Three Essays in Industrial Organization

by

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ABSTRACT

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Understanding the behavior of organizations that are not solely governed by a profit-maximizing objective function is of central importance in microeconomics and for public policy. For example, the hospital industry, representing roughly 6% of United States Gross Domestic Product in 2012, is dominated by nonprofit hospitals. Similarly, the United States Postal Service is a quasi-government regulated entity that is charged with binding "the Nation together through the personal, educational, literary, and business correspondence of the People."[1] The choices of these organizations make can have important direct consequences on the health and communicative ability of U.S. residents. While there is a substantial empirical literature about these industries, most studies are plagued by econometric difficulties.

The studies comprising this dissertation examine the behavior of nonprofit hospitals in response to increased market power due to mergers and analyze the price elasticity of consumers of Postal Service products. The central finding related to hospital mergers is that nonprofit hospitals increase price per discharge and profit in post-consolidation years, conforming to expectations related to for-profit firms and the exercise of market power. I develop a model that predicts this outcome, and I confirm it via an empirical analysis. I find

[1] 39 U.S.C. 101

that merging nonprofit hospitals increase their average price per discharge by as much 10% and "profit" by more than 50%. These increases are only observable in the long run after a merger occurs. In addition, updated econometric techniques reveal that consumers of U.S. postal products are more price elastic than conventional estimates suggest.

The results of these studies have important policy implications for antitrust and postal regulators. In the past, hospitals have experienced relative freedom to merge, particularly when one or more nonprofit hospitals were involved in the transaction. The present analysis, together with other recent literature, suggests that jurists should exercise the same scrutiny when considering mergers involving nonprofit hospitals as they do in for-profit merger cases. Finally, in face of the fiscal crisis facing the U.S. Postal Service, better information regarding consumer price sensitivity is of central importance to regulators and public policy makers.

CHAPTER I

An Empirical Analysis of Mergers Between Nonprofit and For-Profit Firms: an Application in the Hospital Industry

1.1 Introduction

The theoretical and empirical literature has well-founded predictions for the effects of mergers among for profit firms on prices and profit. However, no clear predictions exist for mergers involving nonprofit organizations. In this paper I provide evidence that merging nonprofit firms in the hospital industry conform to for-profit expectations by exploiting market power to increase prices and profit.

Empirical research on the topic of hospital mergers has generated ambiguous results regarding the effects of a merger on various hospital performance measures. Research has primarily focused on whether merging hospitals reduce costs or raise prices, and the merger effect in these studies is most commonly identified by a merging hospitals dummy variable. Without regard to the distinction between nonprofit and for-profit hospitals, Dranove and Lindrooth (2003) and Dafny (2009) note that the prevalence of mixed empirical results is due to bias introduced by endogeneity between the merger decision and outcome measures. Both papers provided empirical strategies to address this endogeneity.

The uncertainty surrounding the effects of nonprofit mergers is particularly relevant in the hospital industry, which is composed of approximately 60% nonprofit organizations and experienced intense consolidation in the 1990s. Accounting for roughly 6% of U.S. Gross Domestic Product, the magnitude of the hospital industry coupled with the fact that almost all hospital mergers have involved at least one nonprofit firm underscores the importance of understanding the implications of nonprofit mergers in this sector.

My empirical analysis improves upon the literature in several important ways. For the first time, I separately identify the short-run and long-run effects of nonprofit hospital mergers that occurred in the mid to late 1990s. I am able to do this because I utilize a longer panel of data that now includes the 2000 to 2009 period. This is an important improvement because I only identify a significant effect of mergers on prices and profit five or more years after a merger has occurred. Past empirical research studying the merger wave of the 1990s has rarely observed hospitals beyond the year 2000. Because of this, these studies are at best able to identify short-run effects. My results suggest that the previous ambiguous empirical results may be attributed to a lack of significant short-run effects in addition to the endogeneity problem.

My analysis controls for endogeneity of mergers arising from selection on observable characteristics by reweighting hospitals that did not merge to balance their observable characteristics with those of hospitals that did merge. This represents an improvement upon the matching methodology implemented by Dranove and Lindrooth (2003). In addition, my analysis exploits the variation in the timing of consolidations throughout the merger wave by using an event study analysis and explicitly considers how the merger effect differs amongst nonprofit and for-profit hospitals.

Previous literature has not considered the differing effects of the type of merger in which a hospital participates or the relative advantage experienced by the acquiring hospital. To this end, I isolate the specific merger effect for mergers between two nonprofit hospitals and for target versus acquiring hospitals. Finally, this analysis is the first to examine the effect of mergers on a hospital's "net income", defined as hospital profit less contractual discounts offered to insurers.

I find that after a hospital merger, price per discharge at all merging hospitals increase by as much as $400 per discharge, representing a more than 10% increase, and net income nearly doubles, increasing by an average of $2.4 million per hospital. Nonprofit merging hospitals increase price by as much as $430 and net income by $1.9 million. This provides empirical evidence that the behavior of a consolidating nonprofit hospital conforms to the more commonplace expectation related to for-profit firms.

The paper proceeds as follows. Section 2 reviews the previous literature on merger effects in the hospital industry. Section 3 contains an overview of the hospital industry and peculiarities of the merger analysis. Section 4 describes the sources of my data. Section 5 outlines the details of the methodology for the empirical analyses and discusses the identification strategy. Section 6 presents empirical results, and section 7 provides further discussion. Section 8 concludes.

1.2 Literature Review

There is a deep empirical literature estimating the effect of a hospital merger on financial performance measures such as prices and costs. Until very recently, however, these estimations yielded mostly inconclusive results, partially due to the endogeneity between the decision to merge and expectations of hospital performance. Moreover, there has been an inconsistent focus on isolating the merger effects specific to the nonprofit hospital ownership structure. Here I provide a brief overview of the literature related to cost and price effects. For a comprehensive review of the hospital merger literature, see Gaynor and Town (2012).

A distinct thread of the empirical hospital merger literature is concerned with estimating the efficacy of hospital mergers in terms of reducing costs. Connor et al. (1998) and Dranove and Lindrooth (2003) implement difference-in-difference techniques and find that hospitals experience between 5% and 14% cost reduction, although Dranove and Lindrooth identify this effect only for those merging hospitals that did not join a hospital system. In more recent analysis Spang et al. (2009) explicitly consider differing merger effects for nonprofit and for-profit hospitals and find that only for-profit hospitals successfully lower costs post consolidation. Finally, Harrison (2011), using a nonparametric regression technique, finds that hospitals take advantage of economies of scale cost savings in the years immediately after merger, but that these cost savings decline in the long run.

In addition to cost reduction, a major focus of past hospital merger research has been to study the effect of consolidation on prevailing prices. In an often-cited analysis, Lynk (1995) specifically tests the assumption that nonprofit hospitals exercise market power in the form of higher prices. Using California OSHPD discharge data in conjunction with OSHPD hospital financial data from 1989, Lynk finds that nonprofit hospitals have statistically significant lower list and net prices than do their for-profit competitors after they merge.[1] However, Dranove and Ludwick (1999) later argue that Lynk's methodological choices may have imparted both simultaneity and omitted variable biases on the results. Keeler et al. (1999), seeking to improve upon Lynk's methodology, find evidence that price has played an increasingly important role in the nature of competition amongst hospitals. In particular, the authors find that nonprofits set higher prices in more concentrated markets.

An important case study, conducted by Vita and Sacher (2001), analyzes the merger of Dominican Santa Cruz's acquisition of its rival, AMI Community Hospital. In this paper, the authors exploit the fact that two nonprofit hospitals merged and increased the HHI by 1700 points to 6,350 without triggering review by the DOJ or the FTC due to the small size of the transaction. Their result that Dominican raised prices in the aftermath of the transaction as did its closest rival, Watsonville, is robust to several empirical specifications. Because both hospitals are nonprofit, the authors conclude that nonprofit hospitals behave like for-profit hospitals. In fact, in the wake of the merger wave of the 90s, the Federal Trade Commission has undertaken a directed effort in retrospective analyses of consummated mergers. To this end, Haas-Wilson and Garmon (2011) and Tenn (2011) also consider specific transactions involving nonprofit hospitals and find empirical evidence that the transactions in question

[1] Office of Statewide Health Planning and Development (OSHPD), California

lead to statistically significant post-merger price increases.

Moving beyond the Lynk analysis, Krishnan (2001) takes a unique approach in analyzing the effects of mergers on Diagnosis-Related-Group (DRG) level prices, rather than on aggregate hospital prices and finds that merging hospitals used their increased market share in individual DRGs to raise prices for those DRGs. Dafny (2009) is the first to analyze the effects of hospital consolidation by considering the effect of a rival's merger on own-firm prices and to implement an instrumental variables analysis to control for endogeneity. Additionally, Dafny introduces a unique price measure available for national hospitals, defined as the case-mix adjusted revenue per in-patient discharge. She finds substantial evidence of post-merger increases in price. Finally, Gaynor and Vogt (2003) is one of the few merger analyses to be based on a structural demand model rather than a reduced-form estimating equation. In this paper, the authors develop a BLP-like model to estimate demand and then use this model to simulate the effect of a merger with a supply side specification including a different objective function for nonprofit and for-profit firms. They conclude that nonprofit hospitals set lower prices but have higher mark-ups than for-profit hospitals and that nonprofit hospitals are not less likely to exploit market-power than are for-profit hospitals.

Despite the depth of the empirical literature examining the price effects of hospital mergers, there is little consensus amongst researchers. Early research on the specific topic of nonprofit mergers (Lynk (1995), Dranove and Ludwick (1999), Keeler et al. (1999)) do not address issues of endogeneity and found evidence both in support of and contradicting the hypothesis that nonprofit hospitals raise prices post consolidation. More recent empirical work (Krishnan (2001), Dranove and Lindrooth (2003), Dafny (2009)) has refined this empirical approach, either by focusing on disaggregated hospital prices or directly controling for potential endogeneities. However, recent research has not focused on separately identifying merger effects for nonprofit and for-profit hospitals. Finally, because the merger wave of the 90s is a relatively recent historical event, past literature has been restricted in its ability to identify only short-run merger effects through the inclusion of a singular dummy variable identifying merging hospitals.

In contrast, my empirical strategy identifies the effects of a merger through a series of event dummies indicating the number of years before or after a merger has occurred in the style of Jacobson et al. (1993). The panel structure of the hospital data in combination with this estimation strategy allows me, for the first time, to separately identify short-run and long-run merger effects. With this approach, I can control for ownership type to isolate the nonprofit merger effect. In addition, I analyze how the type of transaction, whether involving one or two nonprofit hospitals, or status as the target or acquiring hospital within a consolidation is related to the estimated merger effect.

Methodologically, I build upon the work of Dranove and Lindrooth (2003) in implementing a reweighting matching scheme to control for merger selection based on observable hospital and market characteristics. However, Dranove and Lindrooth have not implemented matching in the tradition of the program evaluation literature. In particular, the authors exploited the methodology to identify a suitable comparison group, but they do not compute the average treatment effect statistic identifying the merger effect. In addition, they do not offer evidence that their propensity score specification satisfies one of the fundamental requirements of the matching methodology: the assumption of unconfoundedness. When this assumption is not satisfied, estimates are known to be biased.

Finally, my empirical analysis relies upon publicly available aggregate Hospital Cost Report Information System (HCRIS) data available from the Center for Medicare and Medicaid Services (CMS). These data are available at the facility level, so a hospital facility that survives consolidation will remain observable in the post consolidation years of the HCRIS data. In contrast, the commonly employed American Hospital Association (AHA) data is kept at the hospital license level. In this way, data from several facilities are consolidated into one observation in the AHA data, making it difficult to track facility level observations in the post consolidation years. Because of this, researchers relying on the AHA dataset, including Dranove and Lindrooth (2003), had to carry out a separate strategy for comparison of pre and post consolidation observations. By employing HCRIS data, I can consistently compare these facilities, representing a further improvement in the literature.

1.3 Background

Historically, the U.S. hospital industry has been dominated by the nonprofit ownership form. In exchange for access to tax preferred financing and relief from federal and many state taxes, nonprofits accept several legal restrictions. For example, they are prohibited from distributing accounting profit to equity holders and are required to promote a public purpose, although the provision of health care implicitly fulfills this federal Internal Revenue Service (IRS) requirement.[2]

In comparison to other service industries in the U.S., the hospital industry is unique in its majority nonprofit organizational composition. Moreover, most mergers in the hospital industry involve at least one nonprofit, yet there is no theoretical consensus as to the nonprofit objective function and associated behavior related to mergers. As a result, the typical merger analysis, which was developed for merging for-profit firms, is not suited for analysis of merging nonprofits.

Although the evidence regarding financial performance differences between nonprofit, for-profit, and public hospitals is mixed, Horwitz (2003) demonstrates that the mix of service provided highlights important behavioral differences. In particular, Horwitz suggests that government hospitals are the "hospitals of last resort," providing unprofitable services needed by the poor and uninsured like psychiatric and emergency care and burn center treatments. Quite uncontroversially, for-profit hospitals are the most likely to provide profitable services like cardiac care and diagnostic imaging. Finally, nonprofit hospitals are a hybrid; they are less likely to respond to financial pressures but are also less likely to offer unprofitable services.

Hospital care in the U.S. is a major industry. According to the U.S. Census, spending on

[2]For a detailed discussion of nonprofit structure, see Sloan (2000)

hospital care in 2009 was $759.1 billion, or 5.2% of GDP, and the Office of the Actuary in the Centers for Medicare and Medicare Services projects spending on hospital care to grow to $831.4 billion in 2012 and to $1.4 trillion by 2020.[3] In response to dramatic increases in health care spending since the 1990s, political discourse has turned national focus toward bending the trajectory of health care spending and costs.

In the 1990s, more than 900 mergers and acquisitions occurred in the hospital industry. The impetus of this merger wave is generally believed to be the introduction of the Prospective Payment System (PPS) in 1984. Prior to 1984, hospitals were reimbursed on a cost-plus basis. However, with PPS doctors and hospitals are paid a fixed fee for services preformed, shifting the risk of profit loss from Medicare to hospitals. In only half a decade the margins on services for Medicaid patients were more often than not negative; hospitals, faced with losses began looking for ways to cut costs and increase efficiency (Dafny (2009)). The 1990s merger wave is understood to be a reaction to the then increasingly bleak outlook on hospital profitability and viability. Gaynor and Town (2012) show that the mean Herfindahl-Herschmann Index (HHI) was 2,340 in 1987, and by 2006 the mean HHI had risen to 3,261.[4,5]

A common legal justification for approving many mergers between hospitals has been in reference to their nonprofit status. As an example, in September 1996 a merger involving two of the largest nonprofit hospitals in Grand Rapids, MI was sanctioned by the district judge with the justification that the merging hospitals were unlikely to raise their prices even in the face of increased market concentration.[6] Eventually, the Federal Trade Commission attempted to take up the cases retrospectively through price analysis. However, these endeavors were largely unsuccessful until very recently.[7] For example, in April 2012, the FTC

[3]For historical spending and projections, see www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/index.html

[4]The Department of Justice classifies a market as "highly concentrated" when the HHI is greater than or equal to 2,500

[5]This HHI represents population weighted averages for Metropolitan Statistical Areas (MSAs), based on admissions, with population less than 3 million in 1990.

[6]FTC v. Butterworth Health Corp., 946 F. Supp. 1285, 1300-1301 (W.D. Mich. 1996).

[7]For a summary of the antitrust peculiarities in the hospital industry, see Gaynor and Town (2012).

successfully ordered ProMedica Healthcare, a nonprofit healthcare system, to sell St. Luke's Hospital, a nonprofit hospital, citing likely anticompetitive effects of a merger that would have given the combined entity control of 58 percent of the market.[8]

Anecdotal evidence also suggests that nonprofit hospitals respond to market concentration with increased prices. Consider the system of hospitals owned by Sutter Health Co., located in the San-Francisco to Sacramento region of California. Sutter Health has substantial market power in the region, accounting for over a third of the market, and it is able to sustain prices between 40 and 70% higher than its rival (Waldman (2010)). Although Sutter is operated under a nonprofit ownership, it was among the most profitable hospital groups in the U.S. in 2009, earning a 5.9% operating margin with revenues of $8.8 billion. A 5.9% operating margin is more than 70% higher than the average nonprofit operating margin in 2009. Futher, Peter V. Lee, the director for health care delivery reform in the U.S. Department of Health and Human Services (HHS), claimed of Sutter that "instead of leveraging its system to be more cost-effective, we've seen Sutter leveraging its system for monopoly pricing."

Sutter Health, which has successfully acquired over 30 hospitals in the past 20 years, faced legal opposition in 1999 when California's Attorney General (AG) sued in an attempt to block the acquisition of Summit Hospital in Oakland, CA. However, the judge ruled against the AG, claiming that there was sufficient competitive pressure to prevent Sutter from raising prices. Contrary to the judge's prediction, an FTC staff study revealed that Sutter's prices had risen by as much as 72% over a range of insurers in this region two years after the merger (Waldman (2010))

[8]See FTC Docket No. 9346 "Citing Likely Anticompetitive Effects, FTC Requires ProMedica Health Systems to Divest St. Luke's Hospital in Toledo, Ohio, Area"

1.4 Data

1.4.1 Hospital Data

Annual hospital facility-level data are publicly available from the Healthcare Cost Report Information System (HCRIS), administered by the Centers for Medicaid & Medicare Services (CMS). The cost reports contain information related to facility characteristics, utilization data, and broad financial measures. I have compiled this information into a twenty-year panel of hospital facility data from 1990 to 2009. I have limited the data set to those facilities that entered the panel before 1995.

Although data on approximately 5,000 hospitals is available, I consider only those hospitals with non-missing data for all variables included in the analysis, reducing the sample to about 4,100 hospitals and 68,000 observations.[9] Because a hospital's Medicare/Medicaid reimbursement depends upon the annual submission of data to HCRIS, entry and exit within the panel only occurs as a result of a facility opening or closing.

Facilities are classified according to the type of services provided.[10] The main sample of hospitals is limited to General, Short-Term hospitals, which collectively represent over 90% of the overall population of HCRIS facilities. In addition to service classifications, hospitals are classified according to their ownership structure. In particular, a hospital can be either nonprofit, for-profit, or government owned.[11] The hospital market is composed of approximately 60% nonprofit hospitals, 15% for-profit hospitals, and 25% government hospitals. The means of a set of facility level characteristics measured in 1994 for the sample of General Short Term hospitals are reported in Table 1.1. Table 1.1 also reports means according to a facility's ownership type.

The average hospital has 139 hospital beds serviced by 547 fulltime equivalent employees (FTEs). These hospitals care for 5,022 patients per year on average, 43% of which are

[9] The primary source of missing data is due to case-mix index measures for specialty hospitals. I exclude these hospitals from analysis.

[10] Hospital classifications are found on Worksheet S-2 Line 19

[11] Hospital Ownership Structure is found on Worksheet S-2 Line 18

Table 1.1: Mean Hospital Characteristics

	All	**NonProfit**	**For-Profit**	**Government**
# of Hospitals	4,109	2,454	498	1,157
Inputs				
Labor	547	670	405	331
Hospital Beds	139	160	149	89
Discharges	5,022	6,112	4,476	2,897
Medicare Discharges	1,808	2,203	1,738	1,007
Medicare Discharge Share	0.43	0.42	0.42	0.45
Case Mix Index	1.23	1.25	1.31	1.13
Finances				
Thousands of $2000				
Revenue	$98,386	$117,644	$94,095	$56,507
Cost	$49,142	$59,715	$39,591	$59,715
Profit	$45,699	$54,417	$53,364	$23,001
Net Income	$2,692	$3,147	$3,611	$1,370
Liability to Asset Ratio	0.47	0.50	0.59	0.36
Price ($2000)				
1990	$3,711	$3,718	$4,507	$3,336
1995	$3,933	$3,988	$4,348	$3,616
2000	$3,927	$3,946	$4,243	$3,745
2005	$4,690	$4,266	$4,966	$4,767

paid for by Medicare or Medicaid. In comparison, nonprofit hospitals are larger with, on average, more hospital beds, 160 per facility, serviced by 670 FTEs. Although government hospitals are the smallest, with 89 hospital beds and 331 FTEs on average, they serve the largest share of Medicare/Medicaid discharges, 45%. This reflects the reality that many government hospitals are rural hospitals in underserved communities.

The Case Mix Index (CMI) is the average diagnosis-related group weight for a hospital's Medicare/Medicaid volume. These measures are provided by CMS annually for all general short term hospitals and are used to adjust the average cost per patient in a way that reflects the types of cases treated in a particular year.[12] The average hospital's CMI is equal to 1.23. For-Profit hospitals report an average CMI of 1.31, indicating that they treat, on average, more severe cases. This might reflect a correlation between the severity of illnesses treated and the profit margin of associated treatments. In contrast, government hospitals have an average CMI of 1.13.

The average hospital earns $98 million in total patient revenues and incurs $49 million in total operating expenses.[13] However, this revenue measure reflects a "charge," or the list-price of a service performed. In reality, payers negotiate with providers for discounted rates. As such, I focus on net income as a more accurate measure of profit. Net Income takes into account other sources of income (gift shop revenues, investment income, contributions etc) and the total amount of contractual allowances and discounts provided.[14] Based on revenue and operating costs alone, the typical hospital appears to earn $45 million annually, but accounting for contractual discounts reveals that hospitals actually earn an average of $2.7 million annually. Government hospitals are the least profitable, earning $1.3 million annually, and for-profit hospitals are the most profitable, earning $3.6 million annually.

Prices are calculated as in Dafny (2009). The hospital level price is the inpatient revenue

[12] Less than 1% of CMI data are missing for General Short-Term Hospitals. However, more than 95% of specialty hospitals have missing CMI data.

[13] Total Patient Revenues can be found on Worksheet G-3 Line 1 and Total Operating Expenses can be found on Worksheet G-3 Line 5.

[14] Net Income can be found on Worksheet G-3 Line 31

per case-mix adjusted discharge.[15] By excluding Medicare discharges and accounting for contractual discounts awarded to privately insured patients, this price reflects the price paid by privately insured or uninsured patients per hospital visit. Table 1.1 reveals that real price per discharge has been increasing since 1990, with the most dramatic change in price occurring between 2000, when the average price was $3,927, to 2005, when the average price was $4,690. This trend is similar for both nonprofit and government hospitals. For-profit hospitals had much higher prices historically. By 2005, nonprofit and government hospital price trends have all but caught up to the for-profit price level.

