass surgery than are non-star hospitals. (Research Question #3)

The model is subject to some limitation because the number of stars and the interaction among peers is not measured. This is addressed in Empirical Model 2.

5.3 Empirical Model 2

The results of Empirical Model 1 show that hospitals with star physicians are more likely to diffuse laparoscopic gastric bypass surgery. Empirical Model 2 seeks to bring the analysis to the level of the individual physician behavior, concentrating on the significance of the interactions between star and non-star physicians at co-located hospitals. Model 2 follows the methodology of Burke, Fournier and Prasad (2007) by adding interaction terms to capture any impact on diffusion attributable to the influence from star to non-star physicians and/or from non-star to star physicians. Separate equations are used to test the interactions: (i) on adoption and (ii) on utilization.

We seek an equation describing adoption.

Let $\widehat{z_{i,t}}$ = the log odds of physician i adopting laparoscopic surgery at time t.

Let $V_{i,t-1}$ = physician's lagged number of cumulative bariatric procedures.

Let $\widehat{p_i}$, $\widehat{c_t}$, and $\widehat{\alpha_h}$ = dummy variables for each physician, calendar quarter, and hospital, respectively.

Let $x_{1,rt}$ = mean patient age

Let $x_{2,rt}$ = patient gender

Let S_t = number of star peers at time t.

Let NS_t = number of non-star peers at time t.

Let $g1$ = member of group including star physicians.

Let $g2$ = member of group including non-star physicians

Equation 13 estimates the log odds of the probability of all physicians adopting laparoscopic gastric bypass at time t.

$$\widehat{z_{\iota,t}} = \widehat{p_\iota} + \widehat{c_t} + \widehat{\alpha_h} + \widehat{\beta_1}x_{1,rt} + \widehat{\beta_2}x_{2,rt} + \hat{\gamma}\, g2 * S_{rt} + \hat{\mu}\, g1 * NS_{rt} + \hat{\delta}V_{r,t-1} + e_{it}$$

[Equation 13]

The interaction terms capture peer effects: the term $\hat{\gamma}\, g2 * S_{rt}$ captures the effect of non-stars on stars; and the term $\hat{\mu}\, g1 * NS_{rt}$ captures the effect of stars on non-stars. Table 26 shows the means, standard deviations, and expected signs for the terms in the Equation 13.

We seek an equation describing utilization rates among physicians.

Let $\hat{u}_t$= the ratio of number of laparoscopic gastric bypass surgeries performed by a physician to the total number of gastric bypass surgeries, open and laparoscopic, performed by that same physician. Replacing $\widehat{z_{\iota,t}}$ with $\hat{u}_t$ in Equation 13 yields Equation 14, the utilization equation estimate for each physician.

$$\hat{u}_{it} = \widehat{p_i} + \widehat{c_t} + \widehat{\alpha_h} + \widehat{\beta_1}x_{1,st} + \widehat{\beta_2}x_{2,st} + \widehat{\gamma_r}\, g2 * S_{rt} + \widehat{\gamma_s}\, g1 * NS_{rt} + \hat{\delta}V_{r,t-1} + e_{it}$$

[Equation 14]

Table 27 shows the means, standard deviations, and expected signs for the terms in the Equation 14.

5.3.1 Hypothesis Tested by Model 2

Model 2 addresses Research Question 2: Does the presence of a star physician(s) at a hospital impact the diffusion rate of laparoscopic bariatric surgery technology to non-star physicians? This question is addressed in two steps. First, a logistic regression of physician adoption is tested. Second, conditional on adoption, a linear regression of physician utilization rates is tested.

5.3.2 Descriptive Statistics

Table 29 presents the means and standard deviations for the data in Model 2. The data set has a more limited number of observations than the data set used in Model 1. There are 2,448 observations in the sample. The final sample for the adoption model includes 37-70 physicians per quarter and includes 101 observations over eight quarters, from 2000:1 to 2001:4. Physicians are included if they have performed surgeries over three consecutive quarters.