1.4.2 Market Data

I define a hospital market to be a Hospital Referral Region (HRR) as in the Dartmouth Atlas of Health Care. Each of the 306 HRRs in the U.S. represents a regional health care market for tertiary medical care that requires a referral. The regions are defined by determining where patients are referred to for major cardiovascular or neurosurgical care. Table 1.2 shows that the average market contains 17 hospitals and mimics the composition of the overall market with 60% nonprofit hospitals, 15% for-profit hospitals, and 25% government hospitals. Moreover, 60% of hospitals within an HRR are classified as urban facilities.

Based on this market definition, I calculate the distance between a hospital and its closest within-market neighbor. The distance measure in this paper is an improvement on past measures of distance, which are typically calculated "as the crow flies" based on the exact latitude and longitude of a particular hospital. In contrast, I calculate the distance between hospitals based on the shortest driving time as mapped by Google. This provides a more realistic description of the distance between hospitals as might be experienced by patients.

[15] price = [(hospital inpatient routine service charges + hospital intensive care charges + hospital ancillary charges) x discount factor - Medicare primary payor amounts - Medicare total amount payable] / [total discharges excluding swing/skilled nursing facility - total Medicare discharges excluding swing/skilled nursing facility) x case mix index]. The discount factor is defined as 1 - (contractual discounts/total patient charges), and reflects discounts awarded to private insurers. See Dafny (2009)

Table 1.2: Mean Market Characteristics

	All Markets	**Merger Markets**
# of Markets	306	55
Market Composition		
Nonprofit Hospitals	9.7	9.1
For-Profit Hospitals	3.2	1.9
Government Hospitals	4.3	4.4
% Urban	59.7	63.7
Income Statistics		
Per-Capita Income	$26,283	$28,158
% in Poverty	12.1	11.5
Insurance Statistics		
HMO Penetration Rate	11.6	12.9
Under 65, No Insurance	17.1	16.5
Demographics		
Population	437,301	403,918
Median Age	36.4	36.4
Total Driving Time (mins)	24.2	21.6
Market Power		
HHI	2,434	2,230
For-Profit Hospital HHI	236	116

I have enriched the HCRIS panel data with a set of county-level demographic statistics made available in the Area Resource File, which is a centralized database of health-care related demographic variables compiled by the Department of Health and Human Services. Because these data are reported at the county level, they are matched to hospitals based upon the address provided in the HCRIS data. Table 1.2 reports mean income, insurance, and demographic characteristics for all HRRs. In particular, the average population in an HRR is 437,301, average age is 36.4 years, and average per-capita income is $26,283. 17% of the population in an HRR is under 65 without health insurance and 12% of the population is in poverty. The Medicare Advantage penetration rate, correlated with the overall HMO penetration rate, is 11.6%. The average drive time between hospitals is 24 minutes. Finally, the average Herfindahl-Hirschman Index (HHI) is 2,434.[16]

1.4.3 Transaction Data

A comprehensive list of mergers and acquisitions in the health care industry is compiled annually by Irving Levin Associates' Health Care Acquisitions Reports. I consider all hospitals participating in exactly one transaction between 1996 and 2001.[17]

I classify the type of transaction that occurred based on the hospital's organization. For example, if two nonprofit hospitals merge, this merger is classified as "N+N." The number of merging hospitals and associated type of transactions that occurred between 1996 and 2001 are detailed in Table 1.3. 60% of transacting hospitals were involved in a merger between two nonprofit hospitals, by far the dominant transaction type. Another 24% of transacting hospitals were involved in a merger where one hospital was nonprofit. There are many fewer observations of transacting hospitals in the early 2000s, when the merger wave slowed.

Table 1.4 reports the mean facility characteristics and financial measures separately for those hospitals that did and did not participate in a merger. All means are measured in

[16]The HHI is measured as the sum of squared market shares where an individual hospital's market share is represented by the percentage of the total discharges in the market attributed to a particular hospital.

[17]Hospitals participating in more than one transaction during this period are not included in this analysis

Table 1.3: Annual Transaction Type

	N+N	N+F	N+G	F+F	F+G	G+G	Unknown	Total
1996	35 (66%)	2 (4%)	9 (17%)	1 (2%)	0 (0%)	0 (0%)	6 (11%)	53
1997	45 (73%)	3 (5%)	8 (13%)	0 (0%)	2 (3%)	0 (0%)	4 (6%)	62
1998	29 (66%)	5 (11%)	4 (9%)	0 (0%)	0 (0%)	0 (0%)	6 (14%)	44
1999	22 (48%)	5 (11%)	5 (11%)	2 (4%)	3 (7%)	3 (7%)	6 (13%)	46
2000	11 (38%)	9 (31%)	4 (14%)	0 (0%)	0 (0%)	2 (7%)	3 (10%)	29
2001	8 (57%)	1 (7%)	4 (29%)	0 (0%)	1 (7%)	0 (0%)	0 (0%)	14
Total	150 (60%)	25 (10%)	34 (14%)	3 (1%)	6 (2%)	5 (2%)	25 (10%)	248

1994 for those hospitals that do not merge and two years before a merger for those hospitals that do merge.

Hospitals that participate in a merger are larger along all measures of size. The average merging hospital has 209 hospital beds serviced by almost twice the labor compliment of a typical nonmerging hospital. On average, merging hospitals have 8,418 discharges annually, again almost twice the number of discharges as a nonmerging hospital; however they service relatively fewer Medicare/Medicaid patients. While merging hospitals are overwhelmingly more likely to be nonprofit, a hospital type that has already been shown to be larger than a typical hospital, merging hospitals are large even when compared to the subsample of nonprofit hospitals.

At first glance it may appear that merging hospitals are quite financially successful in the pre-merger years with an average net income of \$4.7 million. If one instead considers the net income per discharge, both merging and non-merging hospitals earn approximately \$545 per discharge. Fig. 1.1 displays net income separately for the three different ownership types as well as for merging hospitals. Prior to 1996 transacting hospitals' net income tracked

Table 1.4: Comparing Non-Merging and Merging Hospital Characteristics

	Non-Merging Hospitals	**Merging Hospitals**
# of Hospitals	3,864	225
Inputs		
Labor	524	912
Hospital Beds	135	209
Discharges	4,808	8,418
Medicare Discharges	1,734	3,006
Medicare Discharge Share	0.43	0.40
Case Mix Index	1.22	1.36
Finances		
Thousands of $2000		
Revenue	$93,122	$187,899
Cost	$46,945	$83,480
Profit	$43,329	$93,827
Net Income	$2,587	$4,709
Other		
Liability to Asset	0.46	0.52
Total Driving Time (mins)	26.1	14.84
Urban	0.52	0.84
Teaching Hospital	0.22	0.49

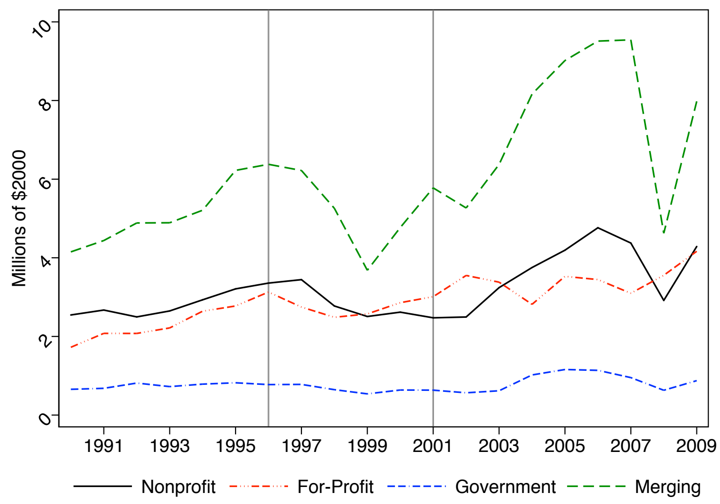

Figure 1.1: Annual Mean in Net Income, by Hospital Type

the trend of the nonprofit closely. However, net income rapidly increases in the post merger years.

Fig. 1.2 shows prices for hospitals of all three organizational forms as well as for merging hospitals. Prior to 2001 price per discharge was relatively steady, hovering around $4000. Transacting hospitals' prices quickly increase in the early part of the 2000s, reaching a new average price of roughly $5000 by the end of the decade. Non-merging hospitals also experience a price increase, however the change in trend is less severe when compared to merging hospitals. The task at hand is to identify how much more rapidly prices increased for merging hospitals due to the merger event.

Table 1.2 included mean market characteristics for the 55 markets in which a merger occurred. These merger markets are slightly smaller with 15 hospitals on average and hospitals that are 21.6 minutes apart. The HMO penetration level is slightly higher, the population under 65 without insurance is smaller, and the percentage of the market in poverty is 11.5%. All three of these statistics suggest that mergers occur in markets where a hospital is relatively less likely to take on bad debt in the form of, for example, uninsured patients or patients without means to pay. Finally, the HHI in markets with mergers is slightly smaller

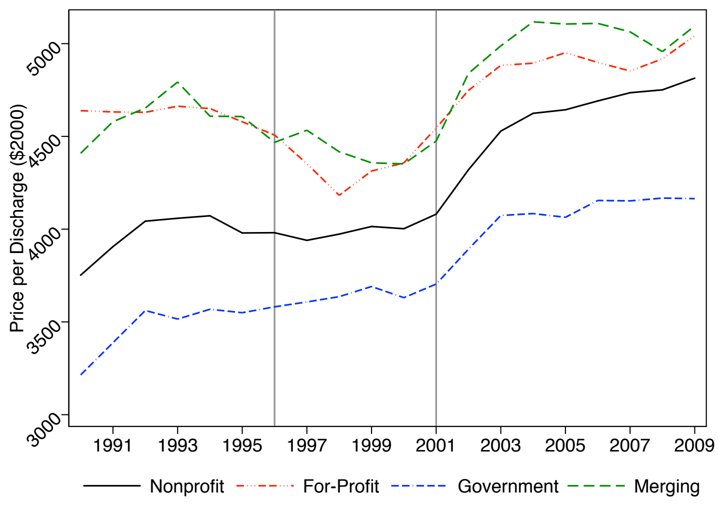

Figure 1.2: Annual mean in Price per Discharge, by Hospital Type

at 2,230.

Finally, within each transaction the Irving Levin data identifies both the target and acquirer, and Table 1.5 reports these mean facility level characteristics separately. Acquiring hospitals are much larger, with 262 beds and 1,300 FTEs, and produces 11,500 discharges with the smallest share of Medicare/Medicaid discharges, 37%. Moreover, they earn a net income of $7.7 million, approximately $667 per discharge, whereas target hospitals are less successful with a net income of $2.7 million or $349 per discharge. In all, this could reflect an imbalance in managerial ability between two merging parties.

1.5 Methodology–Two Stage Model

I estimate the effect of a hospital merger on two outcomes likely to be related to market power: price and net income. Let $M_{is} = 1$ if hospital i participated in a merger at date s and $M_{is} = 0$ otherwise. Price is $p_{it}(M_{is})$, and net income is $\pi_{it}(M_{is})$ for hospital i in period t. I generically refer to these outcomes as $y_{it}(M_{is})$. The effect of a merger on merged hospital outcomes, otherwise known as the average effect of the treatment on the treated (ATT), is

Table 1.5: Comparing Target and Acquiring Mean Hospital Characteristics

	Target	Acquirer
# of Hospitals	131	114
Inputs		
Labor	668	1,298
Beds	173	262
Discharges	6,225	11,509
Medicare Discharges	2,398	3,892
Medicare Discharge Share	0.43	0.37
Case Mix Index	1.30	1.44
Finances		
Thousands of $2000		
Revenue	$119,843	$268,620
Cost	$58,106	$120,358
Profit	$61,082	$129,002
Net Income	$2,171	$7,686
Other		
Liability to Asset	0.54	0.50
Urban	0.78	0.91
Total Driving Time (mins)	13.58	15.67
Teaching	0.38	0.63

given by

$$\mathbb{E}\left(y_{it}(1)\,|M_{is}=1\right)-\mathbb{E}\left(y_{it}(0)\,|M_{is}=1\right) \tag{1.1}$$

Because only $\left(y_{it}(0)\,|M_{is}=0\right)$ is observable, the estimates of the ATT will be biased if outcomes vary systematically for hospitals that do and do not merge. For example, a financial distressed hospital may be more likely to merge but, given financial distress, is also more likely to have lower future profit than would be expected given observable characteristics, leading to a downward bias in estimated merger effects.

I address this potential bias using a two-stage estimation strategy. In the first stage, I use observable determinants of a hospital's decision to participate in a merger to construct a propensity score. This allows me to create a good counterfactual comparison group from among the non-merging hospitals by reweighting all non-merging hospitals in the second stage according to their estimated propensity score. Propensity score reweighting ensures that the distribution of observable merger characteristics is the same for hospitals that do and do not merge. By implementing this reweighting strategy in combination with an event study specification, I estimate a treatment effect that can vary flexibly over time. This allows me to identify the short-run and long-run effects of these mergers on price per discharge and net income, controlling for endogeneity in the form of selection on observable characteristics.

1.5.1 Stage One: Determinants of Merger

The first stage analysis is conducted at the facility level for approximately 4,100 facilities that entered the panel before 1995. I model the probability that a hospital participated in a merger as a function of both facility-level and market-level variables. Included variables should simultaneously influence the outcome (price, net income) and the probability of merging and must be unaffected by the merger. For this reason, all time-varying determinants of participation are measured in 1994 for non-merging hospitals or two years before a merger occurred for merging hospitals.[18] The propensity score is a logit estimation including the

[18] A thorough discussion of propensity score matching can be found in Caliendo and Kopeinig (2002)

following variables:

- *Measures of Hospital Size.* Larger hospitals have more market power, traditionally leading to higher prices and increased profits. A comparison of several measures of hospital size for merging and non-merging hospitals is available in Table 1.4, showing that merging hospitals are larger than non-merging hospitals. To this end, I include the total number of discharges as a measure of absolute size and the hospital share of total market beds as a measure of relative market size or market power.

- *Influence of Medicare Share.* The merger wave of the 1990s is thought to be linked to the introduction of the prospective payment system in the late 1980s that reduced Medicare and Medicaid reimbursement rates. Medicare discharges are not typically high-margin, and more importantly, hospitals are unable to negotiate these reimbursement rates. A hospital with a high share of Medicare discharges may be less able to translate higher market power into higher prices and profits. Table 1.4 demonstrates that merging hospitals have a smaller Medicare share.

- *Insurer Market Power.* In the health care industry, private prices are negotiated between insurers and providers. The market penetration rate of private insurers affect a hospital's bargaining power in setting reimbursement rates. Insurer market power is captured by including the Medicare Advantage HMO penetration rate within a given market.

- *Uninsured Population.* Hospitals in markets with a relatively high concentration of uninsured patients may be likely to incur bad debt in the form of unpaid medical bills. Moreover, uninsured patients seeking hospital care are likely to be sicker than insured hospital patients, increasing the cost of their treatment. Taken together, hospitals in these markets may be more financially distressed and less able to recover losses, so merging will be a less attractive option.

- *Urban vs. Rural.* Rural markets are more likely to be served by a few community hospitals operated by the government and established to serve the needs of an underserved, low-income community. These markets do not provide the typical competitive environment and present fewer opportunities for market-power exploitation. From Table 8, merging hospitals are overwhelmingly classified as urban hospitals.

- *Travel Time to the Closest Hospital.* Consumption of hospital care is primarily driven by the proximity of a hospital to its patients, so hospitals that are closer together will compete more intensely. A hospital that is located in a more densely occupied area will see greater returns to increased market power than will a more isolated hospital. (See Dafny (2009)) As a measure of distance and density, I include the driving time in minutes from a hospital to its closest neighbor.

Rosenbaum and Rubin (1983) suggest the use of a balancing test in determining the propensity score specification for a given set of observable characteristics. This tests a necessary assumption for successful propensity score matching: that, conditional on the estimated propensity score, the distribution of observable characteristics is independent of the treatment assignment. The intuition is that after conditioning on the propensity score, the merger event has no predictive power for the observable characteristics after having controlled for the propensity score.[19] Evidence of the balance is shown in Table A.1, and this specification can be seen in column (1) of Table 1.6. I employ the same propensity score specification in all second stage analyses.[20]

[19] In particular, I regress each covariate included in the base specification of the propensity score on the estimated propensity score in the following way, where M is a dummy variable indicating whether or not a hospital experienced a merger.

$$X_k = \beta_0 + \beta_1 \hat{\rho}(X) + \beta_2 \hat{\rho}(X)^2 + \beta_3 \hat{\rho}(X)^3 + \beta_4 M \hat{\rho}(X) + \beta_5 M \hat{\rho}(X)^2 + \beta_6 M \hat{\rho}(X)^3 + \eta$$

Balance has been achieved if the estimated coefficients on all interaction terms $(\hat{\beta}_4, \hat{\beta}_5, \hat{\beta}_6)$ equal zero. This indicates that the covariates are independent of the treatment once the propensity score has been included. See Smith and Todd (2005) for a discussion of other standard balancing tests.

[20] Any observable characteristics that affect price will likewise affect net income and the merger probability. This suggests that the set of potential variables is the same for all outcome variables.

Table 1.6: Propensity Score Logit Estimation

	General, Short-Term Hospitals Full Sample (1)	**NonProfit Hospital Subsample (2)**
Total Time	-4.95E-04*	4.89E-07*
	(2.74E-04)	(2.86E-07)
Total Time^2	4.99E-07*	
	(2.55E-07)	
Total Time x HHI		-3.86E-07*
		(2.28E-07)
Discharges	1.01E-03*	4.65E-03**
	(5.54E-04)	(2.14E-03)
Discharges^2		-5.70E-05
		(4.73E-05)
FP x Discharges	-0.0051**	
	(0.002)	
Medicare Discharges Share	0.0005*	0.0007
	(0.0003)	(0.0005)
HMO Penetration	-7.75E-04***	-8.99E-04**
	(2.83E-04)	(4.28E-04)
Under 65, No Insurance	-0.002**	-0.001
	(0.001)	(0.001)
Urban	0.060***	-0.074
	(0.014)	(0.054)
Urban x Case Mix Index		0.113***
		(0.029)
Case Mix Index	0.102***	
	(0.02)	
Market Sare		-1.84E-03*
		(9.93E-04)
HHI		1.78E-05*
		(1.02E-05)
Market Share x HHI	-1.21E-07	
	(8.88E-08)	
Government	-0.0124***	
	(0.003)	

Standard Errors in Parenthesis
Market Share is measured by a hospital's % share of market beds

1.5.2 Stage Two: Event Study Estimates of Merger Effects

Given the descriptive statistics in Table 1.4, there is evidence that merging hospitals are statistically significant different in terms of many observable characteristics from non-merging hospitals. In this second stage, I control for selection based on these observable characteristics by reweighting "control" hospitals, or non-merging hospitals, based on their estimated propensity to merge. Reweighting ensures that the distribution of observable characteristics is the same for hospitals that do and do not merge.[21] In addition to reweighting, I control for time-invariant unobservable hospital-specific characteristics that may affect the decision to merge by estimating a fixed effects model. Finally, I control for any temporal variation that is common to all hospitals, including aggregate macroeconomic and inflationary trends, by including year fixed effects in the regression model.

Implementation of a reweighted second stage estimation to control for selection on observables requires the assumption of *unconfoundedness*, or that the set of observable characteristics, X, are independent of the treatment assignment. A balanced propensity score estimation, as was previously described, supports this assumption. Rosenbaum and Rubin (1983) show that if the assumption of unconfoundedness holds conditional on covariates X, then unconfoundedness also holds conditional on a propensity score, $\rho\left(M = 1|X\right)$, and conditioning on a propensity score addresses the problem of high dimension X vectors. The second requirement for matching is the assumption of "common support", ruling out the phenomenon of perfect predictability of M given X. In Fig. A.1 I provide a kernel density plot of the propensity score estimation for merging and non merging hospitals. That there is not substantial divergence between the two populations demonstrates the validity of the common support assumption.

With this, I create a control group against which to compare merged hospitals, and the difference between these groups identifies the average treatment effect of a merger on merged

[21] If hospital i has estimated propensity score $\hat{\rho}_i$ in stage 1, then in stage 2 hospital i is reweighed by $\frac{\hat{\rho}_i}{1-\hat{\rho}_i}$. Merging hospitals are unweighted. See, for example, DiNardo et al. (1996)

hospitals. Ultimately, I implement the reweighting methodology first developed by DiNardo et al. (1996). However, it is important to note that any systematic differences between merging and non-merging hospitals that are related to unobserved characteristics are not explicitly accounted for except through time-invariant hospital level fixed effects so may still bias my estimates. I follow Hirano et al. (2003) in bootstrapping the standard errors of the estimated coefficients.

Second Stage Full Model Specification. I pool information on all hospital mergers that occurred between 1996 and 2001 by introducing a series of dummy variables identifying the number of years before or after a merger, as in Jacobson et al. (1993). Let $m_{it}^{k} = 1$ if hospital i experienced a merger k periods ago, and let M_{it}^{j} if a hospital i will experience a merger j years in the future. Similarly, $M_{it}^{\mathrm{VLR}} = 1$ is a dummy variable identifying a period nine or more years before a merger, the "very long run," and m_{it}^{5+} is a dummy variable identifying a period 5 or more years before a merger. The excluded dummy identifies the year in which the merger occurred, so merger effects are measured relative to the merger year. Taken together, these dummy variables identify all years surrounding a merger in the panel data. By pooling all hospital mergers in this way, I assume that a hospital participating in a merger in 1997 was in the same position in 2000 as a hospital merging in 1999 was in 2002.

The base specification is as follows:

$$y_{it} = \alpha_i + \tau_t + \beta X_{it} + \delta_{5+} m_{it}^{5+} + \sum_{k=1}^{4} \delta_k m_{it}^{k} + \sum_{j=1}^{8} \Delta_j M_{it}^{j} + \Delta_{\mathrm{VLR}} M_{it}^{\mathrm{VLR}} + \nu_{it} \tag{1.2}$$

Here, the δ_j and Δ_k identify the effect of a merger on the outcome variable of interest, either price or net income. The vector X_{it} consists of those time-varying facility and market characteristics that were included in the propensity score estimation: the total number of discharges, the Medicare share of discharges, the share of market hospital beds, the HHI, and the for-profit HHI. I include year fixed effects, τ_t, to control for the general time pattern of the outcome variable in the economy including inflationary trends. Finally, the model is estimated using hospital fixed-effects to summarize the impact of time-invariant differences among hospitals and is estimated by reweighted ordinary least squares. The standard errors of each of the coefficients of the model are clustered at the hospital level and are estimated by a bootstrap simulation with 500 replications.