This is consistent with the method of Burke, Fournier and Prasad (2007). They use eight quarters of data to capture the time period with the greatest rates of initial adoption, which when considering an S-shaped diffusion curve, would be the steepest areas of the curve. The twenty-four quarters of data they consider is similar in length to the twenty-eight quarters of data on laparoscopic gastric bypass extending from the year 2000 considered in this study. The years 2000 and 2001 represent the time period with the greatest annual increases in bariatric surgery throughout Pennsylvania, with annual increases of 95% and 104%, respectively. See Table 2 and Figure 4. Finally, this time frame is also consistent with the timing of earliest publications (Schauer, Ikramuddin, Gourash & Luketich, 1999 and Schauer, Ikramuddin & Gourash, 2000)of physician Philip Schauer pioneering laparoscopic gastric bypass surgery in Pennsylvania.

Utilization regression. The utilization rate for each physician for each quarter is calculated as the ratio of the number of laparoscopic gastric bypasses performed to the total number of all gastric bypass surgeries performed. Conditional on adoption, there are 334 utilization observations. Table 29 presents Model 2 variable means and expected signs.

Table 26
Model 2 Variable Means, Standard Deviations: Adoption

	Variable Name	Mean (Std Dev)	Minimum	Maximum
Adoption model (n = 101 observations)				
$V_{r,t-1}$	Lagged physician volume	7.137 (10.912)	0	46
	Patient gender			
	Mean patient age	42.010 (1.636)	35.857	45.444
S_{rt}	number of stars encountered at time t	1.543 (1.769)	0	5
NS_{rt}	number of non-stars encountered at time t	1.348 (1.133)	0	3
grp1	Physicians in grp1, (star)	.380 (.488)	0	1
grp2				
grp1nst	$grp1*NS_{rt}$	.848 (1.266)	0	3
grp2st	$grp2*S_{rt}$	.533 (1.338)	0	5

Note: N = 101.

Table 27
Model 2 Variable Means, Standard Deviations: Utilization

	Variable Name	Mean (Std Dev)	Minimum	Maximum
Utilization model (n = 334 observations)				
	Utilization rate	.286 (.371)	0	1
$V_{r,t-1}$	Lagged physician volume	9.86 (13.64)	0	100
	Physicians in grp1, ("star")	.26 (.44)	0	1
	Mean patient age	43.14 (2.77)	20	61
S_{rt}	number of stars encountered	.57 (1.09)	0	6
NS_{rt}	number of non-stars encountered	1.05 (1.25)	0	9
grp1nst	grp1*nst	.39 (1.00)	0	9
grp2st	grp2*st	.31 (.81)	0	6

Note: N = 334 observations.

Table 28
Number of Physicians and Laparoscopic Surgeries

Qtr	Physicians	Cumulative Adopters(%)	Leave Sample	Enter Sample	Number Lap Surgeries	Utilization Rate
1999:1	12	2	0	11	3	2.70
1999:2	19	4	0	9	6	3.90
1999:3	26	4	0	5	6	3.70
1999:4	27	5	1	3	15	8.02
2000:1	29	7	1	3	21	8.61
2000:2	37	8	1	9	18	6.19
2000:3	37	10	1	2	24	7.79
2000:4	44	12	1	5	47	11.81
2001:1	50	16	0	6	54	11.09
2001:2	58	19	2	8	44	6.88
2001:3	66	21	1	5	75	11.13
2001:4	70	23	2	3	87	12.17
2002:1	70	25	2	1	101	12.29
2002:2	70	29	3	4	104	10.26
2002:3	76	28	3	4	146	12.37
2002:4	79	32	1	7	142	11.41
2003:1	80	37	3	4	200	14.30
2003:2	87	41	1	7	207	11.95
2003:3	94	48	1	8	227	12.30
2003:4	98	52	2	3	243	12.43
2004:1	99	54	4	4	211	9.94
2004:2	98	54	6	4	185	10.16
2004:3	97	52	4	2	309	15.62
2004:4	85	69	0	3	756	45.35
2005:1	93	72	5	2	1002	59.64
2005:2	93	69	5	1	1060	61.95
2005:3	87	74	5	2	1056	64.35
2005:4	85	74	4	1	1017	67.08
2006:1	84	75	4	2	910	69.89
2006:2	80	79	3	0	921	72.01
2006:3	82	76	3	2	865	66.74
2006:4	80	74	3	2	864	73.03
2007:1	78	75	1	1	945	75.60
2007:2	78	76	0	0	912	76.51