Second Stage Condensed Model Specification. Based on the results of the Full Model Specification, I estimate a model with condensed merger effect dummy variables. In particular, the condensed model combines merger effect dummies for the short run, defined as one to four years, the long run, defined as five to eight years, and the very long run.

$$y_{it} = \alpha_i + \tau_t + \beta X_{it} + \delta_{5+} m_{it}^{5+} + \delta_{\mathrm{SR}} m^{\mathrm{SR}} + \Delta_{\mathrm{SR}} M^{\mathrm{SR}} + \Delta_{\mathrm{LR}} M^{\mathrm{LR}} + \Delta_{\mathrm{VLR}} M_{it}^{\mathrm{VLR}} + \nu_{it} \quad (1.3)$$

Because my model includes hospital fixed effects, I cannot separately identify marginal effects associated with time-invariant characteristics from the identification of α_i. Instead, I identify the marginal merger effect associated with time-invariant characteristics by interacting these with the merger effect dummy variables. However, the small sample size of merging hospitals does not provide enough statistical power for the identification of the full set of merger effect dummy variables in addition to interaction terms. For this reason, I rely on the added statistical power of the condensed model to estimate the marginal merger effects associated with several time-invariant characteristics: hospital organizational form, the transaction type, and differences between the target and acquiring hospital. After estimating this benchmark model, I interact the condensed merger effect dummy variables with dummy variables identifying these time-invariant characteristics..

For example, to estimate the marginal merger effect of the various organizational forms, I include interaction terms between the condensed merger dummy variables and a dummy variable identifying a for-profit hospital, F_i, or a government hospital, G_i, in the following way:

$$
\begin{aligned}
y_{it} \;=\; & \alpha_i + \tau_t + \beta X_{it} + \delta_{5+} m_{it}^{5+} + \delta_{\mathrm{SR}} m^{\mathrm{SR}} + \Delta_{\mathrm{SR}} M^{\mathrm{SR}} + \Delta_{\mathrm{LR}} M^{\mathrm{LR}} + \Delta_{\mathrm{VLR}} M_{it}^{\mathrm{VLR}} \\
& + \gamma_{5+} m_{it}^{5+} F_i + \gamma_{\mathrm{SR}} m^{\mathrm{SR}} F_i + \Gamma_{\mathrm{SR}} M^{\mathrm{SR}} F_i + \Gamma_{\mathrm{LR}} M^{\mathrm{LR}} F_i + \Gamma_{\mathrm{VLR}} M_{it}^{\mathrm{VLR}} F_i \\
& + \theta_{5+} m_{it}^{5+} G_i + \theta_{\mathrm{SR}} m^{\mathrm{SR}} G_i + \Theta_{\mathrm{SR}} M^{\mathrm{SR}} G_i + \Theta_{\mathrm{LR}} M^{\mathrm{LR}} G_i + \Theta_{\mathrm{VLR}} M_{it}^{\mathrm{VLR}} G_i + \nu_{it} \quad (1.4)
\end{aligned}
$$

The coefficients on the un-interacted merger effect dummy variables ($\delta_{5+}, \delta_{SR}, \Delta_{SR}, \Delta_{LR}, \Delta_{9+}$) identify the merger effect specific to non-profit hospitals, and the coefficients on the interacted merger dummy variables ($\gamma_{5+}, \gamma_{SR}, \Gamma_{SR}, \Gamma_{LR}, \Gamma_{9+}, \theta_{5+}, \theta_{SR}, \Theta_{SR}, \Theta_{LR}, \Theta_{9+}$) identify the marginal merger effect of for-profit and government hospitals relative to the merger effect for nonprofit hospitals.

Similarly, to estimate the marginal merger effect of transaction type, I include interaction terms between the condensed merger effect dummy variables and a dummy variable indicating transactions involving exactly one nonprofit hospital.[22] The coefficient on the un-interacted merger effect dummy variables identify the merger effects specific to "homogenous" mergers involving two nonprofit hospitals, and the interacted merger effect dummy variables identify the marginal merger effect of involvement in a "heterogeneous" merger relative to a homogenous merger.

Finally, to separate the merger effects between target and acquiring hospitals, I include interaction terms between the condensed merger effect dummy variables and a dummy variable identifying the target hospital. The coefficients on the un-interacted merger effect dummy variables identify merger effects specific to the acquiring hospital, and the coefficient on the interacted merger dummy variable identifies the marginal merger effect of the target hospital relative to the acquiring hospital.

A word of caution must be expressed regarding the sample size of the previously mentioned interaction models. In particular, only 10% of merging hospitals are for-profit and

[22] In this estimation, I do not include those hospitals that participate in a transaction in which neither party is nonprofit because the sample size of hospitals involved in these transactions is small: 14 out of the 225 hospitals with an identifiable transaction type.

10% are government hospitals. Moreover, 67% of transactions observed involve two nonprofit hospitals and 26% involve exactly one nonprofit. Given these small sample sizes, I expect large standard errors to be associated with the marginal merger effects coefficients. However, by adding these interaction terms, I expect to isolate the merger effect specific to nonprofit hospitals, specific to homogenous nonprofit mergers, and specific to acquiring hospitals through the un-interacted merger effect dummies in each of these models.

1.6 Results

1.6.1 Propensity Score Estimation

Results of the first stage propensity score estimation can be seen in Table 1.6. All estimates are reported at the mean of the independent variables. In order to ensure that the propensity score is balanced, I have included several squared and interacted terms in the specification. The main sample results are displayed in column (1).

Distance to a particular provider is well understood to be a primary driver of demand for health care. If hospitals that are closer together compete more intensely, the increased market power likely to result from a merger will be more meaningful amongst the closest hospitals. To this point, Table 1.4 demonstrates that merging hospitals are approximately 11 minutes closer to their neighbors than are non-merging hospitals. This is reflected in the propensity score results: a greater driving time between a hospital and its nearest neighbor decreases the likelihood of participating in a merger.[23]

Hospital size is controlled for through the total number of discharges and through the interaction of a hospital's own market share and the market HHI. We have already seen that merging hospitals are larger, and indeed the total discharge measure enters into the propensity score with a positive and statistically significant sign.

Because the merger wave is thought to be driven by the fiscally fragile hospital's response

[23] That distance enters negatively into the propensity score estimation mirrors the results seen in Dranove and Lindrooth (2003)

to the introduction of the PPS, I have included the Medicare/Medicaid share of hospital discharges. The PPS controls reimbursement rates for Medicare and Medicaid patients, so its introduction should have been more significant for those hospitals with a high Medicare share of discharges. To this end, hospitals with a higher share of Medicare/Medicaid discharges will be more likely to merge. The positive and statistically significant sign on the Medicare share of discharges is consistent with this hypothesis.

More generally, the propensity score estimates conform to the relationships suggested by the mean comparisons seen in Table 1.2 and Table 1.4. For example, merging hospitals are overwhelmingly likely to be urban facilities, and the propensity score estimate of the urban indicator reflects this. Table 1.4 showed that merging hospitals had a higher average CMI of 1.36 than non-merging hospitals, and the propensity score estimates for the CMI confirm this relationship.

1.6.2 Estimated Merger Effect on Price

1.6.2.1 Full and Condensed Specification

The fully specified model identifies the merger effect on price separately for each of the years surrounding the merger. The condensed model differs from the full model through the specification of the merger effect dummies. In particular, the condensed model collapses the years surrounding the merger into the short run (one to four years before or after a merger), the long run (five to eight years after a merger), and the very long run (nine or more years after a merger has occurred). The results of both models are shown in Table 1.7. In addition, the results from the full model are displayed in Fig. 1.3. All prices are measured relative to the left out merger event dummy, the year in which the merger occurred.

In the years preceding a merger, prices are \$150 to \$290 higher per discharge when compared to the year in which the merger occurred. The full model reveals stead decrease in price per discharge of \$270 in the three years immediately preceding a merger. Falling prices may be indicative of the financial distress merging hospitals purported to experience

Table 1.7: Estimated Merger Effect on Price

Pre-Merger Years

	≥ 5 Years	4 Years	3 Years	2 Years	1 Year
Full Model	242.46 **	167.90 *	290.40 *	149.98 *	19.24
	(114.41)	(95.26)	(102.73)	(84.70)	(70.23)
	≥ 5 Years	**1 - 4 Years**			
Condensed Model	221.56 *	144.84 *			
	(115.44)	(80.77)			

Post Merger Years

	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	≥ 9 Years
Full Model	103.24	38.82	151.05	52.51	125.39	261.79 *	258.32 *	298.99 *	401.22 **
	(89.40)	(114.58)	(127.12)	(128.10)	(155.48)	(146.64)	(150.33)	(159.78)	(178.70)
	1 - 4 Years				**5 - 8 Years**				**≥ 9 Years**
Condensed Model	83.35				229.36 *				371.46 **
	(94.49)				(134.60)				(175.45)

Facility-Level Characteristics

	Discharges	Medicare Share	Market Power	HHI	For-Profit HHI	MktPower x HHI	Constant
Full Model	0.08	94.22 **	20.76	-0.17	-0.18	-0.004	624.45 *
	(20.48)	(5.64)	(19.66)	(0.10)	(0.11)	(0.004)	(328.48)
	Discharges	**Medicare Share**	**Market Power**	**HHI**	**For-Profit HHI**	**MktPower x HHI**	**Constant**
Condensed Model	0.08	94.41 **	20.63	-0.17 *	-0.17 *	-0.003	601.44 *
	(20.69)	(5.50)	(20.51)	(0.10)	(0.10)	(0.004)	(330.28)

# of Hospitals: 4,075 # of observations: 68,388

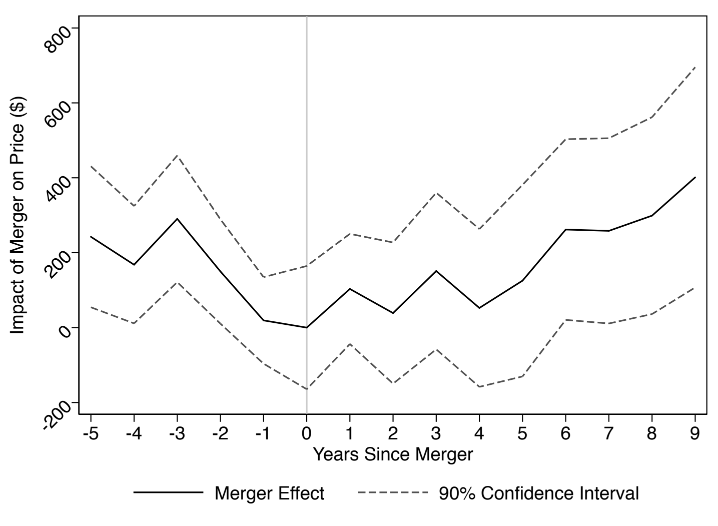

Figure 1.3: Estimated Merger Effect on Price

as a result of the introduction of the PPS.

In the short run immediately following a merger, the average price per discharge is slow to recover, and the merger effects are quite noisy. Merging hospitals experiencing an average increase of only \$83 per discharge in the first four years following a merger, and the condensed model masks the erratic behavior of price effects bouncing between an average increase of \$38 to \$151 per discharge in a non-monotonic fashion.

In the long run, the merger effect stabilizes. Six years after a merger, the average price per discharge increases by \$261 per discharge relative to the year in which the merger occurred, and this increase is statistically significant at the 10% level. The average increase in the long run is \$229 per discharge, and this effect becomes even more pronounced in the very long run with prices as much as \$400 higher per discharge. Given that the average price per discharge in the year 2000 was \$3,700, this represents a more than 10% increase in the average price per discharge. Because this model is estimated with year fixed effects identified by all hospitals, this increase in price is then a real increase.

My model specification captures the effect of several facility and market characteristics on the average hospital price per discharge. There is a clear consistency in these estimates between the full and condensed model. Many of the inputs that are just barely statistically insignificant at the 10% level in the full model become statistically significant in the condensed model, highlighting the increase in power of the condensed model.

The included facility and market characteristics control for various measures of hospital size, market power, competition, and potential financial distress. Interestingly, the Medicare share of discharges is highly statistically significant; a one percent increase in the share of Medicare discharges leads to a \$94 increase in the average price per privately insured/uninsured discharge. Hospitals with a high share of Medicare patients may recoup associated losses from these patients by charging a higher price to their privately insured or uninsured patients. The for-profit market concentration, measured by summing the market share of the for-profit hospitals in a given market, captures the effect of competing against

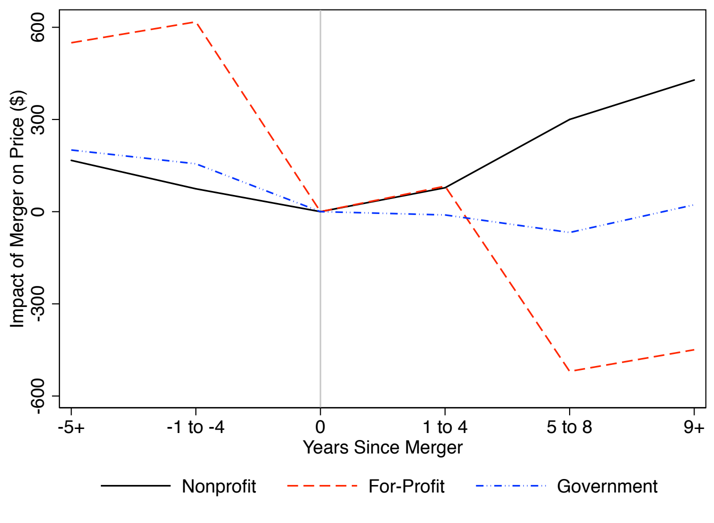

Figure 1.4: Estimated Merger Effect on Price, by Hospital Type

for-profit hospitals. Recall from Table 1.2 that there are very few for-profit hospitals in any given HHR with an average for-profit only HHI of only 116. If the level of for-profit competition in the market increases by one standard deviation, the average price per discharge to decreases by only $57.

1.6.2.2 Condensed Model with Interactions

I estimate several forms of the condensed model in order to isolate the nonprofit merger effect. To begin, I estimate a condensed model including organizational form interaction terms, isolating nonprofit hospitals from for-profit and government hospitals. Next, I include a transaction interaction to isolate nonprofit hospitals merging with nonprofit hospitals. Finally, I consider the differing merger effect for target and acquiring hospitals.

Panel A of Table 1.8 presents the results of the organizational model, where the merger effect for nonprofit hospital price is identified by the coefficient on the merger dummy variables. The sample of for-profit and government merging hospitals is small, so I expect noisy estimates of the marginal merger effect for these hospital types.[24] For a merging nonprofit

[24]Out of 248 merging hospitals, 26 are for-profit (10%) and 25 are government hospitals (10%)

Table 1.8: Estimated Merger Effect on Price, Interacted Models

Panel A

\# of Hospitals: 4,075 # of observations: 68,388

Nonprofit Merger Effect

≥ 5 yrs Before	**1 - 4 yrs Before**	**1 - 4 yrs After**	**5 - 8 yrs After**	**≥ 9 yrs After**
166.87	74.41	77.80	300.15**	428.45**
(119.84)	(84.08)	(88.31)	(133.05)	(175.34)

For-Profit Marginal Merger Effect

≥ 5 yrs Before	**1 - 4 yrs Before**	**1 - 4 yrs After**	**5 - 8 yrs After**	**≥ 9 yrs After**
382.79	543.33	5.19	-819.89*	-877.94**
(485.86)	(336.07)	(445.15)	(468.80)	(415.96)

Government Marginal Merger Effect

≥ 5 yrs Before	**1 - 4 yrs Before**	**1 - 4 yrs After**	**5 - 8 yrs After**	**≥ 9 yrs After**
33.80	81.31	-88.52	-367.93	-406.12
(352.33)	(256.23)	(334.59)	(528.84)	(787.40)

Panel B

\# of Hospitals: 4,075 # of observations: 68,158

Homogeneous Merger Effect (NP+NP)

≥ 5 yrs Before	**1 - 4 yrs Before**	**1 - 4 yrs After**	**5 - 8 yrs After**	**≥ 9 yrs After**
72.81	30.65	21.62	161.21	346.41*
(122.06)	(91.63)	(97.13)	(137.27)	(186.22)

Heterogeneous Marginal Merger Effect (NP + ?)

≥ 5 yrs Before	**1 - 4 yrs Before**	**1 - 4 yrs After**	**5 - 8 yrs After**	**≥ 9 yrs After**
513.02*	429.63*	168.10	334.80	103.63
(285.78)	(228.18)	(243.44)	(377.31)	(495.56)

Panel C

\# of Hospitals: 4,075 # of observations: 68,388

Acquiring Merger Effect

≥ 5 yrs Before	**1 - 4 yrs Before**	**1 - 4 yrs After**	**5 - 8 yrs After**	**≥ 9 yrs After**
266.38*	179.21**	118.44	337.45**	675.52***
(147.27)	(91.09)	(93.31)	(155.93)	(199.97)

Target Marginal Merger Effect

≥ 5 yrs Before	**1 - 4 yrs Before**	**1 - 4 yrs After**	**5 - 8 yrs After**	**≥ 9 yrs After**
-76.45	-62.70	-65.99	-234.90	-678.43**
(211.25)	(146.53)	(191.80)	(276.74)	(331.67)

hospital, the average hospital price per discharge increases by \$300 in the long run and by \$428 in the very long run. These effects are slightly higher than the effect on all merging hospitals seen in Table 1.7. The merger effect for both for-profit and government hospitals is much smaller than for nonprofit hospitals. In fact, the average for-profit merging hospital charges prices that are \$800 lower than a nonprofit merging hospital in the long run and the very long run. Fig. 1.4 displays the estimated merger effects for all three hospital ownership types. Here it can be seen that the nonprofit merger effect is the largest in the long run after a merger for a nonprofit hospital.

A theoretical model of mergers between hospitals of two different ownership types suggests that the magnitude of the merger effect differs depending on which firms are involved in the transaction.[25] To test this hypothesis, I estimate a version of the condensed model that includes a dummy identifying a hospital that participated in a heterogeneous merger, shown in Panel B of Table 1.8. The coefficient on the merger effect dummies identify the merger effect for homogenous mergers involving two nonprofit hospitals.

For two merging nonprofit hospitals, the effect of the merger is to increase prices by \$161 in the long run and by \$346 in the very long run, a statistically significant result at the 6% level. In comparison, the merger effect for hospitals involved in a heterogeneous merger is larger, \$495 in the long run and \$450 in the very long run, although the marginal merger effect is not statistically significant at traditional levels. However, the lack of statistical significance may be due to the small sample of heterogeneous mergers: 59 observations, or roughly 26% of all observations. Despite this, it is clear that mergers between two nonprofit hospitals result in higher prices in the long run after a merger occurs.

Finally, when comparing inputs of the target and acquiring hospital, Table 1.5 shows that acquiring hospitals were larger along all measures of size. Given this, the merger effect on the price per discharge might be different for target versus acquiring hospitals. I explore this by estimating a condensed model including an interaction term identifying the target hospital

[25] See Chapter 2, "A Theoretical Analysis of Mergers between Nonprofit and For-Profit Firms: an Application in the Hospital Industry"

in a merger. The results are presented in Panel C of Table 1.8, where the un-interacted merger effect dummies then identify the merger effect for the acquiring hospital.

For the acquiring hospital, the merger effect in the years surrounding the merger mimics and amplifies the effects identified in Table 1.7. In the long run the price per discharge at the acquiring hospital is \$337 higher and in the very long the price is \$675 higher. The average acquiring hospital is quite successful at reversing declining price trends by participating in a merger, whereas the effect for target hospital prices is less pronounced. The merger effect for the target hospital is universally smaller, although not statistically different from that of the acquiring hospital until the very long run. Taken together, these results suggest that there is an imbalance of ability between the target and acquiring hospital to raise prices post consolidation.

1.6.3 Estimated Merger Effect on Net Income

1.6.3.1 Full and Condensed Model

The full model identifies the effect of a merger on net income separately for each of the years surrounding the merger. The condensed model differs from the full model through the specification of the merger effect dummies. In particular, the condensed model collapses the years surrounding the merger into the short run (one to four years before or after a merger), the long run (five to eight years after a merger), and the very long run (nine or more years after a merger has occurred). The results of both models are shown in Table 1.9. In addition, the results from the full model are displayed in Fig. 1.5. All prices are measured relative to the left out merger event dummy, the year in which the merger occurred.

Recall that prices on average are falling for several years preceding a merger. In contrast, net income is relatively stable, hovering around \$1.4 million until the few years immediately preceding a merger. For example, two years before a merger, net income is \$1.56 million more than the year in which a merger occurred. However, net income decreased by \$0.5 million in the year before a merger, and by the time the merger occurs net income decreases

Table 1.9: Estimated Merger Effect on Net Income

Pre-Merger Years

	≥ 5 Years	4 Years	3 Years	2 Years	1 Year
Full Model	1.47 **	1.18 **	1.64 ***	1.56 **	0.97 **
	(0.60)	(0.57)	(0.62)	(0.61)	(0.49)

	≥ 5 Years	1 - 4 Years
Condensed Model	1.42 **	1.31 ***
	(0.58)	(0.47)

Post Merger Years

	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	≥ 9 Years
Full Model	0.66	0.31	1.77 **	1.30	1.61	2.16 *	2.85 **	1.29	2.46 **
	(0.53)	(0.71)	(0.87)	(0.96)	(1.02)	(1.14)	(1.13)	(1.17)	(1.12)

	1 - 4 Years	5 - 8 Years	≥ 9 Years
Condensed Model	0.95	1.88 **	2.40 **
	(0.61)	(0.88)	(1.09)

Facility-Level Characteristics

	Discharges	Medicare Share	Market Power	Case Mix Index	HHI	For-Profit HHI	MktPower x HHI	Constant
Full Model	0.004	0.03	0.47 ***	4.40 ***	-0.0009 **	0.0004	-0.00003	-6.02 *
	(0.238)	(0.03)	(0.18)	(1.54)	(0.0004)	(0.0008)	(0.00002)	(3.21)
Condensed Model	0.004	0.03	0.47 ***	4.44 ***	-0.0009 **	0.0004	-0.00003	-6.01 *
	(0.239)	(0.03)	(0.18)	(1.54)	(0.0004)	(0.0008)	(0.00002)	(3.22)

# of Hospitals: 4,108 # of observations: 69,292

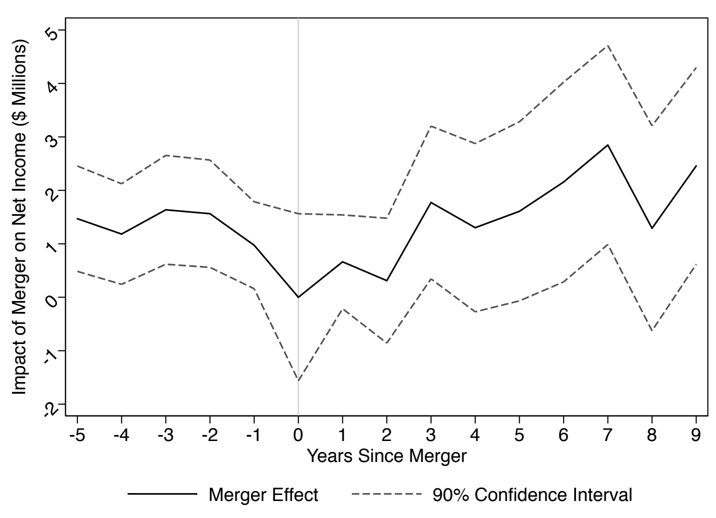

Figure 1.5: Estimated Merger Effect on Net Income

by an additional \$1 million. Table 1.1 showed that net income is approximately \$2.6 million for an average hospital. A decrease of \$1.5 million over the course of two years represents a 50% loss in net income. This is consistent with the hypothesis that merging hospitals in the 1990s were financially distressed hospitals.