Note: Utilization rate is calculated as the ratio of the number of laparoscopic gastric bypass surgeries to the total number of laparoscopic and open gastric bypass surgeries.

5.4 Empirical Model 2 Results

Empirical Model 2 tests Research Question 2: Does the presence of star physician(s) at a hospital influence the diffusion rate of laparoscopic bariatric surgery technology to non-star physicians?

The probability of adoption increases from 4% for non-stars with no co-located stars to 96% for non-star physicians co-located with star physicians. This result is for the eight calendar quarters, from first quarter 2000 to fourth quarter 2001. Consistent with the findings of Burke, Fournier and Prasad (2007), the logistic regression shows a positive, asymmetric influence of star physicians on non-star physicians; however, the data set is small, with 101 observations.

The utilization linear regression, conditional on a physician having adopted laparoscopic surgery, shows that utilization rates for non-star physicians increase by 4.88% every one co-located star physician above the average number of co-located stars. There are 344 observations. Tables 30 and 31 summarize the results.

Table 29

Model 2 Variable Descriptions, Expected Signs and Results

Variable Name	Variable Description	Expected Sign	Results
adopt_lap	Physician adopts laparoscopic surgery		
grp2st	Equals group 2 * number of stars	+	+
grp1nst	Equals group 1 * number of nonstars	-	-
$V_{r,t-1}$	Lagged number of open surgeries	+	+
$x_{1,rt}$	Patient age	NS	NS
$x_{2,rt}$	Patient gender	NS	NS
Dummy variables			
c_t	For each quarter	NS	NS
α_h	For each hospital	NS	NS
$\boldsymbol{p_i}$	For each physician	NS	NS

Note: *N* = 101. NS denotes results which are not significant.

5.4.1 Adoption Model Results

For non-star physicians co-located with star physicians, the probability of adoption increases from 4% to 96%. This result is for the eight calendar quarters, from first quarter 2000 to fourth quarter 2001. It may be that non-star physicians seek out facilities where star physicians are operating in order that they may learn from the stars. It may be that non-star physicians seek out facilities where star physicians are operating because these non-stars possess certain characteristics which align them with stars in ways that make them more likely to adopt new technology. Let us consider each variable in turn.

Variable: $g2*S_{rt}$

Having a star physician co-located with the non-star at a hospital means that the probability of the non-star physician adopting laparoscopic surgery is 96% compared with the probability of a 4% that a non-star physician adopts gastric bypass when a star physician is not present. In other words, having a star physician co-located with a non-star physician increases the log-odds of that non-star adopting a technology by 3.106.

Variable: $g1*NS_{rt}$

As expected, the coefficient reflecting the influence of nonstars on stars is not statistically significant. Stars (group 1) are not statistically influenced by the presence of non-stars.

Variables: p_i, c_t , α_h, $\widehat{\beta_1}x_{1,st}$, $\widehat{\beta_2}x_{2,st}$

The control variables for physician, hospital or calendar quarter are not statistically significant. The coefficients on patient age and gender are not statistically significant.

5.4.2 Utilization Model Results

Utilization Model

The utilization linear regression, conditional on a physician having adopted laparoscopic surgery, shows that utilization rates for non-star physicians increase by 4.88% for every one co-located star physician.