As with price, net income is slow to recover in the first few post-merger years. In contrast to the volatile short run prices, the short run merger effect gradually increases net income in a more monotonic fashion. In the first four years after a merger net income does not recover from the \$1.5 million loss, increasing only an average of \$0.95 million. However, as the hospital adjusts to the increased market power in the long run, it more than recovers net income lost during the premerger years. Six years after a merger net income has increased by \$2.16 million, and seven years after a merger net income has increased by another \$0.7 million.[26] The full model reveals that in the long run and the very long run net income is more than \$2.4 million higher than the year in which the merger occurred. Then the merger nearly doubles the net income of the average hospital. If hospitals are merging as a strategy to combat quickly declining net income, whether due to the introduction of PPS or for other reasons, these estimates provide evidence that hospitals are successful.

When one considers the relationship between facility and market characteristics and net income, a different pattern emerges than that which was seen with the price models. Where the Medicare share of discharges had a highly statistically significant effect in the price regression, measures of market power have highly statistically significant effects in the net income regressions. The facility share of beds in a market is a proxy for own-hospital market power, and estimates reveal that a 1% increase in bed share leads to a \$0.5 million increase in net income. However, the overall level of concentration in the market, measured by the HHI, enters negatively into the net income equation. Unlike the price model, where the CMI was embedded in the formulation in price, with the net income model I have explicitly include

[26]There is a decrease in the merger effect in year eight, however this is likely to be driven by the anomalous decrease in average net income seen in Fig. 1.1 in 2008. Moreover, this outlier is almost certainly driving down the estimate of the long run effect in the condensed model, estimated to be \$1.88 million.

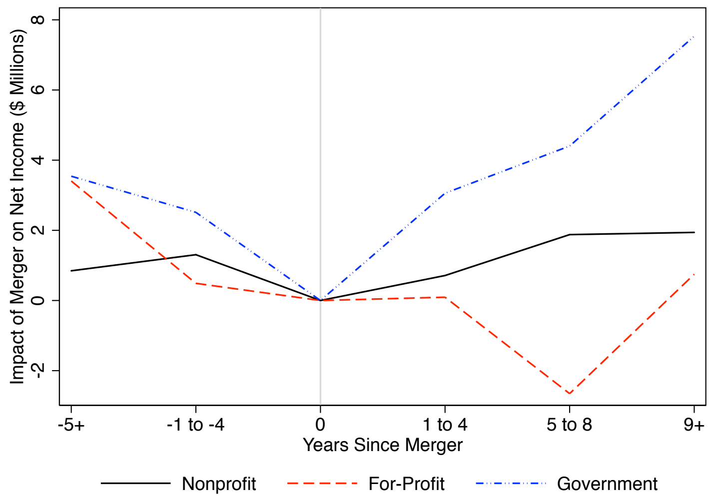

Figure 1.6: Estimated Merger Effect on Net Income, by Hospital Type

the CMI as an independent variable. Indeed, the CMI coefficient is positive and highly statistically significant. This is consistent with the notion that the treatment of severe cases is associated with high profit margin procedures, for example cardiac care.

1.6.3.2 Condensed Model with Interactions

As with the price effects model, I estimate several forms of the condensed model with interactions to separate the merger effects for certain groups of hospitals. In particular, I analyze the net income merger effect separately for nonprofit hospitals, for nonprofit hospitals merging with nonprofit hospitals, and for acquiring versus target hospitals. Generally, I expect noisy estimates of the interacted merger dummy variables because of the small sample of for-profit and government merging hospitals

I isolate the merger effect on a nonprofit hospital's net income in Panel A of Table 1.10. The merger effect for nonprofit hospitals is identified by the un-interacted merger dummy variables, and the interacted merger dummy variables identify the marginal merger effect of a for-profit or a government ownership type. For nonprofit hospitals, a merger increases net income by $1.9 million in both the long run and the very long run. The average net income

Table 1.10: Estimated Merger Effect on Net Income, Interacted Models

Panel A

# of Hospitals: 4,108 # of observations: 69,292

Nonprofit Merger Effect

$\geq$ 5 yrs Before	1 - 4 yrs Before	1 - 4 yrs After	5 - 8 yrs After	$\geq$ 9 yrs After
0.85	1.31**	0.71	1.88*	1.94*
(0.67)	(0.55)	(0.64)	(0.99)	(1.18)

For-Profit Marginal Merger Effect

$\geq$ 5 yrs Before	1 - 4 yrs Before	1 - 4 yrs After	5 - 8 yrs After	$\geq$ 9 yrs After
2.56*	-0.82	-0.62	-4.53**	-1.19
(1.31)	(0.86)	(1.57)	(2.07)	(3.14)

Government Marginal Merger Effect

$\geq$ 5 yrs Before	1 - 4 yrs Before	1 - 4 yrs After	5 - 8 yrs After	$\geq$ 9 yrs After
2.70	1.21	2.35	2.53	5.59
(1.69)	(1.65)	(2.43)	(2.77)	(4.21)

Panel B

# of Hospitals: 4,108 # of observations: 69,058

Homogeneous Merger Effect (NP+NP)

$\geq$ 5 yrs Before	1 - 4 yrs Before	1 - 4 yrs After	5 - 8 yrs After	$\geq$ 9 yrs After
1.41**	1.62***	0.95	1.47	2.13*
(0.63)	(0.58)	(0.68)	(1.07)	(1.20)

Heterogeneous Marginal Merger Effect (NP + ?)

$\geq$ 5 yrs Before	1 - 4 yrs Before	1 - 4 yrs After	5 - 8 yrs After	$\geq$ 9 yrs After
-0.81	-1.62	-1.50	1.67	2.60
(1.33)	(1.33)	(0.99)	(1.26)	(2.03)

Panel C

# of Hospitals: 4,108 # of observations: 69,292

Acquiring Merger Effect

$\geq$ 5 yrs Before	1 - 4 yrs Before	1 - 4 yrs After	5 - 8 yrs After	$\geq$ 9 yrs After
0.40	1.54*	0.45	2.83*	2.87*
(1.01)	(0.81)	(1.05)	(1.47)	(1.64)

Target Marginal Merger Effect

$\geq$ 5 yrs Before	1 - 4 yrs Before	1 - 4 yrs After	5 - 8 yrs After	$\geq$ 9 yrs After
1.96*	-0.41	0.94	-2.15	-1.03
(1.19)	(0.96)	(1.17)	(1.71)	(2.03)

Standard Errors in Parenthesis

of a nonprofit hospital is $3.1 million, so this represents a 60 percent increase. Figure NI2 displays these results. The net income merger effects are consistent with the price merger effects seen in Fig. 1.6.

I test the hypothesis that the magnitude of the net income effect depends on which types of hospitals are involved in Panel B of Table 1.10. The un-interacted dummy variables identify the merger effect for homogenous mergers involving two nonprofit hospitals. In general, the net income effects parallels the effect on price previously described. Net income for a nonprofit hospital involved in a homogenous merger is $1.46 million higher in the long run and is $2.01 million higher in the very long run.[27] This provides evidence that prices increase in the post merger years for two merging nonprofit hospitals. I find the marginal merger effect for hospitals involved in heterogeneous mergers to be positive, and I attribute the statistical insignificance of these marginal effects to the relatively small sample size of observable heterogeneous mergers.

Finally, I explore how the merger effect differs between the target and acquiring hospital in Panel C of Table 1.10. The price effect model revealed dramatically different price effects for target and acquiring hospitals, and the results of the net income analysis are similar. The acquiring hospital in a merger raises net income by $2.8 million in the long run and the very long run. In comparison, the target hospital experiences a much smaller merger effect with net income increase only $0.5 million in the long run and $1.8 million in the very long run. In combination with the price analysis, this suggests that acquiring hospitals have more to gain in the merger than do target hospitals.

1.7 Sensitivity Analysis

To directly analyze the behavior of nonprofit firms, I estimate the merger effect for the subsample of nonprofit hospitals. This analysis differs from the estimation of the condensed model with hospital type interactions by limiting both merging and non-merging hospitals

[27] As with the price model, this increase is only statistically significant in the very long run.

Table 1.11: Estimated Merger Effect on Price, Robustness: Nonprofit Subsample

Pre-Merger Years

	≥ 5 Years	4 Years	3 Years	2 Years	1 Year
Full Model	234.70 **	164.60 *	290.49 ***	150.91 *	20.11
	(117.76)	(96.60)	(103.28)	(84.94)	(70.52)

	≥ 5 Years	1 - 4 Years
Condensed Model	108.68	35.79
	(118.99)	(77.95)

Post Merger Years

	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	≥ 9 Years
Full Model	98.34	32.87	147.38	50.83	124.30	260.32 *	255.54 *	293.84 *	392.27 **
	(89.74)	(115.71)	(128.18)	(130.75)	(157.89)	(150.08)	(154.43)	(164.40)	(184.58)

	1-4 Years After	5-8 Years After	≥ 9 Years
Condensed Model	40.71	250.96 **	362.15 *
	(83.92)	(123.53)	(184.99)

Facility-Level Characteristics

	Discharges	Medicare Share	Market Power	HHI	For-Profit HHI	MktPower x HHI	Constant
Full Model	0.14	95.15 **	20.43	-0.17	-0.20	-0.004	579.90 *
	(20.69)	(6.21)	(20.37)	(0.11)	(0.13)	(0.004)	(350.79)
Condensed Model	-37.17 ***	90.68 **	42.18 ***	-0.16	-0.19	-0.005	1,048.09 ***
	(9.25)	(5.50)	(14.33)	(0.11)	(0.14)	(0.003)	(294.59)

# of Hospitals: 2,429 # of observations: 41,840

to the nonprofit subsample. This allows me to analyze the sensitivity of the merger effect results to the inclusion of government and for-profit hospitals. The nonprofit subsample includes 2,429 nonprofit hospitals.

Column (2) of Table 1.6, Table 1.11 and Table 1.12 provide results of the nonprofit subsample analysis. The estimated merger effects on price from the nonprofit subsample are virtually identical to the full sample results. In the long run, a merger increases nonprofit prices by \$250 per discharge, and in the very long run, a merger increases hospital nonprofit prices by \$362 per discharge. The merger effect on nonprofit net income also provides qualitatively similar results to that of the full sample net income model particularly when compared to the condensed model with hospital type interactions (Panel A of Table 1.10). This provides further evidence that nonprofit hospitals raise price and increase profit after a consolidation.

Table 1.12: Estimated Merger Effect on Net Income, Robustness: Nonprofit Subsample

Pre-Merger Years

	≥ 5 Years	4 Years	3 Years	2 Years	1 Year
Full Model	1.15	1.34 *	1.56 **	1.65 **	0.77
	(0.77)	(0.70)	(0.72)	(0.69)	(0.51)

	≥ 5 Years	1 - 4 Years
Condensed Model	1.06 *	1.27 ***
	(0.58)	(0.47)

Post Merger Years

	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	≥ 9 Years
Full Model	0.62	-0.11	1.76 *	1.05	1.28	1.65	2.89 **	2.27	1.42
	(0.64)	(0.78)	(0.96)	(1.07)	(1.22)	(1.27)	(1.33)	(1.50)	(1.25)
	1 - 4 Years				5 - 8 Years				≥ 9 Years
Condensed Model	0.79				1.88 *				1.27
	(0.67)				(1.06)				(1.21)

Facility-Level Characteristics

	Discharges	Medicare Share	Market Power	Case Mix Index	HHI	For-Profit HHI	MktPower x HHI	Constant
Full Model	0.003	0.02	0.56 **	4.88 **	-0.001	0.001	-0.00004	-6.78 *
	(0.257)	(0.04)	(0.22)	(2.13)	(0.0006)	(0.0009)	(0.00003)	(4.09)
Condensed Model	0.003	0.02	0.56 **	4.88 **	-0.001	0.001	-0.00004	-6.78 *
	(0.257)	(0.04)	(0.22)	(2.13)	(0.0006)	(0.0009)	(0.00003)	(4.10)

# of Hospitals: 2,429 # of observations: 41,840

In addition, I consider an alternative set of merger dummy variables that identifies effects for up to 2 years before a merger occurred as opposed to the full panel of pre-merger years available in the data. A full panel of pre-merger year dummy variables allows for an exact interpretation of the constant, which is identified by the following left out group: hospitals that merged in the year that they merged and all non-merging hospitals in the year 2000. However, it is unlikely that a hospital anticipates an upcoming merger three years or more before the merger occurrs. For this reason, it is difficult to interpret the merger effects identified for these distant pre-merger years. Table 1.13 and Table 1.14 provide results of the merger analysis that includes a smaller set of pre-merger dummy variables. Again, these results are virtually identical to the full model results where the long run effect of a merger is to increase price by $216 per discharge and profit by $1.97 million, and the very long run effect of a merger is to increase price by $335 per discharge and profit by $2.57 million.

Finally, I test the sensitivity of my results to the existence of an unobserved variable that is correlated with the merger and outcome measures. To simulate this situation, I generate a random variable that is correlated with the decision to merge and outcome net of controls included in my analysis. Having generated this variable, I include it as a covariate in both stages of my estimation and ask the question, "How highly correlated must the unobserved variable be with outcomes in order to drive my results to insignificance?" Results are shown in Table A.2.

From this, it can be seen that the price merger effects are sensitive to the existence of unobserved variables whereas the net income merger effects are robust. A correlation of 0.07 for such an unobserved variable is enough to drive the very long-run merger price effect to insignificance. However, a correlation of 0.5 is needed to drive a test of joint-significance of all long-run net income merger effects to insignificance. These results suggest that it is unlikely that unobservable variables are driving my result.

The relative sensitivity of the price effects is likely due to the measurement error introduced by use of an aggregate per-discharge price metric. There is a great deal of price

Table 1.13: Estimated Merger Effect on Price, Robustness: Restricted Pre-Merging Year Effects

Pre-Merger Years

	2 Years	1 Year
Full Model	169.63 **	31.07
	(84.94)	(70.52)

	1 - 2 Years
Condensed Model	95.04
	(75.66)

Post Merger Years

	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	≥ 9 Years
Full Model	74.64	14.16	95.98	33.57	103.83	245.66 *	251.10 *	285.04 *	364.14 **
	(87.31)	(110.72)	(127.56)	(125.65)	(152.83)	(145.99)	(149.50)	(158.14)	(169.56)

	1 - 4 Years	5 - 8 Years	≥ 9 Years
Condensed Model	61.88	216.00	335.61 **
	(92.42)	(134.06)	(168.77)

Facility-Level Characteristics

	Discharges	Medicare Share	Market Power	HHI	For-Profit HHI	MktPower x HHI	Constant
Full Model	0.15	99.65 ***	9.25	-0.17 *	-0.13	-0.001	493.95 *
	(18.40)	(5.19)	(16.91)	(0.09)	(0.11)	(0.003)	(293.71)

	Discharges	Medicare Share	Market Power	HHI	For-Profit HHI	MktPower x HHI	Constant
Condensed Model	0.15	99.65 **	9.25	-0.17 **	-0.13	-0.001	493.95
	(18.83)	(5.16)	(17.62)	(0.08)	(0.11)	(0.003)	(300.85)

# of Hospitals: 4,075 # of observations: 67,009

Table 1.14: Estimated Merger Effect on Net Income, Robustness: Restricted Pre-Merging Years

Pre-Merger Years

	2 Years	1 Year
Full Model	1.62 ***	0.94 *
	(0.61)	(0.49)
	1 - 2 Years	
Condensed Model	1.26 ***	
	(0.49)	

Post Merger Years

	1 Year	2 Years	3 Years	4 Years	5 Years	6 Years	7 Years	8 Years	≥ 9 Years
Full Model	0.67	0.40	1.76 **	1.34	1.69	2.20 *	2.89 ***	1.52	2.65 **
	(0.54)	(0.73)	(0.86)	(0.95)	(1.03)	(1.12)	(1.12)	(1.16)	(1.09)
	1 - 4 Years				**5 - 8 Years**				**≥ 9 Years**
Condensed Model	0.98				1.97 **				2.57 **
	(0.61)				(0.88)				(1.06)

Facility-Level Characteristics

	Discharges	Medicare Share	Market Power	Case Mix Index	HHI	For-Profit HHI	MktPower x HHI	Constant
Full Model	0.003	0.02	0.42 **	3.70 **	-0.0009 **	-0.0003	-0.00002	-3.79
	(0.224)	(0.03)	(0.17)	(1.53)	(0.0004)	(0.0008)	(0.00002)	(3.27)
	Discharges	**Medicare Share**	**Market Power**	**Case Mix Index**	**HHI**	**For-Profit HHI**	**MktPower x HHI**	**Constant**
Condensed Model	0.003	0.02	0.42 **	3.70 **	-0.0009 **	-0.0003	-0.00002	-3.79
	(0.224)	(0.03)	(0.17)	(1.54)	(0.0004)	(0.0008)	(0.00002)	(3.28)

# of Hospitals: 4,108   # of observations: 67,903

variability across patients and cases masked by the price measure employed by this analysis. The use of this price, suggested by CMS, represents an improvement over previous empirical research that has relied upon patient discharge data from OSHPD for the state of California. While discharge data are available at the patient level patient level, they typically are available on a state-by-state basis so do not permit a national analysis of price merger effects, nor are they well suited to longitudinal panel analysis.

1.8 Discussion

I identify positive and statistically significant merger effects five or more years after a merger has occurred, and this result is robust across all models. In contrast, the merger effect in the first few years after a merger is statistically insignificant, although an examination of point estimates reveals small positive effects. The surprising disparity between short-run insignificant results and long-run significant results might be due to a variety of factors and legal restrictions.

To begin, I have shown that merging hospitals are large, even when compared to their non-merging counterparts. Moreover, there is a distinct level of complexity in the method by which hospitals set prices. In particular, prices are negotiated annually between a hospital or facility and a particular provider. Together, these factors suggest that significant changes to operations may not be immediately implementable for all hospitals, and the resulting price stickiness may dampen the observable merger effects in the short run.

In addition, there may be short-run legal frictions that restrict a merging hospital's behavior. For example, a merging hospital that wishes to convert its ownership status, whether as a result of a merger or through other arrangements, may be subject to oversight at both the state and federal level. Several states have authorized periodic review and call for periodic reporting for at least five years post transaction, especially in the case of a nonprofit to for-profit conversion.[28] At the Federal level, oversight is provided primarily through the

[28] C.R.S.A. Section 6-19-495; LSA-R.S. 40:2115.19(A)

IRS, the FTC, and the Department of Justice through their tax and antitrust authorities.[29] These various avenues of legal oversight in the short run may dampen the observable merger effects seen in the short run.

That I find statistically insignificant results in the short run conforms broadly to previously ambiguous empirical analysis of the merger effect on hospital prices. For example Spang et al. (2001) analyzed 204 hospital mergers across the United States and found that merging hospitals experienced lower price growth relative to their rivals. In fact, much of the earlier hospital merger literature finds no effect or a negative effect of hospital mergers on price. The peak of the merger wave occurred in the mid 1990s, so any analysis conducting before 2002 would have observed, at most, 5 to 6 post merger years. My work suggests that any analysis of hospital mergers must be undertaken only after enough time has passed to enable a long-run analysis. In fact, the more recent empirical literature has begun to find empirical evidence supporting the hypothesis that hospital consolidation leads to higher prices.[30]

1.8.1 Acquiring and Target Hospitals: Further Discussion

Because these hospital data are at the facility level, I am able to analyze the merger effect separately for target and acquiring hospitals. In contrast, the American Hospital Association data typically relied upon by researches does not allow them to observe these facilities separately after a merger occurs because the records of merging hospitals are unified under one identifier.

My analysis shows that acquiring hospitals are more successful at raising prices than are target hospitals, increasing price per discharge by nearly $700 compared to the merger effect for target hospitals, which experienced no price effect in the very long run. To better understand why acquiring hospitals experience such pronounced merger effects, I consider the movement of the various components of the price per discharge calculation. For example,

[29]GAO "Hospital Conversion Issues Prompt Increased State Oversight", 6-7, (1998)
[30]For example, see Dafny (2009) and Thompson (2011).

if, all else equal, target hospitals experience a dramatic increase in discharges relative to acquiring hospitals, this would result in a relatively lower price per discharge for target hospitals not related increase in the price charged to patients. Fig. A.2 plots separately the following price components: the average number of discharges, the discount factor, and the discounted inpatient charges

Fig. A.2 reveals that while both target and acquiring hospitals experience an increase in total discharges in the post-merger years, target hospitals' discharges increase at a greater rate. In the long run after a merger target hospitals treat, on average, three thousand more discharges than in the year in which they merged whereas acquiring hospitals treat two thousand more discharges. This disparity will tend to increase price at acquiring hospitals relative to target hospitals.