This model seems to have a structural break at quarter 20. This results in signs going in opposite direction from the expected direction. It is possible that the sample set is too small(there are just over 300 observations), there are omitted variables, or the structural form of the test is wrong. The model may capture the number of other physicians in the market; however, the viability of this statistic as a proxy for social interaction may be the wrong proxy for hospital level interaction.

Table 31 presents the results of the adoption model. The variable grp2st which measures the influence of stars on nonstars on the adoption of laparoscopic gastric bypass surgery is significant at the 10% level.

Table 30
Model 2 Results of Logistic Regression: Adoption

	Variable	Coefficient	z	P>|z|	Odds Ratio
grp2st	grp2*st	3.106 (1.752)	1.77	.076	22.323
grp1nst	grp1*nst	-3.277 (2.407)	-1.36	.173	.038
$V_{r,t-1}$	Lagged number of open surgeries	-.229 (.115)	-1.99	.047	.795
	Dummy variables				
$\widehat{c_t}$	For each quarter				
$\widehat{\alpha_h}$	For each hospital				
$\widehat{\boldsymbol{p_\iota}}$	For each physician				

Note: *N* = 101.

Table 31
Model 2 Results of Linear Regression: Utilization

	Variable	Coefficient	t	P>|t|
grp2st	grp2*st	.0488 (.023)	2.14	.033
grp1nst	grp1*nst	.007 (.014)	.48	.629
$V_{r,t-1}$	Lagged number of open surgeries	9.857 (13.642)	-2.27	.024
	Dummy variables			
$\widehat{c_t}$	For each quarter			
$\widehat{\alpha_h}$	For each hospital			
$\widehat{\boldsymbol{p}_\iota}$	For each physician			

Note: *N* = 334.

CHAPTER 6

IMPLICATIONS FOR POLICY AND FUTURE RESEARCH

6.1 Summary of Results

The goal of this dissertation is to study the role of star power in the diffusion of a medical technology. Certain physicians and hospitals are considered to be stars, that is, highly attractive to patients. In the case of physicians, stars are defined as those who have graduated from a Top 30 Medical School or completed a residency at a Top 30 Hospital, or are included in Castle & Connolly's Top Docs publications. In the case of hospitals, stars are defined as members of the American Association of Medical College's Council of Teaching Hospitals. The suitability of the proxy measures is substantiated by interviews with physicians and administrators. Three hypotheses test (1) whether hospitals with star physicians are more likely to diffuse technology than hospitals with no star physicians; (2) whether non-star physicians are more likely to diffuse technology when star physicians are practicing at the same hospital; and (3) whether star hospitals are more likely to diffuse a technology than non-star hospitals.

The hypotheses are empirically tested using quarterly data of all bariatric surgeries performed in hospitals in Pennsylvania from fourth quarter 1995 to second quarter 2007. The approach used to test the empirical model is logistic and ordinary least squares regression analyses. Logistic regression is used to test Hypotheses 1 and 3, which measure hospital level effects of star power. A two stage approach is used to test Hypothesis 2, which measures physician level effects of star power. First, logistic regression is used to test the role of star physicians on adoption rates of non-stars. Second, conditional on adoption, OLS regression is used to test the role of star physicians on utilization rates on non-stars. Using this approach, the empirical results, for the most part, indicate that hospitals with star physicians and hospitals which are stars are more likely to diffuse bariatric surgery than hospitals without such characteristics. The empirical results indicate that star physicians exert positive asymmetric influence on the adoption and utilization rates of non-stars at the same hospital. Hence, my findings are consistent with the hypotheses.

Because the results of this study are based on a specific medical technology, over a particular time period, across only one state, any implications must be made with caution.

6.2 Support and Extension of Other Research

There are two areas in which this study supports and extends earlier research in technology diffusion: (1) finding positive evidence for the role of key individuals, "stars," and (2) finding evidence for the role of market and institutional factors in technology diffusion.

6.2.1 Stars and Social Learning

An area of technology diffusion research recognizes the role of individuals in influencing others when individuals face imperfect information and uncertainty in returns to their investments. Uncertainty comes from institutional and environmental factors and market rewards for performance. Early work in technology diffusion recognizes opinion leaders as influential in the diffusion process in agriculture (Rogers, 1962, 1995 and 2003). Early empirical work in the diffusion of medical technology showed physicians with certain academic credentials were more likely than others to adopt and diffuse new technology (Coleman, Katz and Menzel, 1957). More health economics research supports the identification of key individuals and institutions in technology diffusion (Skinner and Staiger). Foster & Rosenweig (1997) and Munschi (2004) find a role for asymmetric influence in the face of uncertain returns in samples of individuals in India's Green Revolution, 1968-1970. Farmers learn from neighbors' outcomes. More recent empirical work by Burke, Fournier and Prasad (2007) emphasize the role of social learning by testing the role of star physicians in diffusion of a technology to non-star physicians. They find star physicians exert asymmetric influence on non-star physicians in the diffusion of a medical technology among cardiac surgeons in Florida. This study supports Burke, Fournier and Prasad's findings by testing their theory on a set of observations for a different technology.

Burke, Fournier and Prasad (2007) use a sample of 148,174 patients who received angioplasty in the state of Florida over a six year period. This yields 373 physician adoption observations and 6137 utilization observations. Though this study uses a smaller data set, which results in only 101 physician adoption and 343 utilization observations in Model 2, it provides statistical support of Burke, Fournier and Prasad's finding in cardiac surgery with data from another state and for a different technology. The value of this study is that careful consideration of individual market definitions are used to tease out institutional and market factors which may affect diffusion.

Lack of star physicians may mean welfare losses occur. This suggests an area for policy intervention. Efforts to draw star physicians to hospitals without stars could improve welfare in two ways: (1) the star physicians can diffuse gastric bypass surgery and (2) non-stars may learn from or may be inspired by co-located stars and increase diffusion rates. This could be welfare enhancing because it could improve access to bariatric surgery.

6.2.2 Star Hospitals

Another area of technology diffusion research recognizes certain characteristics of institutions and markets as correlated with higher rates of medical technology diffusion. Skinner & Staiger (2005 and 2009), Huckman (2003), and Ho (2000 and 2009) find certain institutional factors correlate with higher rates of medical technology diffusion. Higher rates of technology diffusion are welfare enhancing. Lower rates of diffusion are welfare reducing. Chandra & Staiger (2007) find lower diffusion rates correlate with decreased hospital productivity. This study finds that diffusion of a medical technology is more likely when certain hospital and market features are present: a large hospital with a star physician is more likely to diffuse technology than a smaller hospital or a hospital with no star physicians.

Like previously mentioned research, this study also raises the issue that laggards in technology diffusion impose welfare costs on society. Twenty-seven percent of hospitals in this study are either categorized as stars or have diffused gastric bypass surgery by the end of the sample period. All else equal, is it efficient or equitable for only some Pennsylvania hospitals to have diffused laparoscopic gastric bypass surgery by the end of the sample period? Should all hospitals have laparoscopic gastric bypass surgery? If so, this suggests an area for policy intervention.