I next consider the change in the discount factor awarded to insurers. Fig. A.2 demonstrates that discount factors are universally decreasing in the post merger years, and this trend is similar amongst target and acquiring hospitals. As such, relative discount factors are unlikely to contribute to divergent merger effect trends.

Finally, I consider the total patient charges less Medicare charges collected by hospitals. Although there is an increasing trend in both target and acquiring hospitals' charges across all years, relative increased charges for acquiring hospitals is more pronounced than for target hospitals in the post merger years. In particular, acquiring hospitals increase discounted patient charges by about $10 million more than do target hospitals in the long run. The magnitude of a $10 million increase in charges is significant and will increase the price for acquiring hospitals relative to target hospitals. Taken together, these data demonstrate that acquiring hospitals treat relatively fewer patients and charge these patients more than do target hospitals in the post merger years. That acquiring hospitals appear to successfully restrict quantity (discharges) and increase price (charges) is consistent with the hypothesis that acquiring hospitals are more successful than target hospitals at exploiting increased market power.

1.8.2 Limitations

This analysis has important identification and data limitations. To begin, I observe only a small sample of merging hospitals during the later half of the 1990s merger wave. This sample size is sufficient for identification of long-run merger effects and isolated nonprofit merger effects. However, the sample of for-profit and government merging hospitals during this time period, comprising only 20% of all merging hospitals, is too small to permit identification of any additional marginal merger effects. Similarly, I cannot identify the marginal merger effect of participating in a heterogeneous merger involving only one hospital. In future work, I hope to expand my merger data to include first half of the 1990s, during which the volume of transactions was at its peak. Including these data may provide a rich enough sample of for-profit and government hospitals to allow for additional analysis.

That my merger data does not permit me to observe those hospitals that merged before 1996 provides an additional limitation in the identification of non-merging hospitals. I cannot say whether a hospital that did not merge between 1996 and 2001 also did not merge before 1996. For this reason, some of my early non-merging hospital observations may actually be post-merger observations from hospitals that merged in the early 1990s. These misidentified observations would dampen the results of this analysis.

While analyzing HCRIS data represents an improvement over the use of AHA data in the analysis of hospital mergers, these data remain aggregate in nature, limiting the type of analysis that is feasible. Many previous analyses rely on patient discharge data, which allows the researcher to observe patient-specific payment and insurance information and can be disaggregated according to the type of service performed. Krishnan (2001) finds that hospitals exercise market-power at the DRG level, increasing prices for specific services offered. My analysis, however, does not provide information on price at a disaggregate level. Instead, an average price for all inpatient services has been imputed based on hospital charges and aggregate discounts offered to insurers. This undoubtably masks important variation in price that occurs at the DRG level, limiting my ability to identify the effect of hospital mergers on price.

1.9 Conclusion

An important unanswered question remains: Are increases in price per discharge and profit accompanied by a change in the quality of health care provided? Empirical research analyzing the effect of a hospital merger on health care quality is sparse, most likely due to the difficulty in measuring hospital quality. Typical hospital quality measures are based on mortality figures, which are not publicly available at the hospital level. Moreover, mortality can be a particularly misleading quality measure. The sickest patients may be transferred to the nearest hospital equipped for treatment. In this sense, some of the highest quality hospitals may be associated with relatively high mortality rates due to the sample bias introduced by the patient mix treated.

Empirical difficulties aside, if merging hospitals offered high quality health care at an elevated price, and if society values high quality health care then these issues must be balanced by the antitrust authority in analyzing whether or not to challenge a merger. Ho and Hamilton (2000) provide one of the only analyses of the impact of a merger on hospital quality, finding mixed evidence. Romano and Mutter (2004) provide a candid assessment of the data and tools available for measuring quality, and Mutter et al. (2011) undertake a more comprehensive analysis, finding no consistent relationship between consolidations and hospital quality. Further research is certainly warranted on this important topic.[31]

At the direction of the U.S. Congress, the Department of Health and Human Services (HHS) has maintained the "Hospital Compare" database since 2005, which compares hospital quality among a variety of indicators and is based on patient survey ratings. Unfortunately, this database is in the early stages and cannot be integrated with the research I've presented in this paper. However, in future research one may be able to harness these data and employ

[31] To this end, my theoretical model in Chapter 2 shows that although increased prices are generally accompanied by increased quality, the net effect is to decrease total welfare.

a similar empirical identification strategy to analyze the impact of hospital mergers on health care quality.

Ultimately, my analyses show that hospitals increase the price per discharge by more than 10%, or $400 per discharge in the long run after a merger occurs. This increase is even higher, $430, when considering only nonprofit merging hospitals. Finally, when considering the acquiring merging hospital, the merger effect is most pronounced: a $675 per discharge increase in price. These results are magnified by a net income analysis revealing that merging nonprofit hospitals nearly double the average hospital's annual net income. All told, this analysis provides further evidence that hospitals, including nonprofit hospitals, successfully exploit increased market power in the post-merger years by increasing price and profit.

CHAPTER II

A Theoretical Analysis of Mergers Between Nonprofit and For-Profit Firms: an Application in the Hospital Industry

2.1 Introduction

How do nonprofit firms compete in an oligopoly setting? And, what effects do mergers involving nonprofit firms have on equilibrium prices? The objective of this paper is to develop a model of oligopoly competition between nonprofit and for-profit firms and to use this model to develop clear predictions about the outcome of both homogeneous and heterogeneous mergers. These predictions can provide guidance in the legal assessment of mergers and acquisitions involving nonprofit firms, particularly in the case of the hospital mergers that have been prevalent since the early 1990s.

While there is a deep theoretical literature exploring the behavior of nonprofit firms, there is little consensus amongst researchers regarding the exact nature of the nonprofit objective function. Generally, researchers agree that nonprofit firms maximize a utility function that depends on profit. Whether this utility function also depends on either quantity or quality defines the proverbial "fork in the road." The variation in these approaches produces a wide range of theoretical predictions. However, few theoretical models offer functional form specifications, limiting their ability to draw testable empirical conclusions.

My analysis improves upon the theoretical research by developing an oligopoly model of vertically differentiated products that is generalizable to both nonprofit and for-profit firms. This is a departure from previous literature, which has typically assumed linear demand. I define the objective function for all firms to be a linear combination of profit and quality, as was seen in Steinberg (1986). In this specification, nonprofit and for-profit firms differ only through a quality taste parameter, β. Individual consumers have preferences for both the price and the quality of the good they purchase. Together, the firms and the consumers describe the market leading to equilibrium predictions for price and quality.

My analysis develops predictions for a variety of duopoly and three firm oligopoly market structures, including both "homogeneous" markets involving only nonprofit firms and "heterogeneous" markets involving a mix of nonprofit and for-profit firms. Given these equilibrium predictions, I provide a 3-2 merger analysis by comparing three firm oligopoly and duopoly equilibria. In this analysis, I make the distinction between short-run and long-run merger prediction where the short run is defined by a fixed quality level, and the long run is defined flexibly for both price and quality. Finally, I provide an analysis of the impact of a merger on total welfare.

Understanding the implications of mergers involving nonprofit firms is particularly relevant in hospital industry because it is largely a nonprofit industry. Of approximately 6,000 Medicare certified hospitals in the U.S. 60% are nonprofit, 15% are for-profit, and 25% are government owned. In the 1990s, more than 900 mergers and acquisitions occurred in the hospital industry. Moreover, the majority of hospital mergers involve at least one nonprofit firm. Given the varied theoretical predictions developed in the literature, the typical merger analysis, which was developed for merging for-profit firms, may not be suitable in the context of merging nonprofit firms.

My model predicts that immediately following a merger, all hospitals raise prices. Further, even in the long run as all market participants adjust to increased concentration, the average price in a condensed market is predicted to increase. These predictions are robust to which types of firms are merging and to the composition of the market, be it homogeneous or heterogeneous. My model also provides predictions for the effects of merger on individual firm quality of the good provided in a particular market. In markets with an increased share of nonprofit firms due to consolidation, the average quality of the good provided increases and in markets with an increased share of for-profit firms due to consolidation, the average quality of the good provided falls.

Taken together, these results suggest that although prices are predicted to increase due to a merger, these effects are typically accompanied by an increase in average quality. In the context of the hospital care, this suggests that an analysis of the effects of hospital mergers should consider the impact of a merger on societal total welfare. The benefit to consumers from higher quality hospital care should be weighed against the harm to consumers from higher prices. Moreover, a complete welfare analysis weighs any potential net cost to consumers against increased producer surplus resulting from the merger. In this model, I find that the cumulative effect of increased prices and quality decreases total market welfare.

In section 2, I provide a review of the theoretical literature. In section 3, I set up the model. In sections 4 and 5, I describe the duopoly and three firm oligopoly equilibrium outcomes for price and quality. In section 6, I present the model predictions of the effects of mergers on price and quality. Finally, in section 7, I provide concluding thoughts.

2.2 Literature Review

Despite their "nonprofit" title, retained earnings are not useless to a nonprofit firm. Nonprofit firms are legally barred from distributing accounting profits to any controlling member of the firm, and in the case of many nonprofits, this typically refers to the Board of Directors. However, nonprofit firms are not barred from distributing profits to various input departments. In the case of the hospital, this could mean distributing profits to doctors and other employees. Further, if a nonprofit wants to make any kind of investment, retained earnings will be necessary. In the case of a hospital this may be either facility level investments or health care quality improvements. The theoretical literature assumes that nonprofits gain utility from several inputs that always include profit.

The literature diverges in two directions regarding which other inputs belong in the utility function of the nonprofit firm: quantity or quality.[1] There is no doubt that both of these specifications of utility stem from the seminal nonprofit hospital paper written by Newhouse (1970). Here, Newhouse makes the claim that the objective function of the hospital should include both quantity and quality, and he maximizes a combination of these two inputs subject to a binding budget constraint. Newhouse does not, however, give the objective function of the nonprofit a specific functional form, and he does not analyze merger outcomes.

The earlier wave of nonprofit literature assumes that hospitals maximize a utility function that depends on profit and quality. It is commonly accepted that consumers value the quality of care they receive, especially in the health care market. In particular, Ma and Burgess (1993) look at the effects of regulation on firms that compete in quality and price. Here, the authors model a two stage game: firms compete in quality in stage one and compete in price in stage two. However, Ma and Burgess, like many of their counterparts, assume a linear demand function in order to address claims of social efficiency. I depart from this assumption by suggesting that demand is determined instead in a vertical differentiation model.

An alternative literature developed in tandem assuming that the nonprofit utility function depends on profit and quantity. The desire to maximize the quantity produced in the health care industry in intrinsically linked to the public consensus that all people are entitled to health care as a basic right. The public is better off when more health care is consumed. For example, see Gaynor and Vogt (2003) and Lakdawalla and Philipson (1998).

I depart from this quantity literature by suggesting that the utility of government hospitals depends on profit and quantity, in contrast to nonprofit hospitals, which maximize utility over profit and quality. Although government non-teaching hospitals are run in much

[1] For a thorough summary of both the quantity and quality literature for nonprofit firms, please see Harrison and Lybecker (2005) and Dranove and Satterthwaite (2000)

the same organizational way as a nonprofit hospital, they cannot legally refuse treatment to a patient if there are available beds. Moreover, government non-teaching hospitals typically exist in rural areas that are not serviced by other hospitals. This suggests that their primary objective in entering the market is to increase the quantity of health care provided.

Defining the objective function of the hospital to be a linear combination of profit and an additional input–either quality or quantity–was first seen in Steinberg (1986). In this paper, Steinberg defines the objective function of the nonprofit to differ from that of the for-profit firm through a parameter k. He then attempts to identify this parameter by using data on nonprofit firms in all industries in four major metropolitan areas. I adopt his notation in specifying an objective function for the nonprofit firm that is a linear combination of profit and quality, and a quality taste parameter β, which will identify nonprofit firms.

Finally, there are few papers that combine the nonprofit literature with merger analysis. Gaynor and Vogt (2003) harnesses the assumption that nonprofit firms maximize an objective function which depends on profit and quantity to develop a BLP like demand system. Here, Gaynor and Vogt do not specify a functional form for nonprofit utility. Instead, they differentiate between nonprofits and for-profit through a "behavioral marginal cost" function. Gaynor and Vogt estimate the model using hospital characteristic data and patient discharge data from California and simulate the effects of a merger between nonprofit and for-profit firms. They find that nonprofit firms face the same incentives to exploit increased market power post merger.

Following Steinberg (1986), I define the functional form of the nonprofit objective function as a linear combination of profit and quality. I depart from the nonprofit quality literature by suggesting that demand is governed by a model of vertical product differentiation. In section 3 I outline the model for both the consumer and the producer in the health care market. In section 4 I solve for the market equilibrium for duopoly and three firm oligopoly markets. Finally, in section 5 I use the equilibrium results to analyze the effect of a 3-2 merger involving both nonprofit and for-profit hospitals, and in section 7 I conclude.

2.3 The Model

2.3.1 Consumers

An individual consumer has preferences over price, p, and quality, q, of a singleton good. Her individual taste for quality depends on a uniformly distributed random variable $\theta_i \in [\underline{\theta}, \overline{\theta}]$, where $\overline{\theta} - \underline{\theta} = 1$:

$$U_i = \begin{cases} \theta_i q - p & \text{If agent } i \text{ buys good with quality } q \text{ at price } p \\ 0 & \text{If agent } i \text{ does not buy good} \end{cases}$$

I assume that the market is "covered" by requiring that the price of the lowest quality good be low enough to ensure that the consumer with the lowest preference for quality, $\underline{\theta}$, purchases a good.[2] In addition, I assume that there is a sufficient amount of consumer heterogeneity to ensure that demand for the lowest quality good is positive.[3] These assumptions imply that $\underline{\theta} \in (0, 1]$.

2.3.2 Firms

The objective function of the firm depends on the quality of the good sold and is described as follows:[4]

$$\max_{p_i, q_i} U(\Pi, q_i)$$

Profit is defined as $\Pi = D_i(p_i, p_{-i})\,(p_i - c) - bq_i^2$, where b is an investment cost in quality. Firm i produces a good of quality q_i at a constant marginal cost of production, $c\ \forall i$. The

[2] $p_l^*\left(q_l^*, q_{-i}^*\right) \leq \underline{\theta} q_l^*$. This assumption implies that $\underline{\theta} \neq 0$ and $q_l^* \neq 0$

[3] In the duopoly case, this is the familiar condition: $\overline{\theta} > 2\underline{\theta}$

[4] I make this assumption in relation to the organization of the hospital industry wherein there are three distinct types of firms: nonprofit, for-profit, and government hospitals. I assume that government hospitals are primarily concerned with the quantity of health care provided, in contrast to nonprofit hospitals, which are concerned with the quality of health care provided.

utility function of the firm depends on a quality preference parameter α in the following way:

$$\max_{p_i, q_i} \quad D_i(p_i, p_{-i})\,(p_i - c) - bq_i^2 + \alpha q_i \tag{2.1}$$

I now distinguish between for-profit (F) firms and nonprofit (N) firms based on the quality taste parameter α, which describes an individual firm's preference for the quality of the product itself. Pure nonprofit firms are firms for which $\alpha \to \infty$. They only value quality and have no preference for profit itself. Pure for-profit firms are firms for which $\alpha = 0$. They only value profit and gain no direct utility from quality. "Mixed" firms are firms that have some preference for profit and some preference for quality, $\alpha \in \mathcal{R}^+$. In the hospital industry, I speculate that any firm that has a tax status of nonprofit is certainly a mixed firm, but may not be a pure nonprofit firm.

2.3.3 The Game

Firms play a two stage game. In the first stage, firms select their level of quality, and in the second stage, they select their price. I provide the subgame perfect Nash equilibrium, solving via backwards induction. In the second stage firms select price for a given level of quality. I refer to this as the **short-run** decision and assume that improvements to quality take time. Specifically, the problem facing the firm in stage two is

$$\max_{p_i} \quad D_i(p_i, p_{-i})\,(p_i - c) - bq_i^2 + \alpha \overline{q}_i$$

where $\overline{q}_i$ is the fixed choice of quality from stage one. From this it can be seen that maximizing utility in the short run is akin to maximizing profit. This address the legal precedence of sanctioning a merger involving a nonprofit hospital on the grounds that it will have no incentive to raise prices post-merger. Instead, I demonstrate that in the short run, both nonprofit and for-profit firms face the same profit-maximizing incentives. The long-run equilibrium will be described by the full two stage game. In the long run there may be a difference in equilibrium outcomes based on the firm quality preference parameter, α_i.

2.3.4 Total Welfare

A merger will result in changes to equilibrium price and quality. If a merger leads to higher prices that are accompanied by higher quality, the welfare effect will be ambiguous. To analyze this more fully, I supplement the analysis by consider the effect of a merger on total welfare. Total welfare is defined as the sum of consumer and producer surplus:

$$\text{Total Welfare} = \int_{\underline{\theta}}^{\overline{\theta}} (\theta q^* - p^*)\, d\theta + \sum_{j=H,M,L} U^j\left(q_j^*, p_j^*\right) \tag{2.2}$$

where U^j is the equilibrium utility of the high, medium, or low quality firm. This analysis is similar to the gross surplus analysis seen in Calem and Rizzo (1999) for output maximizing monopolists.

2.4 Equilibrium Outcomes

In order to enhance the tractability of the model, I make a few specific parametric assumptions regarding the objective function of the firm, Eq. (2.1).[5] These transformations will lead to the final form of the firm's objective function,

$$\max_{p_i,q_i} \quad D_i(p_i, p_{-i})\,(p_i - c) - \frac{B}{18}q_i^2 + \left(\frac{\beta}{9}\right) q_i \tag{2.3}$$

Because I am interested in describing the outcome of mergers involving nonprofit firms, I first describe the equilibrium outcome of the duopoly and three-firm oligopoly market. This is followed by an analysis of 3-to-2 mergers.

[5]First, I apply a linear transformation of the quality taste parameter from α to β and from b to B:

$$\alpha = \beta\left(\frac{1}{3}\right)^2 \quad \text{and} \quad b = B\frac{1}{18}$$

2.4.1 Duopoly

2.4.1.1 Short Run Analysis

The equilibrium for two for-proft firms has been fully described in the literature. I follow closely the exposition of this game seen in Tirole (1988).

Given the assumption of covered markets, the duopoly demand functions facing the two firms are

$$D_{h,2} = \overline{\theta} - \left(\frac{p_h - p_l}{q_h - q_l}\right)$$

$$D_{l,2} = \left(\frac{p_h - p_l}{q_h - q_l}\right) - \underline{\theta}$$

where $\left(\frac{p_h - p_l}{q_h - q_l}\right) = \theta_{HL}$ is the preference parameter of the individual that is indifferent between purchasing the high and low quality good. The second-stage Nash equilibrium prices are

$$p_h^*(q_h, q_l) = c + \left(\frac{2\overline{\theta} - \underline{\theta}}{3}\right)(q_h - q_l) \tag{2.4}$$

$$p_l^*(q_h, q_l) = c + \left(\frac{\overline{\theta} - 2\underline{\theta}}{3}\right)(q_h - q_l) \tag{2.5}$$

Together, these imply the following first-stage demand functions for high and quality firms:

$$D_{h,2} = \left(\frac{2\overline{\theta} - \underline{\theta}}{3}\right) \tag{2.6}$$

$$D_{l,2} = \left(\frac{\overline{\theta} - 2\underline{\theta}}{3}\right) \tag{2.7}$$

These formulas, from Tirole (1988), demonstrate that the choice of prices in the second stage will be independent of the parameter β and therefore will be unchanged when describing the solution to the nonprofit problem.

2.4.1.2 Homogeneous Long Run Market Equilibrium

Backwards induction and the second-stage equilibrium prices together imply that in stage one each firm will select q_i according to the following utility maximization problem:

$$\max_{q_i} D_{i,2}\left(p_i\left(q_h, q_l\right) - c\right) - \frac{B}{18}q_i^2 + \left(\frac{\beta}{9}\right)q_i \tag{2.8}$$
$$\text{s.t.} \quad \underline{s} \leq q_h$$
$$\text{s.t.} \quad \underline{s} \leq q_l$$

where $\underline{s} > 0$ is the lower bound on quality in the market.

In equilibrium, the high quality firm will select

$$q_{h,2}^* = \frac{4 + \beta + \underline{\theta}\left(4 + \underline{\theta}\right)}{B} \tag{2.9}$$

Likewise the low quality duopoly firm will select

$$q_{l,2}^* = \frac{\beta + \underline{\theta}\left(2 - \underline{\theta}\right) - 1}{B} \tag{2.10}$$

If the constraint binds, $q_{l,2}^* = \underline{s}$.[6] This occurs for nonprofits with a low quality preference and for for-profit firms, where $\beta_F = 0$.

Plugging the optimal quality choices into the Nash equilibrium prices, Eq. (2.4) and Eq. (2.5), yields the Nash equilibrium interior prices.

$$p_h^* = c + \frac{10 + \underline{\theta}\left(9 + 2\underline{\theta}\left(3 + \underline{\theta}\right)\right)}{3B} \tag{2.11}$$

$$p_l^* = c + \frac{5 - \underline{\theta}\left(3 + 2\underline{\theta}^2\right)}{3B} \tag{2.12}$$

This solution concept is illustrated in Fig. 2.1.[7]

[6] The constraint binds when $\beta < B\underline{s} + 1 - \underline{\theta}\left(2 - \underline{\theta}\right)$.