Ninety-four percent of the diffusion observations occur in large hospitals, those with more than two hundred beds. It may be that economies of scale are present which make it more efficient for larger hospitals to offer laparoscopic gastric bypass surgery; however, there may be questions of access and equity. Large hospitals comprise forty-five percent of the hospitals in the data set and are concentrated in urban areas. This may mean that patients in rural areas have disproportionately less access to care for this obesity treatment than do patients in or near urban centers. Counties in HR1, HR3 and HR9 have the highest obesity rates in Pennsylvania in 2007. Diffusion speed is fast in the HR1 and HR9, which contain the urban centers around Pittsburgh and Philadelphia, respectively; however, diffusion speed is slow in HR3, which contains counties with the lowest population densities in the state. (Table 9 shows 2007 obesity rates by hospital region. Figure 8 shows hospital regions.) This suggests an area for policy intervention. Results of Model 1 show that hospitals with star physicians diffuse technology more quickly than hospitals with no star physicians. Model 2 shows that diffusion occurs more quickly when non-star physicians are co-located with star physicians. Efforts to draw star physicians to small, rural hospitals could improve welfare in two ways: (1) the star physicians can diffuse gastric bypass surgery and (2) non-stars may learn from or may be inspired by co-located stars and increase diffusion rates in rural areas. This could be welfare enhancing because it could improve access to bariatric surgery to rural residents; however, if economies of scale are present and/or rural markets are very small, efficiency losses must be carefully weighed against equity gains. Alternately, it may be helpful to send physicians from rural hospitals to learn from star physicians at other hospitals.

6.3 Areas for Further Study

This study generates questions which might be fertile ground for further economic research. One question is this: what is the role of stars in the diffusion of other technologies? Another question regards market structure: What role does the mix of for-profit, nonprofit and government hospitals as a factor in technology diffusion? What role does market competition play in diffusion? Finally, what role might star physicians play in the diffusion of treatment for other chronic diseases such as diabetes? What is the relationship between market competition and stars diffusion?

6.3.1 Stars and Other Technologies

If star physicians are associated with higher rates of technology diffusion, are there other medical technologies which might be studied to further understand the role of star physicians in the diffusion process? For instance, Lasik eye surgery is an elective procedure which diffused through Pennsylvania around the same time period as bariatric surgery.

Is the influence of stars on non-stars true in another context? For example, Tennessee has some of the highest obesity rates in the nation. Might a study of diffusion in Tennessee show similar patterns? If studying diffusion in other technologies in other markets leads to similar findings of star power, it may mean a stronger argument for policy intervention. Perhaps providing incentives for star physicians to visit or spend short term assignments at hospitals with slow diffusion and non-stars might encourage spread of technology.

6.3.2 Hospital Market Concentration

This study finds the role of market concentration status on diffusion is not statistically significant; however, restricting the time periods to account for the periods of most rapid diffusion may provide some insight into the role of market concentration at pivotal times in diffusion. In this case, restricting analysis to early time periods shows that market power results in less diffusion. Less diffusion could reduce consumer welfare. Further study and documentation of this relationship would be helpful, especially when future hospital mergers are considered.

Policy makers would benefit from research which shows consumer welfare may be negatively impacted as market concentration increases.

6.3.3 Chronic Disease

Bariatric surgery differs from other surgeries in that life-long follow up care to the chronic disease of obesity is required. Successful patients realize maximum weight loss almost 18 months after the procedure. Unsuccessful patients may experience complications which require additional surgical intervention and/or other hospital services. Given the increasing prevalence of chronic disease in the U.S. population, generalizations of this research to treatment of other chronic diseases may result in innovations in other areas of hospitals.

One area of chronic disease closely related to obesity is diabetes. Diabetes is linked to obesity. Approximately ninety percent of those with Type II diabetes are overweight or obese. If access to bariatric surgery improves or resolves diabetes, then understanding the role of star physicians, hospital size becomes important (Centers for Disease Control, 2007). HR1 and HR9 have the highest rates of diabetes and have the fastest rates of diffusion. In HR3, HR2 & HR6, diabetes rates are higher than the national average, yet diffusion rates are slow. Longer term study of star physicians in this process is a promising area of further study into the role of the physician in the patient's choice of hospital and in the patient doctor relationship.

6.4 Conclusion

Although implications drawn from the results of this study are based on a specific medical technology and must, therefore, be made with caution, the results raise interesting and important questions for further research.

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APPENDIX

Hospitals' HHI

Hospital	HHI
Hospital Region 1	
ACMH Hospital	10,000
Allegheny General Hospital	2,842
Alle-Kiski Medical Center	4,315
Butler Memorial Hospital	6,407
Canonsburg General Hospital	2,842
Excela Frick Hospital	5,699
Excela/Latrobe Area Hospital	6,682
Excela/Westmoreland Hospital	5,424
Heritage/Medical Center Beaver	6,682
Heritage/Sewickley Valley Hospital	2,842
Highlands Hospital	5,360
Jefferson Regional Medical Center	2,458
Mercy Hospital Pittsburgh	2,622
Mercy Jeannette Hospital	3,828
Monongahela Valley Hospital	2,938
Ohio Valley General Hospital	2,842
Southwest Regional Medical Center	10,000
St Francis Medical Center	2,636
St. Clair Memorial Hospital	2,842

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix
Hospitals' HHI

Hospital	HHI
Hospital Region 1	
Uniontown Hospital	6,234
UPMC Beaver Valley Hospital	4,022
UPMC Braddock Hospital	2,017
UPMC Children's Hospital Pittsburgh	2,622
UPMC Magee Women's Hospital	2,622
UPMC McKeesport	2,675
UPMC Passavant	4,022
UPMC Shadyside	2,494
UPMC St Margaret	2,842
Western Pennsylvania Hospital	2,842
Western PA/Forbes Regional Hospital	2,648
Washington Hospital	4,208
Hospital Region 2	
Bradford Regional Hospital	4,608
Brookville Hospital	4,080
Charles Cole Memorial Hospital	10,000
Clarion Hospital	10,000
Clearfield Hospital	2,842

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix

Hospitals' HHI

Hospital	HHI
Hospital Region 2 (continued)	
Corry Memorial Hospital	5,289
DuBois Regional Medical Center	5,190
Elk Regional Health System	5,068
Ellwood City Hospital	3,333
Grove City Medical Center	5,082
Hamot Medical Center	4,142
Jameson Memorial Hospital	2,637
Kane Community Center	3,686
Meadville Medical Center	8,489
Millcreek Community Hospital	4,142
Punxsutawney Area Hospital	3,880
Sharon Regional Hospital	8,338
St Vincent Health System	4,142
Titusville Area Hospital	5,870
UPMC Horizon Hospital	7,745
UPMC Northwest	3,056
Warren General Hospital	10,000

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix

Hospitals' HHI

Hospital	HHI
Hospital Region 3	
Altoona Reg Health Sys/Altoona Hospital	5,655
Altoona Reg Health Sys/Bon Secours	10,000
UPMC Bedford	9,344
Conemaugh Valley Memorial Hospital	8,174
Indiana Regional Medical Center	10,000
Meyersdale Community Hospital	7,769
Miners Medical Center	5,395
Nason Hospital	10,000
Somerset Hospital	10,000
Tyrone Hospital	5,503
Windber Hospital	8,174
Hospital Region 4	
Berwick Hospital Center	3,817
Bloomsburg Hospital	6,130
Bucktail Medical Center	5,304
Evangelical Community Hospital	4,778
Geisinger Medical Center/Danville	7,901
Jersey Shore Hospital	3,474
Lewistown Hospital	6,617

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix
Hospitals' HHI

Hospital	HHI
Hospital Region 4 (continued)	
Lock Haven Hospital	3,817
Mount Nittany Medical Center	4,055
Shamokin Area Community Hospital	4,781
Soldiers & Sailors Memorial Hospital	10,000
Sunbury Community Hospital	5,899
Susquehanna Health/Muncy Valley Hospital	10,000
Susquehanna Health/Williamsport Hospital	10,000
Hospital Region 5	
Carlisle Regional Medical Center	4,346
Chambersburg Hospital	10,000
Ephrata Community Hospital	2,305
Fulton County Medical Center	9,344
Gettysburg Hospital	5,183
Good Samaritan Hospital/Lebanon	3,299
Hanover Hospital	3,721
Heart of Lancaster Regional Medical Center	2,502
Holy Spirit Hospital	3,606