[7] All solutions are shown for the following parameter values: $\underline{\theta} = 0.05, B = 1, \underline{s} = 0.25, c = 0.005$

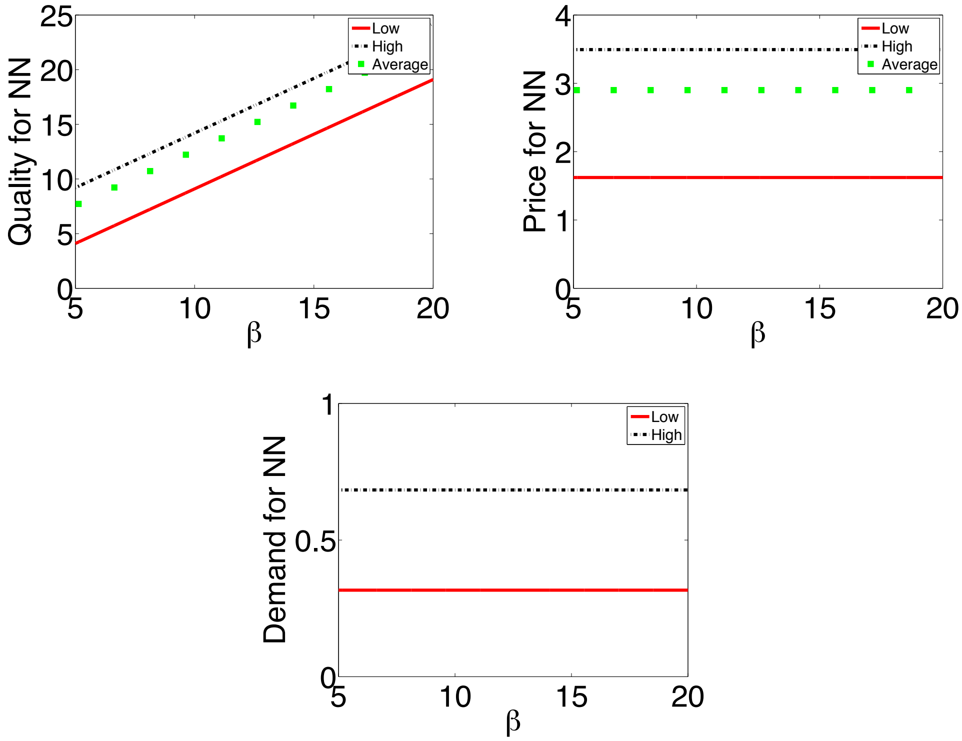

Figure 2.1: Duopoly NN Equilibrium with $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

For interior solutions, price is independent of the nonprofit preference for quality, β. This comes from the formulation of Nash Equilibrium prices, which only depend on the differentitation between the quality choices of the two firms. Although it is true that the nonprofit firm will choose greater quality than the for-profit firm, the strategic effect between the low and high quality firm is unaffected by the firm quality preference, β. That is, the low and high quality firm optimally choose the same level of differentiation, independent of the intensity of their preference for quality over profit.

In constrained solutions, price depends on β. However, the possibility of a constrained nonprofit solution occurs only for firms with very low quality preferences.[8] Qualitatively, these "nonprofit" firms behave more like for-profit firms in placing little weight on quality over profit. For a duopoly homogenous for-profit market, the quality constraint will always bind for the low quality firm. In either constrained case, equilibrium prices are less than in

[8]In the numerical example presented, Fig. 2.1, $\beta < 1$

the unconstrained nonprofit market. In the numerical example presented in Fig. 2.1, the interior nonprofit prices are $p_h^* \approx 3.49$ and $p_l^* \approx 1.62$, and the for-profit prices are $p_h^* \approx 2.72$ and $p_l^* = 1.27$.

Proposition II.1. *In a homogeneous nonprofit market with an interior equilibrium, the Nash equilibrium prices of the high and low quality firm are independent of the nonprofit preference for quality and are greater than in the high and low quality Nash equilibrium prices in the homogeneous for-profit market.*

These result have implications for total welfare. In general, as a firm's taste for quality increases, the average quality in the goods offered in the market increases. At the same time, the average price charged remains constant. This unambiguously increases consumer surplus. From the perspective of the firm, higher quality goods are more costly, reducing profit, but higher quality goods increase nonprofit utility. Taken together and as Fig. 2.3 demonstrates, total welfare is an increasing function of the quality taste parameter. This gives rise to the following proposition:

Proposition II.2. *Total welfare in the homogeneous nonprofit market is greater than the total welfare in the homogeneous for-profit market and is an increasing function of the nonprofit taste for quality, β_N.*

2.4.1.3 Heterogeneous Long Run Market Equilibrium

Next, I consider a heterogeneous market structure with one nonprofit and one for-profit firm. This does not change the first order conditions described in Eq. (2.9) and Eq. (2.10). However, each firm has a different preference for quality, where $\beta_F = 0$ and $\beta_N \neq 0$. There are two possible equilibrium structures of the market: one where the nonprofit firm is the highest quality producer, or the more counter-intuitive outcome where the nonprofit firm is the lowest quality producer. In all equilibrium analysis I restrict my attention to equilibria where the for-profit firm is the lowest quality firm.[9,10]

The equilibrium for-profit quality choice is always constrained, while the high quality choice is unchanged from the homogeneous market, Eq. (2.9). In other words, the lowest quality product available in the heterogeneous market is $q_l = \underline{s}$, lower than what is available in the interior homogeneous nonprofit market. There is no difference between the high quality choice in these two markets. Because of this, the differentiation between the nonprofit and the for-profit firm increases as the nonprofit firm places more value on quality, leading to equilibrium prices in these markets that depend on β_N. This heterogeneous equilibrium is illustrated in Fig. 2.2.

Proposition II.3. *Nash equilibrium prices in the heterogeneous market are an increasing function of β_N, the nonprofit's taste for quality.*

2.4.1.4 Comparison of Homogeneous and Heterogeneous Equilibria

To compare the duopoly equilibria, I compute the average price, quality, and total welfare, seen in Fig. 2.3.[11] This comparison leads to the following conclusion:

Proposition II.4. *The average price in the heterogeneous market is greater than in the homogeneous market. The average quality in heterogeneous market is less than in the homogeneous market.*

Consuming a higher quality good at a lower average price in the homogeneous market unambiguously increases consumer surplus when compared to consumption in the heterogeneous market. However, these produce competing effects on producer surplus. High quality

[9] I begin by considering the counter-intuitive possibility that the nonprofit firm will actually be the lowest quality producer in the market. This implies $q^*_{h,2}(\beta_F = 0)$ and $q^*_{l,2}(\beta_N)$, from Eq. (2.9) and Eq. (2.10) respectively. However, it must also be true that $q_{l,2}(\beta_N)^* \leq q^*_{h,2}(\beta = 0)$. In B.3.1 I show that in order for such an equilibrium to exist, β_N must be below some threshold value. Qualitatively, the existence of an equilibrium where the nonprofit firm is the lowest quality firm is only possible when the nonprofit firm has a low preference for quality. In this case, these "nonprofit" firms are "mixed" firms behaving more like a for-profit firm than nonprofit.

[10] In this case, I am ignoring multiple equilibria in heterogeneous markets with one nonprofit with a low preference for quality. In the associated numerical example, $\beta_N > 5.105$

[11] In this case the average is a weighted average based on the fraction of the market covered by each firm.

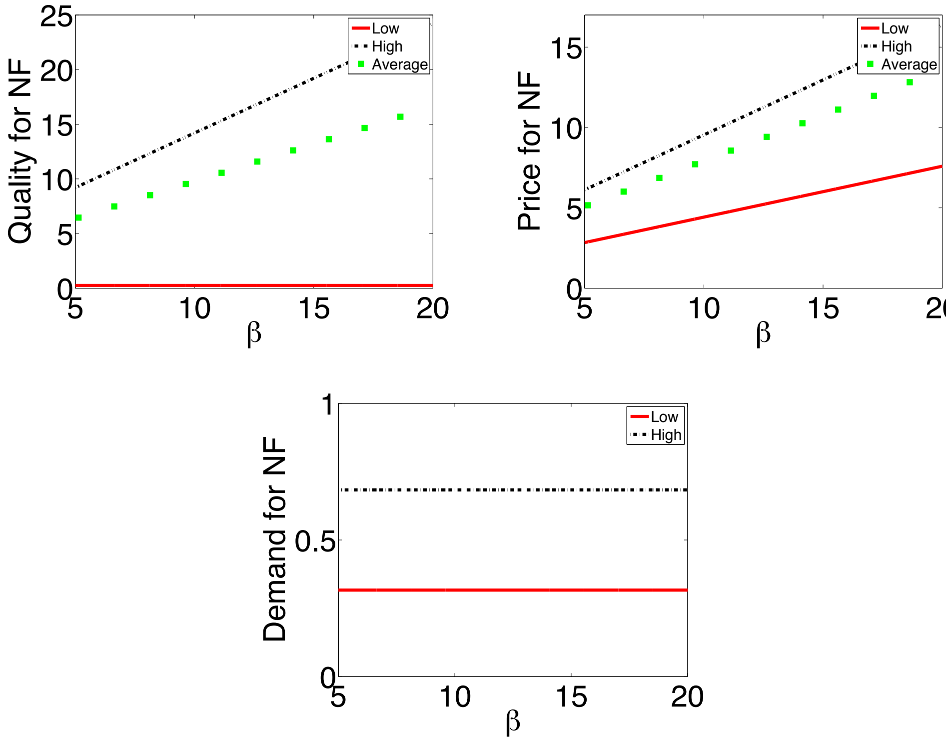

Figure 2.2: Duopoly NF Equilibrium $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

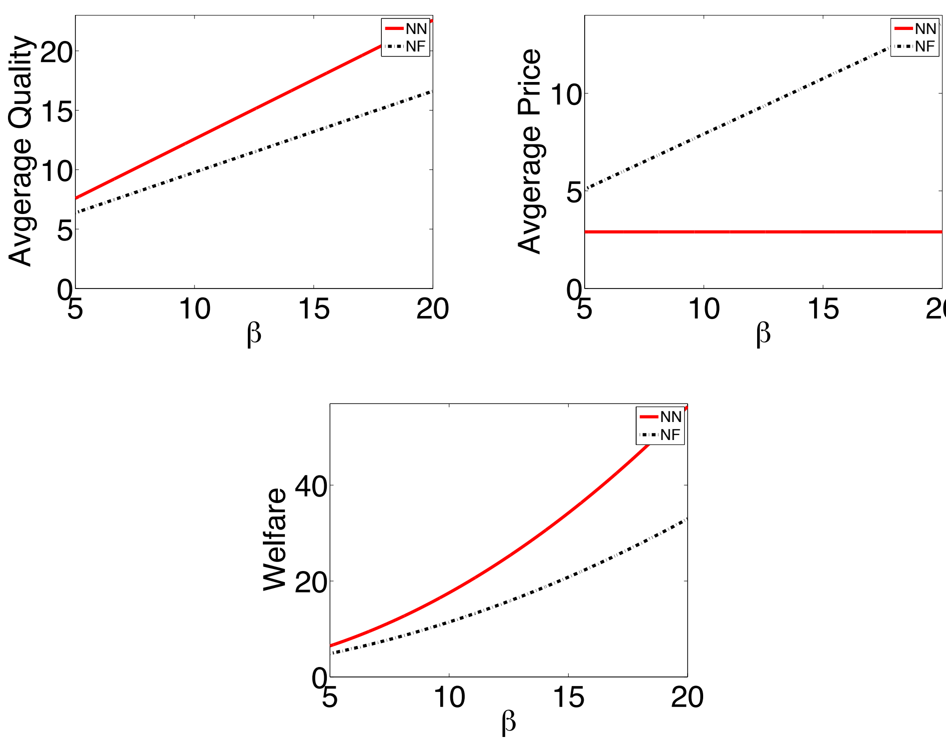

Figure 2.3: Duopoly Equilibria Comparison $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

products are costly to produce, but nonprofit firms gain utility directly from offering a higher quality good. Fig. 2.3 demonstrates that

Proposition II.5. *Total welfare is greater in the nonprofit homogeneous market than in the heterogeneous market.*

2.4.2 Three Firm Oligopoly

2.4.2.1 Short Run Analysis

The short-run analysis leads to the following Nash equilibrium prices:[12]

$$p^*_{h,3} = c + \frac{(q_h - q_m)(q_m - q_l)}{6(q_h - q_l)} + \frac{\overline{\theta}(q_h - q_m)}{2} \tag{2.13}$$

$$p^*_{m,3} = c + \frac{(q_h - q_m)(q_m - q_l)}{3(q_h - q_l)} \tag{2.14}$$

$$p^*_{l,3} = c + \frac{(q_h - q_m)(q_m - q_l)}{6(q_h - q_l)} - \frac{\underline{\theta}(q_m - q_l)}{2} \tag{2.15}$$

These lead to first stage demand functions for high, medium, and low quality goods that, unlike the duopoly market, depend on quality:

$$D_{h,3} = \frac{1}{2}\overline{\theta} + \left(\frac{q_m - q_l}{q_h - q_l}\right)\left(\frac{1}{6}\right) \tag{2.16}$$

$$D_{m,3} = \frac{1}{3} \tag{2.17}$$

$$D_{l,3} = \left(\frac{q_h - q_m}{q_h - q_l}\right)\left(\frac{1}{6}\right) - \frac{1}{2}\underline{\theta} \tag{2.18}$$

[12] A full derivation of the second stage Nash equilibrium prices can be found in the mathematical appendix (C.1).

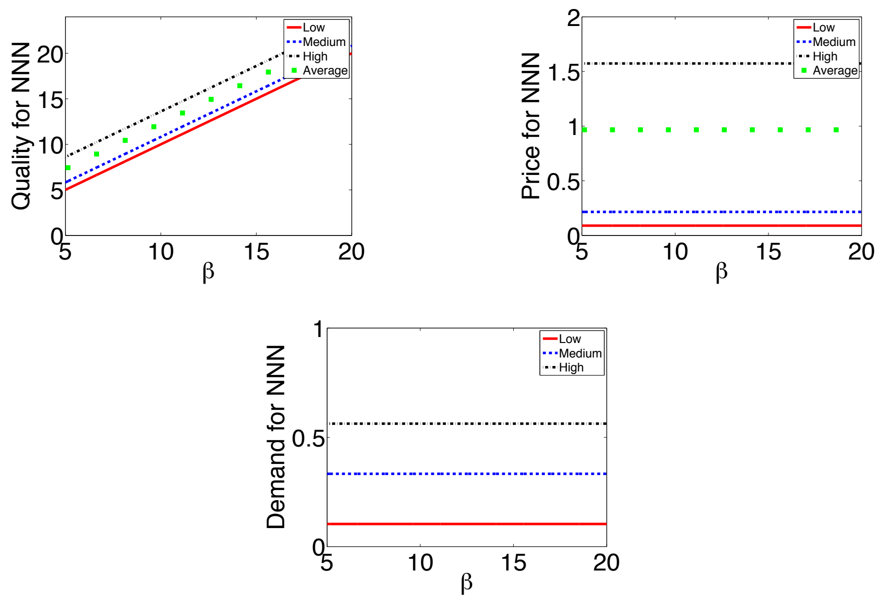

Figure 2.4: Oligopoly NNN Equilibrium $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

2.4.2.2 Homogeneous Long Run Equilibrium

Given equilibrium demand as a function of quality, I turn to the first stage of the game, where firms simultaneously select quality. Firms maximize Eq. (2.3) subject to the demand system described in Eq. (2.16), Eq. (2.17), and Eq. (2.18). The Nash equilibrium choice of quality in the two stage game occurs at the intersection of the best response functions derived in the first stage of the game.

As with the exposition of the duopoly equilibria, the solution depends on the range of parameter values: $\underline{\theta}, B, \underline{s}, \beta, c$. A general solution algorithm can be found in the mathematical appendix, C.2. Fig. 2.4 illustrates the solution concept for $[\underline{\theta} = 0.05, B = 1, \underline{s} = 0.25, c = 0.005]$

As in the homogeneous duopoly market, the equilibrium interior quality choices increase in β, and the strategic effect between the three firms is independent of β. This implies interior prices that are also independent of β. In the case of a very low preference for quality, the lowest quality choice will be constrained by $\underline{s}$, and prices will depend on β.

Proposition II.6. *In the interior three firm homogeneous nonprofit Nash equilibrium, prices*

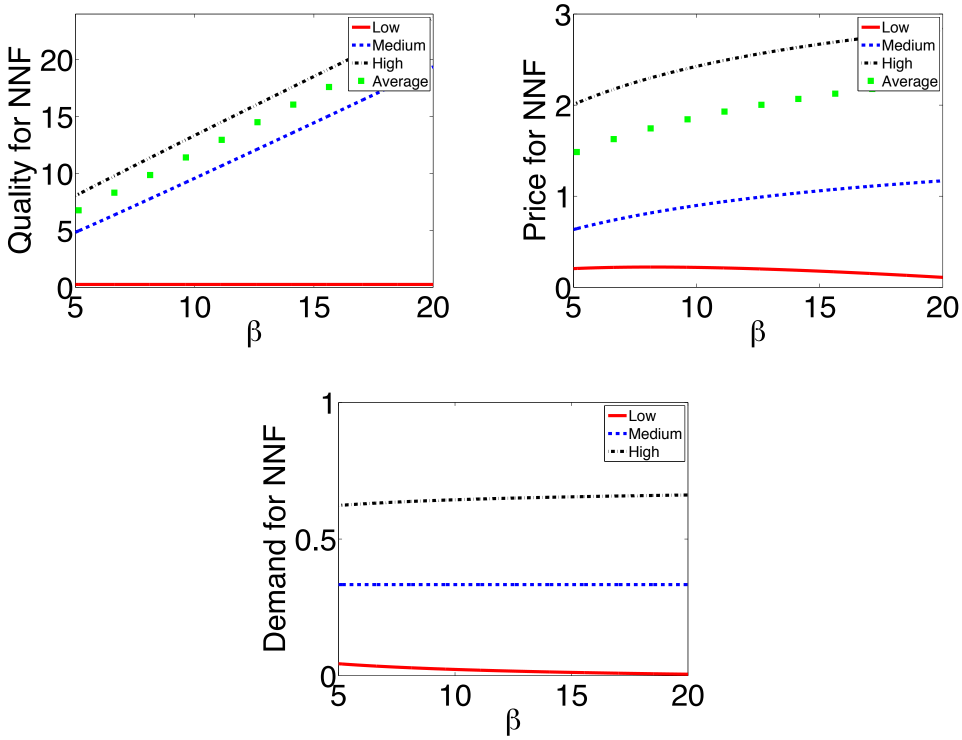

Figure 2.5: Oligopoly NNF Equilibrium $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

are independent of the quality taste parameter, β, and are greater than equilibrium prices in the homogeneous for-profit market.

2.4.2.3 Heterogeneous Long Run Equilibrium

In the case of a three firm oligopoly, there are two possible market configurations: (1) Market$_{2NF}$: two nonprofit firms and one for-profit firm, or (2) Market$_{N2F}$: two for-profit firms and one nonprofit firm. As in the duopoly market outcome, I only focus on market outcomes in which for-profit firms provide the lowest quality good. The intuition caries through from the duopoly outcome that the possibility of the nonprofit firm providing the lowest quality good only occurs when β is below some threshold level $\bar{\beta}$.

In both the 2NF and the N2F market, a constrained solution is guaranteed.[13] The Nash equilibrium prices and quantities for Market$_{2NF}$ and Market$_{N2F}$ are shown in Fig. 2.5 and

[13]The derivation of the 2NF heterogeneous equilibrium can be found in the appendix, C.3, and the derivation of the N2F heterogeneous equilibrium can be found in the appendix, C.4.

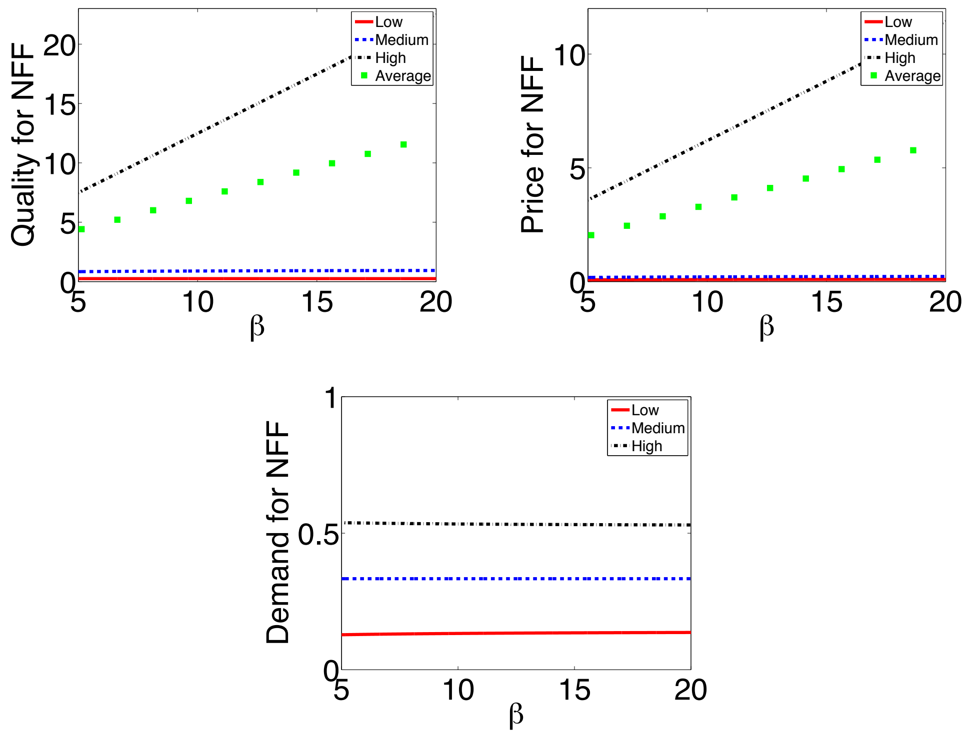

Figure 2.6: Oligopoly NFF Equilibrium $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

Fig. 2.6 respectively. In particular, the low quality for-profit firm optimally chooses a quality level less than zero, so the quality constraint binds. Recall that we have seen a similar result in the heterogeneous duopoly market where in the duopoly market, a non-interior solution was guaranteed for all values of β.

Proposition II.7. *The Nash equilibrium price and quality in a heterogeneous three firm market are an increasing function of β_N, the nonprofit taste in quality.*

2.4.2.4 Comparison of Homogeneous and Heterogeneous Market Outcomes

In order to consider the welfare implications of the various three firm market structures, I compare the average quality and average price. In computing these, I weight each by the associated fraction of demand. Comparative average price and average quality are shown in Fig. 2.7.

In particular, the highest average price occurs in heterogeneous markets with a majority of

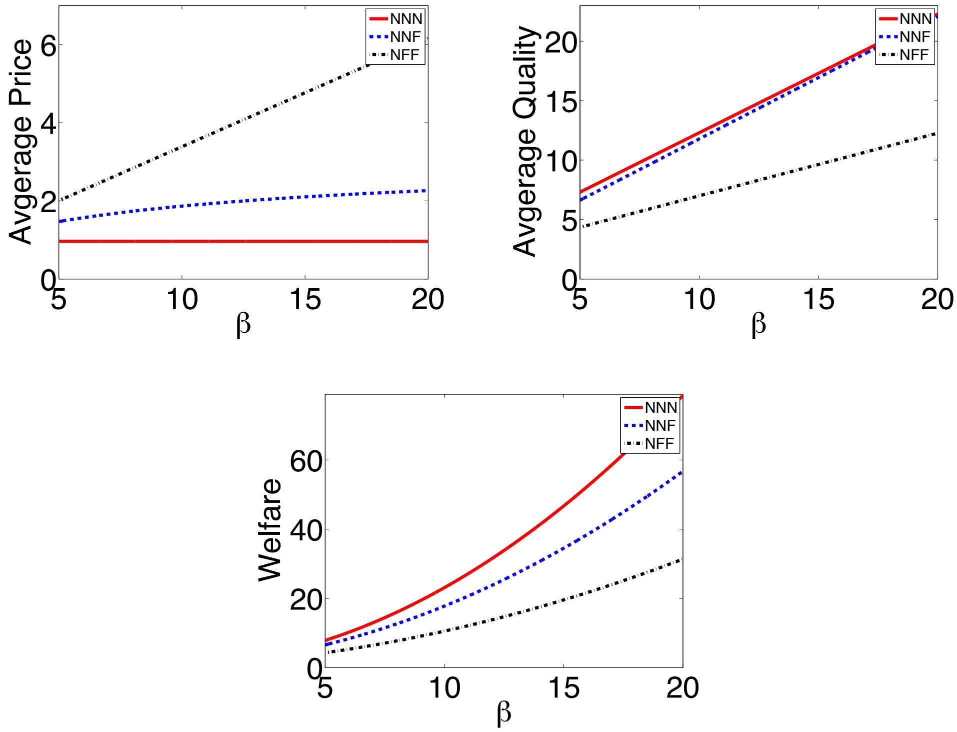

Figure 2.7: Three Firm Oligopoly Equilibria Comparison

for-profit firms, and the lowest average price occurs in homogeneous markets. This provides an intuitive result that as for-profit firms are added to a nonprofit market, the average price level increases. Moreover, homogeneous nonprofit markets provide the highest average quality good, and as more for-profit firms are added, the average quality decreases.

Fig. 2.7 demonstrates that total welfare is an increasing function of the nonprofit taste for quality, implying that total welfare is greater in the homogeneous nonprofit market than the homogeneous for-profit market. Given that the heterogeneous majority for-profit market provides the highest average price and lowest average quality, it is unsurprising that total welfare is the lowest in this market. Likewise, the total welfare is the highest in the homogeneous nonprofit market, which provides the lowest average price and the highest average quality.

Proposition II.8. *The average Nash equilibrium price is the highest in the homogeneous nonprofit market and decreases as for-profit firms are added to the market. The highest* *average Nash equilibrium quality good is provided in the homogeneous nonprofit market and average quality decreases as for-profit firms are added.*

2.5 3-to-2 Predicted Merger Effects

In this section, I evaluate mergers in the context of the hospital industry. In particular, I use data from the Hospital Cost Report Information System (HCRIS) in combination with mergers and acquisition data from 1996 to 2001 available through Irving Leving Associates to determine the most likely market composition and merger outcome. 61% of hospital mergers occur between two nonprofit hospitals, whereas only 10% of mergers occur between nonprofit and for-profit hospitals and 1% of mergers occur between two for-profit hospitals.[14] In addition, 97% of nonprofit merging hospital facilities remain nonprofit after a merger. In comparison, only 50% of for-profit merging hospitals remain for-profit after a merger, and 44% of for-profit merging hospital facilities convert to nonprofit. Finally, the average market contains 13 non-government hospitals, 10 of which are nonprofit and 3 of which are for-profit.[15,16] I consider several different types of mergers:[17]

	Oligopoly	$\rightarrow$	**Duopoly**
(1)	NNN	N+N	NN
(2)	NNF	N+F	NN
(3)	NNF	N+N	NF
(4)	NFF	N+F,F+F	NF

Based on the data, the average hospital market is heterogeneous and dominated by nonprofit hospitals, and the most common merger to occur is between two nonprofit hospitals. I assume that when a merger involves a nonprofit firm, the consolidated firm will remain

[14]17% of hospital mergers involve at least one government hospital, an issue not explored in this model. Another 11% of mergers are not identified by merger type.

[15]The average market contains 17 hospitals, 4 of which are government, a topic not discussed in this paper.

[16]In this paper, a market is defined as a "Hospital Referral Region," as identified by the Darmouth Atlas for Healthcare Group

[17]Because only 1% of mergers are between two for-profit hospitals outcome 4 is very unlikely to be observed in the hospital industry.

nonprofit. In this sense, the most relevant merger analysis for the hospital industry will be (3) NNF $\rightarrow$ NF.

2.5.1 Short Run Merger Effects

In the hospital merger data, few merged hospital facilities close immediately after a merger occurs. For this reason, I assume that when two hospitals merge in the short run they are unable to immediately close either facility and can only make adjustments to price given pre-merger equilibrium quality level. When two firms merge, the merged entity must choose optimal prices for both facilities in the post-merger period given pre-merger equilibrium quality choices:

$$\max_{p_i, p_j} \; U_i\left(\Pi_i, \overline{q}_i\right) + U_j\left(\Pi_j, \overline{q}_j\right)$$

The immediate impact on price can be analyzed by comparing the pre-merger three firm equilibrium prices to short run duopoly equilibrium prices. In Appendix D, I provide proof of the following result:

Proposition II.9. *Nash equilibrium prices always increase in the short run immediately following a merger.*

2.5.2 Long Run Merger Effects

In order to analyze long run merger effects, I compare the weighted average quality and price between the three firm oligopoly and duopoly long run equilibria. In addition, I compare the total welfare.

2.5.2.1 NNN $\rightarrow$ NN

This analysis considers a merger in a homogenous three firm nonprofit oligopoly market resulting in a homogenous duopoly nonprofit market, shown in Fig. 2.8. Only 20 out of 306 hospitals markets, or 6.5%, are homogeneous nonprofit markets, so this merger outcome is a rare occurrence in the hospital industry. A merger in a nonprofit homogeneous market results in a small increase in average quality accompanied by much larger increase in average price. Moreover, because both the pre and post merger market is homogeneous, the increase in equilibrium quality and price is independent of the nonprofit preference for quality. The increase in both quality and price resulting from this merger represents a trade off in utility for consumers and producers.

When comparing the average total welfare, Fig. 2.8 shows that the overall effect of this merger is to decrease total welfare. The loss in total welfare is magnified as the nonprofit preference for quality increases. To see why, I separately consider the consumer and producer surpluses. Consumers experience a loss in consumer surplus due to the merger, but this loss is constant for all values of β. For nonprofit producers, however, total producer surplus decreases with the merger at an increasing rate. While both firms are better off in the long-run consolidated market, the sum of all producer surplus falls do to the loss of the medium quality firm and associated producer surplus

2.5.2.2 NNF $\to$ NN, NF

I first consider a merger in the NNF market resulting in a duopoly nonprofit homogeneous market, NN, shown in Fig. 2.9. This would be the outcome of a merger between a nonprofit and a for-profit firm that resulted in one nonprofit firm. This merger leads to an increase in the average quality and price of goods sold in the consolidated market. As the nonprofit quality preference increases, this dampens the merger effect of average quality and price. The cumulative effect decreases consumer surplus and increases producer surplus resulting in a small overall decrease in total welfare.[18]

Next, I consider a merger in the NNF market resulting in a duopoly heterogeneous market, shown in Fig. 2.9. This market would occur if two nonprofit firms merge into one nonprofit firm. This merger is the most reflective of the hospital merger wave of the 90s

[18] For very low levels of β_N. In this numerical example, total welfare actually increases slightly with the merger. In this numerical example: $\beta_N < 1$

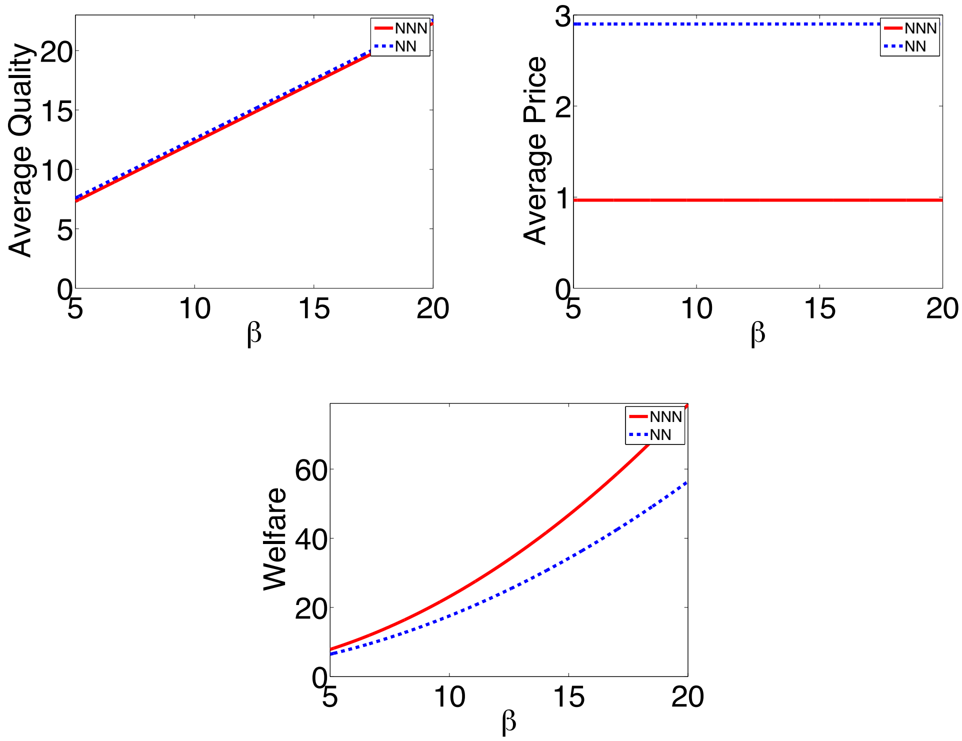

Figure 2.8: Merger Effect: NNN $\rightarrow$ NN: $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

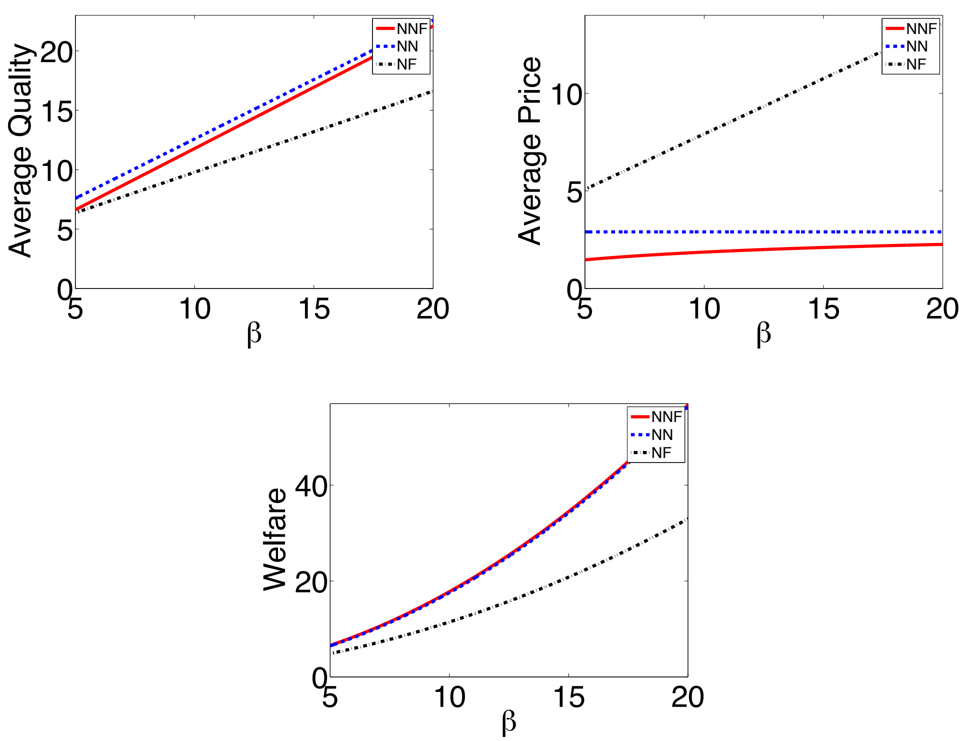

Figure 2.9: Merger Effect: NNF $\rightarrow$ NN, NF $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

because 182 of 306 markets, or 59% of all markets, are majority nonprofit heterogeneous markets, and 60% of all mergers are between two nonprofit firms. The effect of this merger is to decrease average quality at a rate that is increasing with the nonprofit firm's quality preference. In other words, the more the merged nonprofit firm prefers quality, the lower will be the average quality in the consolidated market. However, this seemingly counterintuitive result is due simply to the loss of the medium quality firm in the consolidated market. While the highest and lowest quality choices have not drastically changed, the loss of the medium quality firm implies that more consumers purchase the lowest quality good, driving down the average quality in the market. At the same time, the average price in the consolidated market increases dramatically.

Taken together, this consolidation leads to lower average quality and higher average price. It then comes as no surprise that the effect on consumers is to decrease consumer welfare in the consolidated market. The effect of the consolidation for producer surplus depends on the quality preference of the nonprofit firm. When the nonprofit firms have a low preference for quality, or they behave more like for-profit firms, producer surplus decreases.[19] When the merging nonprofit firms have a high preference for quality, or they behavior more like "pure" nonprofit firms, total producer surplus increases. Ultimately, a merger of two nonprofit firms in an NNF market leads to a decrease in total welfare, largely driven by the associated loss in consumer surplus.

2.5.2.3 NFF $\rightarrow$ NF

This analysis considers a merger in the NFF market resulting in a duopoly heterogeneous market, NF, shown in Fig. 2.11.[20] This outcome arises if either a nonprofit and a

[19] To further explore this potential loss in producer surplus, consider the effect of the merger on individual firm utility, seen in Fig. 2.10. This figure demonstrates that the producer surplus of the high and low quality firm are both greater in the consolidated market. However, total producer surplus in the pre-merger market includes the medium quality firm, which has been consolidated. The loss in total producer surplus that occurs for high nonprofit quality preferences stems from the lost medium quality competitor.

[20] This analysis does not consider a merger in the NFF market that results in an FF duopoly equilibrium because a heterogeneous market with a majority of for-profit firms is very rarely seen in the hospital industry.

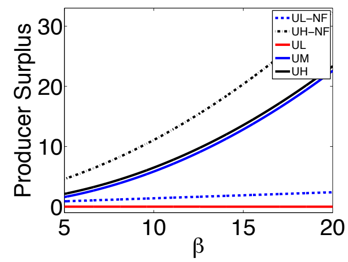

Figure 2.10: Merger Effect on Producer Surplus: NNF → NF

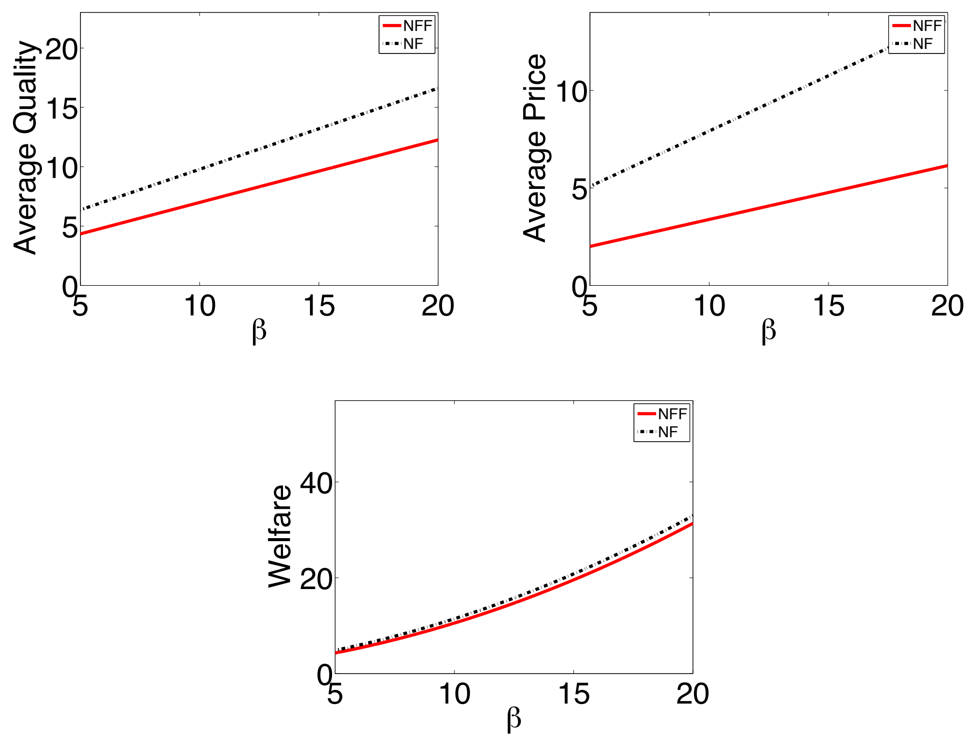

Figure 2.11: Merger Effect: NFF → NF $\underline{\theta} = 0.05$, $B = 1$, $\underline{s} = 0.25$, $c = 0.005$

for-profit firm merge, resulting in one nonprofit firm, or if two for-profit firms merge and remain for-profit. However, only 25 out of 306 hospital markets (8%) are majority for-profit heterogeneous markets, making this merger analysis less relevant to the hospital industry. This merger results in an increase in average quality and average price, and this effect is magnified as the nonprofit preference for quality increases. This leads to reduced consumer surplus but increased producer surplus. The effect of increased producer surplus dominates and leads to an overall increase in total welfare.

2.5.2.4 Combined Results

	Average P	**Average Q**	**Consumer Surplus**	**Producer Surplus**	**Total Welfare**
NNN → NN	↑	↑	↓	↓	↓
NNF → NN	↑	↑	↓	↑	↓
NNF → NF	↑	↓	↓	↑↓	↓
NFF → NF	↑	↑	↓	↑	↑

Table 2.1: Combined Merger Results

I aggregate these merger results in Table 2.1, leading to the following conclusions:

Proposition II.10. *A 3-to-2 merger in markets with nonprofit firms always leads to an increase in the average Nash equilibrium price.*

Proposition II.11. *A 3-to-2 merger leads to an increase in average Nash equilibrium quality in all cases except NNF → NF.*

Proposition II.12. *A 3-to-2 merger leads to a decrease in total welfare in all cases except except NFF → NF.*

2.6 Conclusion

I have shown in the previous analysis that in the long run, a merger of two firms will lead to an increase in average prices, and this result is independent of the quality taste parameter β for the participating firms. This result suggests that although some firms may be nonprofit, these firms still face an incentive to exercise market power in consolidated industries by increasing price. Moreover, when a consolidation results in a market that becomes more nonprofit in composition, the average quality in the market increases, and when a consolidation results in a market that becomes more for-profit in composition, the average quality in the market decreases.

In the case of the hospital industry, higher quality health care would certainly be seen as a positive outcome of the consolidation of the hospital industry. The question of whether or not to allow hospitals to merge then depends on the trade-off between how much society values higher quality health care versus how much society is harmed by the increasing price of attaining health care. The combined effect of a consolidation on Nash equilibrium price and quality always reduces consumer surplus. Moreover, the magnitude of the decrease in consumer surplus is always large enough to offset gains in producer surplus, leading to a decrease in total welfare. However, this paper considers a naïve social welfare function. A more sophisticated social welfare function might weight differently the effect of increased health care quality in light of the importance of public health issues. For example, a Rawlsian social welfare function maximizes the welfare of the least well-off person in society and could have important implications in the management of diseases. This model can be extended to determine the equilibrium outcome that maximizes a chosen social welfare function. This is something that is outside the scope of this paper but is certainly an avenue for further research.

In addition, the next phase of this research should include an analysis of the government-owned firm. The average hospital market is characterized by a distribution of 60% nonprofit hospitals, 15% for-profit hospitals, and 25% government hospitals. Understanding how these government hospitals interact in a competitive environment with nonprofit and for-profit firms is critical to understanding the hospital industry as a whole. There is some work in this area analyzing the behavior of public enterprises (for example, see Sappinton and Sidak (2003) and Sappinton and Sidak (2003-2004)). However, a model incorporating the three different ownership structures (nonprofit, for-profit, and public) has not yet been seen.

Finally, it will be important to harness this model to fully characterize the entry decision of a firm into this industry. Nonprofit hospitals enjoy a tremendous tax advantage over their for-profit rivals because they do not pay income tax on their accounting profits and have access to tax-preferred bonds for raising capital. In 2002 the Joint Committee on Taxation has estimated the valuation of these tax savings to be approximately \$2.5 billion. Then, when a firm makes a decision to enter the market, they have a choice on whether to enter as a forprofit or a non-profit, and these monetary benefits may suggest an equilibria where some for-profit firms whose true quality taste parameter $\beta = 0$ are persuaded to masquerade as nonprofit firms.

CHAPTER III

Estimates of U.S. Postal Price Elasticities of Demand Derived from a Random-Coefficients Discrete-Choice Normal Model[1]

3.1 Introduction

Reliable estimates of demand parameters, particularly own-price and cross-price elasticities, are essential for many applications of economic theory to issues of postal regulation. However, conventional econometric approaches typically fail to produce complete and consistent estimates of these elasticities. The failure occurs because the demand equations for a conventional model typically include each product's own-price but exclude the prices of most of the possible postal substitutes. Two recent examples of models fit to U.S. data that truncate the price variables in this way are by Pearsall (20111) and Thress (2012).

In this chapter we present a table of own-price and cross-price elasticities for selected U.S. postal services taken from a complete matrix of consistent estimates of price elasticities for 15 categories of U.S. postal services for the fiscal year (PFY) 2011. They were produced by fitting a model using an econometric method that derives from the Random-Coefficients Discrete-Choice Logit model and estimation methodology of Berry, Levinsohn and Pakes (Berry et al. (1995) Nevo (2000b) and Nevo (2000a)). To our knowledge, the BLP/Nevo

[1]Margaret M. Cigno, Elena S. Patel, and Edward S. Pearsall

approach has not previously been tried in postal economics.[2]

The BLP/Nevo model is attractive because the elasticities derived from their model are capable of representing any demand behavior, yet they are sufficiently restricted that the estimates usually conform well to *a priori* expectations of signs and magnitudes. However, the standard BLP/Nevo methodology is computationally challenging. Our Random-Coefficients Discrete-Choice Normal model replaces the demographics variables of the BLP/Nevo model with their principal components. The random elements of the coefficients are then assumed to be drawn independently from Normal distributions. This change both simplifies the computations and increases their accuracy so effectively that our model can be fit with just a small fraction of the effort typically required by the BLP/Nevo methodology. A companion paper, Cigno et al. (2012), provides a detailed explanation of the technical aspects of our model and estimation method.