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix

Hospitals' HHI

Hospital	HHI
Hospital Region 5 (continued)	
J C Blair Memorial Hospital	3,191
Lancaster Regional Medical Center	3,632
Memorial Hospital York	4,553
Milton S. Hershey Medical Center	2,857
Pinnacle Health Hospital	3,057
Waynesboro Hospital	10,000
York Hospital	4,553
Hospital Region 6	
Barnes-Kasson Hospital	10,000
Community Medical Center/Scranton	2,048
Geisinger South/Wilkes Barre	2,430
Geisinger Wyoming Valley Medical Center	2,430
Hazleton General Hospital	3,088
Marion Community Hospital	2,214
Memorial Hospital/Towanda	6,940
Mercy Hospital/Scranton	2,048
Mid-Valley Hospital	2,323
Montrose General Hospital	5,340
Moses Taylor Hospital	2,048

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix

Hospitals' HHI

Hospital	HHI
Hospital Region 6	
Pocono Medical Center	10,000
Robert Packer Hospital	7,953
Troy Community Hospital	
Tyler Memorial Hospital	1,154
Wayne Memorial Hospital	5,060
WVHCS Hospital	2,430
Hospital Region 7	
Blue Mountain Health System/Gnaden Huetten Memorial Hospital	5,742
Blue Mountain Health System/Palmerton Hospital	3,448
Easton Hospital	
Lehigh Valley HN/Lehigh Valley Hospital	2,260
Lehigh Valley HN/Muhlenberg	2,564
Reading Hospital & Medical Center	2,430
Sacred Heart Hospital	2,332
Schuylkill Med Ctr/Good Samaritan Reg	2,430

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix

Hospitals' HHI

Hospital	HHI
Hospital Region 7 (continued)	
Schuylkill Med Ctr/Pottsville	2,430
St Joseph Med Ctr/Reading	4,598
St Lukes Hosp & H S/Bethlehem	2,512
St Lukes Hosp & H S/St Lukes Miners	3,559
Hospital Region 8	
Abington Memorial Hospital	638
Barix Clinics of Pennsylvania	794
Brandywine Hospital	3,154
Chester County Hospital	2,066
Crozer-Chester Medical Center	1,034
Delaware County Memorial Hospital	1,034
Doylestown Hospital	
Elkins Park Hospital	
Grand View Hospital	1,604
Holy Redeemer Hospital	643
Jennersville Regional Hospital	4,009
Lansdale/Central Montgomery Hospital	

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix

Hospitals' HHI

Hospital	HHI
Hospital Region 8 (continued)	
Lower Bucks Hospital	1,076
Main Line Health/Bryn Mawr Hospital	
Main Line Health/Lankenau Hospital	
Main Line Health/Paoli Hospital	
Mercy Fitzgerald Hospital	704
Mercy Suburban Hospital	620
Montgomery Hospital	620
Phoenixville Hospital	1,909
Pottstown Memorial Hospital	
Riddle Memorial Hospital	
Springfield Hospital	1,034
St Lukes Hospital & HS/Quakertown	2,023
St. Mary Medical Center	794
Taylor Hospital	
Warminster Hospital	794

Note. Data are from the Pennsylvania Health Care Cost Containment Council.

Appendix
Hospitals' HHI

Hospital	HHI
Hospital Region 9	
Albert Einstein Medical Center	659
Chestnut Hill Hospital	621
Children's Hospital of Philadelphia	659
Frankford Hospital	676
Hahnemann Hospital	659
Hospital of Fox Chase Cancer Center	
Hospital of the University of PA (HUP)	659
Jeanes Hospital	
Jefferson University Hospital	
Mercy Philadelphia Hospital	734
Nazareth Hospital	621
Penn Presbyterian Hospital	659
Pennsylvania Hospital	659
Roxborough Memorial Hospital	697
St Christopher's Hospital	
St Joseph Hospital	
Temple University Hospital	659

Note. Data are from the Pennsylvania Health Care Cost Containment Council.