Our estimates indicate that conventional econometric demand models severely underestimate the price elasticities of postal products. For example, conventional methods yield own-price elasticities for Single-Piece First-Class Letters, Flats and Parcels of around -0.25; our comparable estimate is -0.85. Our estimates are exploratory and experimental at this point in our research and should not to be considered definitive. Important refinements remain to be made to the modeling before the results can be relied upon in policy decisions. Our model has been fit using two alternative measures of postal prices: average revenue per piece (RPP) and fixed-weight index (FWI) prices. Price elasticities and cross-price elasticities have been derived from the parameter estimates for both RPP and FWI prices. The price elasticities with respect to the RPP indices are larger in magnitude than the elasticities with respect to the FWI prices. This confirms and extends an earlier finding that revenues per piece are generally less than unit elastic with respect to the U.S. postal tariff (see Pearsall 2005).

[2]This omission may partly be explained by the extreme computational demands of the BLP/Nevo estimation methodology. A thorough survey of modern econometric models of demand behavior may be found in Nevo (2011). This paper also contains an extensive bibliography of the literature regarding the Random-Coefficients Discrete-Choice Logit model.

This paper will proceed by outlining in section 2 the basic model underlying the application, including the conceptual indirect utility equation and its distribution assumptions. The specific definitions of postal products, measures of their hedonic characteristics, household demographics variables and other variables used to capture changes in postal market conditions are described in section 3. We then present and discuss our equation fits and the estimates of U.S. postal price elasticities in sections 4 and 5. Our results demonstrate that we have found a practical method for estimating the complete matrix of price elasticities of U.S. mail products. We provide suggestions for future postal modeling efforts along the line established by our model and estimation method in section 6.

3.2 The Model

To correctly represent the effects of substitution possibilities and complementarities among the relevant products in a differentiated product market, the price of each product should appear in every demand equation of a conventional econometric model. The United States Postal Service (USPS), like other posts, offers a wide array of postal products and services, some of which are close substitutes for each other. As a result, the number of cross-price elasticities required to describe demand, except at a highly aggregated level, is necessarily large. Postal prices are geographically uniform and tend to be highly correlated over time. Consequently, the equations used to describe demand must be overly restrictive with respect to the price variables in order to avoid near multicollinearity when fit by standard econometric methods. In conventional postal econometric modeling, each equation is usually specified with its own-price but without the entire set of cross-prices. With these restrictions the econometrics yields an incomplete and inconsistent set of estimated parameters including the price elasticities.

A potential solution to the problem exists in the general form of a Random-Coefficients Discrete-Choice Logit Model. The past decade of empirical research in industrial organization has been dominated by the estimation of such models following the method of Berry et al.

(1995). Their model is founded in individual choice behavior yet can be fit with only market-level price and share data in combination with observable product characteristics, population demographics and, when necessary, an effective set of instrumental variables. Most recent applications of the BLP methodology have followed the "Practitioners Guide" and have used the routine developed by Nevo (2000b) and Nevo (2000a).

In this paper, we harness a model similar to the BLP/Nevo model that we call the Random-Coefficient Discrete-Choice Normal model, to estimate own and cross-price elasticities of the U.S. Postal Service. Our application is fit using annual U.S. Postal Service volumes, prices, hedonic mail properties, aggregate demographic and economic variables. A series of exponential trends and dummy variables that describe exogenous influences on U.S. postal markets such as the introduction of new services and the entry of competitors is also incorporated. The fitted parameters of the model apply directly to linear functions describing the indirect utility resulting from the purchase of a small additional quantity of each postal service by a single U.S. household.

Following BLP/Nevo, we define the household indirect utility from the purchase and consumption of one additional unit of each of several postal products plus an "outside good." The outside good allows for the possibility that the household may not purchase an additional unit of any of the named products.

$$U_{ij} = \xi_j + \left(Y_i + C_i - P_j\right)\left(\alpha + \Pi_y D_i\right) + X_j\left(\beta + \Pi_x D_i\right) + Z_j \gamma_j + \varepsilon_{ij} \tag{3.1}$$

Eq. (3.1) describes indirect utility in every time period (or market) $t = 1,,T$, for every household $i = 1,,I$, and for every product $j = 1,,J$, including the outside good, $j = 0$. To simplify notation, the time period index, t, has been dropped. The vector contains the x hedonic properties of product j, with $X_0 = 0$. D_i is a random vector of length d of the demographics characteristics of household i. D_i includes both observable and unobservable characteristics and is mean-centered over the population, allowing us to interpret β as an x-vector of mean responses of the household to changes in the hedonic properties of the products.

Eq. (3.1) is a linear indirect utility function with random coefficients and two mean-centered disturbances. In particular, ξ_j is a disturbance to the mean indirect utility from purchasing one unit of product j, and ε_{ij} is a disturbance to the individual household's indirect utility from the purchase. The other terms represent the gains and losses to household i by purchasing and consuming an additional unit of product j.

A gain in utility occurs when a household consumes product j and is captured by the term $X_j\,(\beta + \Pi_x D_i)$. A loss in utility arises because the act of purchasing requires expenditures equal to each product's price. This loss is captured by $\left(Y_i + C_i - P_j\right)\left(\alpha + \Pi_y D_i\right)$. Y_i is household income and is the accumulated consumer surplus derived from the householdÕs current levels of consumption of the J products. The purchase of an additional unit of product j reduces the household's income and consumer surplus by P_j (with $P_0 = 0$ for the outside good). The monetary loss is converted to a utility loss when it is multiplied by the household's marginal utility of income, $\left(\alpha + \Pi_y D_i\right)$. $\left(\alpha + \Pi_y D_i\right)$ is a scalar random coefficient which combines the mean response to income changes, α , with a component that depends on the d-vector, D_i , of demographic characteristics. $(\beta + \Pi_x D_i)$ is a vector of similar random coefficients.

Finally, the term $Z_i\gamma_j$ represents exogenous effects that may either increase or decrease indirect utility in ways that are unrelated to changes in the properties of the products or the demographics characteristics of the households. In particular, Z_i is a vector of exogenous effects in the market for product j (with $Z_0 = 0$ for the outside good), and γ_j is the associated vector of non-random coefficients. In our application, Z_j often contains dummy variables and exponential trends inserted to capture the effects of either structural changes that have occurred in the U.S. postal market or changes in U.S. Postal Service product offerings.

The household indirect utility function together with the mechanics of preference in a discrete-choice framework and a few distributional assumptions implies an associated market share. We solve this model numerically according to the algorithm described in our companion paper Cigno et al 2012. Fitting the model ensures that simulated market shares do not differ noticeably from observed aggregate market shares. In addition, analytic demand elasticities are derived from the market share equations employing information specific to a time period or market. In this sense, all elasticities depend upon the values of the demographic variables, product characteristics, and external effects used to compute them.

3.3 The Data

We fit the model using two different measures of U.S postal prices. The first fit uses fixed-weight index (FWI) prices taken from worksheets accompanying an econometric demand model submitted by the USPS to the U.S. Postal Regulatory Commission (PRC) (see Thress 2012). The second fit uses revenues per piece (RPP) calculated from quarterly Revenue, Pieces and Weights (RPW) reports from USPS. Both FWI prices and RPP were converted to constant 2005 dollars using the implicit deflator for real GDP.

Table 3.1 describes the taxonomy of these models. Listed in the table are the 15 USPS product categories, the variables for price (P) and product properties (X), the demographic characteristics of households (D), and the effective dates and product associations for the exponential trends and other market influences (Z). The models were fit to a 40-year time series of observations corresponding to postal fiscal years from PFY 1972 to PFY 2011.

Most of the product categories we use are U.S. mail classes and subclasses that have existed since 1972. The presort categories for First-Class Letters (2) and Cards (4) did not exist until PFY 1976. Express mail (6) also begins with PFY 1976. Standard Carrier-Route (10) begins with PFY 1979. The shares model representing the early years was solved for only those products that existed. Finally, the shares for the outside good are derived from the shares of the other products.[3]

[3]The largest combined volume of mail pieces and postal service transactions per household in a single PFY, 1933.65, occurred in PFY 2000. Product shares, including the share for the outside good, were calculated for all PFYs using 2000 as the total number of potential pieces and transactions per household per year.

Market shares, prices and weights per piece were all measured in scaled units. The units were chosen so that a scaled unit of every product except the outside good (0) and penalty, franked and free mail (14) required the same expenditure at average prices over the sample period. The scaled unit for products 0 and 14 is a single average piece. Using scaled units reduces computational error when solving the shares model and allows us to treat the mean disturbance, ξ_j, as homoskedastic but does not alter the estimates of coefficients and elasticities.

The model requires a set of hedonic properties of the mail. To this end, we have included in X_j a subset of the hedonic properties identified in Fenster et al. (2007). Our source for the values of the hedonic properties is the more recent analysis found in Pearsall and C.L.Trozzo (2011). We include in X_j the weight per piece, a measure directly reported by USPS in its quarterly RPW reports. Also in X_j is a presortation index representing the number of sort passes on standard USPS sorting equipment left to be done by USPS for a particular class of mail. A high presort index indicates a greater number of sorts that the mail must undergo. A lower presort index indicates mail that has undergone some amount of worksharing before being delivered, or drop shipped, to the Postal Service. A distance index in X_j corresponds to the average distance traveled according to mailing zones and destination entry levels. In addition to the hedonic indices, we have included a set of shape variables (proportions of letters, cards, flats and parcels for each mail category) to measure the effect of mail shape on household utility, and a dummy variable identifying domestic mail auxiliary services.

Except for weight per piece in the RPP model, all of the measurements of hedonic properties are based upon the U.S. mail stream during PFY 2009. The two applications differ slightly with respect to the treatment of weight per piece. For the FWI application weights per piece are standardized for all periods using the most recent (2011) RPW values. For the RPP application weights per piece are variable and are calculated from the RPW reports for each postal fiscal year. Otherwise, the X_j vector does not change over the sample. The seven demographics variables listed in Table 3.2 were all suggested by conventional econometric

Table 3.1: Definitions of Products and Variables

j	**Product (Postal Service Category)**	**Price (P) and Properties of Mail (X)**		
0	Outside Good	P	FWI	Fixed-Weight Index, or
1	First-Class Single-Piece Ltrs, Flts, & Pcls		RPP	Revenue Per Piece
2	First-Class Presort Ltrs, Flts, & Pcs			
3	First-Class Single-Piece Cards	X	Std.Wgt/Pc	Weight per Piece in 2011, or
4	First-Class Presort Cards		Wgt/Pc	Weight per Piece
5	Priority Mail			
6	Express Mail		Letters	Proportion of Letters
7	Periodicals In-County		Cards	Proportion of Cards
8	Periodicals Outside County		Flats	Proportion of Flats
9	Standard non-Carrier Route Lts, Flts, & Pcls		Parcels	Proportion of Parcels
10	Standard Carrier Route Lts, Flts, & Pcls			
11	Parcel Post and Parcel Select		Presort	Number of USPS Machine
12	Bound Printed Matter			Passes to Sort
13	Media and Library Mail		Distance	Log of Number of Miles
14	Penalty Franked and Free Mail			to Destination
15	Domestic Mail Services ex EVPs and PO Box		Service	Dummy for Domestic Mail Service

Table 3.2: Demographic Variables

hhadults	Adults per Household (22+ years of age)
gdp per hh	Real Gross Domestic Product per Household (Chained 2005 Dollars)
chg gap per hh	Annual Change in Real GDP per Household (Chained 2005 Dollars)
net worth per hh	Real New Worth per Household (Chained 2005 Dollars)
broadband	Proportion of Households with Broadband Access
unemployment rate	Unemployment Rate
linear trend	Linear Trend from 1970 to 2012

Table 3.3: Service Innovations and Market Conditions (Z-Vector)

Effective Date	*Products*	*Exponential Trend Description*
07/06/1976	1,3	Start of presort discounts for bulk entry FCM presorted to the 3/5 digit ZIP code level.
03/21/1981	1,2,3,4,9	Start of presort discounts for bulk entry FCM presorted by carrier route.
02/03/1991	1,2,3,4	Start of discounts for bulk entry FCM with preprinted barcodes.
07/01/1996	1,2,3,4,7,9,10	Effective date of mail reclassifications and changes for automation resulting from MC95-1.
05/24/1994	15	Effective date for MC96-3 reclassification of special (auxiliary) services.
04/03/1988	4,10	Start of discounts for bulk mail with extended ZIP code addressing.
02/03/1991	11	Introduction of parcel select service and discounts for parcels drop shipped.
01/07/2001	5,6,9,11	Effective date of misc changes resulting from R-2000 rate case.
07/06/1981	7,8,10	Separation of In/Out-county periodicals. Start of Carrier-Route discounts.
02/17/1985	12,13	USPS allowed fliers and advertisements to be bundled with BPM catalogs.
05/14/2007	1,2,12	Effective date of changes affecting parcels resulting from R-2006 rate case.
01/28/1979	9	Start of presort discounts for bulk entry Standard mail presorted to 3/5 digit.
01/10/1999	9,15	Effective date of misc changes resulting from the R-97 omnibus rate case.
09/13/1975	5	USPS introduces Express mail service.
02/03/1991	5	Up to two pound Priority Mail envelope level rate for anywhere in the U.S.
01/01/1995	5	Priority Mail rates are leveled up to 5 lbs.
01/01/1979	6	Federal Express enters the express mail delivery market.
03/21/1981	6	USPS introduces customer pickup service for Express Mail.
04/03/1988	9	5-digit barcode discount introduced for Standard mail.
USPS	5	UPS Coverage of Lower 48 States
USPS	5	Minimum Weight for Priority Mail
	9,10	Election Year Fraction
USPS	11	UPS Man-Days lost to strike (normalized)
07/06/1976	12	Bound Printed Matter Definition Expanded
05/29/1976	12	Bound Printed Matter Pound Rates in Effect
01/01/1993	12	Sears Catalog Discontinued
11/21/1993	13	Library Rate Rule Change

Table 3.4: Mean Responses of Indirect Uility, Fixed-Weight Index Prices

P, X-vector	FWI	Weight/Pc	Letters	Cards	Flats	Parcels
	-α (P)	$\beta(x_1)$	$\beta(x_2)$	$\beta(x_3)$	$\beta(x_4)$	$\beta(x_5)$
Coefficient	-2.52	1.50	5.21	7.92	3.86	7.95
t-value	-24.56	13.44	65.05	76.68	34.23	69.14

P, X-vector	Presort	Distance	Service
	$\beta(x_6)$	$\beta(x_7)$	$\beta(x_8)$
Coefficient	-1.27	0.08	2.31
t-value	-41.34	4.51	32.53

studies of U.S. postal demand conducted by Pearsall (2005), Pearsall (20111) , and Thress (2012) (various years, most recently 2012). Quarterly time series from 1971 to 2012 are readily available at the national level for all of these variables. The quarterly time series were aggregated and averaged by PFY. "Real" GDP and Net Worth per household are measured in thousands of 2005 dollars.[4]

Finally, we have included a set of mostly exponential trend variables to account for exogenous influences on U.S. postal markets, seen in Table 3.3. These were selected by scanning the equations fit by Pearsall (20111) and selecting the exponential trends and other variables that appeared in these demand equations with statistically significant coefficients. The exponential trends were recalculated for the PFYs using the rates of adjustment re-estimated for the PRC by Pearsall in 2012. Exponential trends were first employed to control for the effects of product innovations and other market interventions in Pearsall (2005).

3.4 Results

Coefficient estimates and t-values for the mean responses of indirect utility to changes in the properties of the products using FWI prices are shown in Table 2. Each response is *ceteris paribus* and must be considered separate from other responses. The extreme t-values for many of the estimated coefficients is primarily a reflection of the exactness of the fit.

[4]The variance-covariance matrix of the demographics variables was estimated from their quarterly series in the absence of a suitable household-level sample. The roots and matrix of characteristic vectors were computed and used with the demographics vectors, D, to calculate the vectors of principal components. All seven principal components were used to fit the models.

Price affects indirect utility with a negative sign, implying, as expected, that consumers lose utility with a higher postal tariff.

The remaining coefficient estimates describe the effects of the hedonic properties on mean indirect utility. Regardless of shape, household utility depends positively on the average weight per piece, indicating that households place a higher value on services that permit heavier mailings. The four coefficients for shapes show the relative utility to the mean household of service for differently shaped pieces. Cards and Parcels are the most highly valued, and Flats are the least valued.

The negative coefficient on the presortation index reflects a preference for mail that may be workshared as opposed to single-piece mail which cannot be. Recall that our presort index reflects the amount of sorting left to be done by USPS. Our result may seem counter-intuitive when considering household utility, however, ÒhouseholdsÓ encompasses all mail recipients and senders, including bulk mailers. U.S. bulk mailers are offered discounted rates and other advantages based on the level of presortation preformed before the mail is entered into the USPS mail stream. Presortation allows for an efficient division of mail preparation tasks between USPS and the mailers themselves.

Presortation also brings with it many other advantages including bulk entry, simplified weight-based payment, faster service and qualification for a variety of other discounts including many discounts for automated addressing and drop shipping. Therefore, a preference for work shared mail reflects a preference for mail that is eligible, versus mail that is ineligible, for efficient processing, access to better service and a discounted tariff.

Although distance enters positively into the household indirect utility, the relatively low magnitude of the estimate and its t-value suggests that the distance that a piece will be transported is a hedonic characteristic of low importance to consumers. We have no a priori expectation for the sign of the dummy variable identifying domestic mail ancillary and other services.

There are over 25 different exponential trends and other exogenous variables included to

Table 3.5: (Selected) Estimated Exogenous Effects on the Market, FWI

Exp Trend from 03/21/1981	**Coefficient**	**t-value**
First-Class Single-Piece Letters	1.02	7.4088
First-Class Single-Piece Cards	0.37	2.30
First-Class Workshared Letters	-0.01	-0.15
First-Class Workshared Cards	0.34	3.32
Express Mail	-0.34	-2.33
Standard non-Carrier Route	0.14	0.90
Exp Trend from 07/01/1996	**Coefficient**	**t-value**
First-Class Single-Piece Letters	0.81	6.51
First-Class Single-Piece Cards	-0.24	-1.93
First-Class Workshared Letters	-1.02	-8.22
First-Class Workshared Cards	-2.07	-16.98
Periodicals Within County	-0.14	-2.26
Standard non-Carrier Route	-0.27	-1.95
Standard Carrier Route	-0.55	-8.01

account for various structural changes in the U.S. postal market. Table 3, based on our fit using FWI prices, highlights only a few statistically significant parameters to illustrate the importance of exogenous effects on U.S. postal markets.

March 21, 1981 marks the start of presort discounts for bulk entry Standard (formerly Third Class) mail presorted to the 3 and 5 digit levels. Our estimates indicate that this change positively affected household utility for First-Class Mail products. On July 6, 1981, the separation of In-County Periodicals from Outside-County Periodicals was implemented, which increased household indirect utility for all Periodicals. July 1, 1996 was the effective date for mail reclassifications and changes that reconfigured automation-based discounts. Modeling this resulted in mean household effects with very high t-values for eight different products.

In general, the estimates and t-values for the coefficients of the variables in the vectors, Z_j, do a remarkably precise job of separating variables that are statistically important from those that are not. The pattern of t-values is unlike the pattern one would get from a conventional econometric fit. Many of the estimated components are statistically significant at extremely high levels. An examination of all estimated exogenous effects reveals that others are quite close to zero, and that there are surprisingly few coefficients with t-values in the middle, with magnitudes in the ambiguous range of one to two. The high t-values confirm previous findings of shifts in utility due to these effects.

3.5 Estimated Price Elasticities

Table 4 shows a selection of estimates of own-price and cross-price elasticities based on the FWI prices. Own-price elasticities are shown along the diagonal; the off-diagonal elements display the cross-price elasticity of demand for products listed down with respect to the prices of products listed across. The right columns show respectively the sum, by product, of the own-price and all cross-price elasticities using FWI and, for illustrative purposes, RPP.

Overall, our estimates of price elasticities are larger in magnitude than the estimates that the USPS and the PRC have customarily relied on to recommend and set postal rates. Consider the elasticity of First-Class Single-Piece Letters, Flats, and Parcels with respect to its FWI price. Our estimate is -0.846. While this still reflects an inelastic aggregate demand, it is much higher than previous elasticity estimates. For example, the most recent estimate from USPS of this own-price elasticity is -0.189.[5]

Nominal postal prices have changed infrequently, but usually in concert, after a period of public consideration and due process dictated by U.S. postal law. Since 2006, postal rates have been tied to CPI-based class-level price caps imposed by the Postal Accountability and Enhancement Act (PAEA). As a result, the movements of all real postal prices are highly correlated over time.

The postal demand models currently in use in the United States mostly include just own-prices in the demand equations, and are fit to postal time series. When these equations are fit the own-prices become proxies for the movements, not only of each product's own-price, but also for movements in the prices of the product's postal substitutes and complements. These movements are nearly proportionate to movements in the own-price of the postal products themselves. The conventional econometric own-price elasticity represents (approximately) the sum of the own-price elasticity and all of its postal cross price elasticities. This, in effect,

[5]See Thress (2012)

Table 3.6: Own & Cross-Price Elasticities Using Fixed-Weight Index Prices, PFY 2011

Own-Price or Cross-Price Product

		1	2	3	4	7	8	9	10	11	12	13	14	15	**FWI Sum**	**RPP Sum**
First-Class Single-Piece Ltrs, Flats, & Pcls	1	-0.846	0.147	0.005	0.006	0.001	0.018	0.134	0.050	0.045	0.006	0.004	0.000	0.068	-0.285	-0.763
First-Class Presort Ltrs, Flats, & Pcls	2	0.137	-0.878	0.006	0.007	0.001	0.021	0.152	0.057	0.052	0.007	0.005	0.000	0.079	-0.268	-0.492
First-Class Single-Piece Cards	3	0.258	0.326	-2.288	0.024	0.005	0.064	0.313	0.137	0.140	0.022	0.019	0.000	0.192	-0.557	-1.105
FIrst-Class Presort Cards	4	0.214	0.263	0.016	-1.646	0.003	0.046	0.249	0.106	0.107	0.016	0.013	0.000	0.147	-0.292	-0.328
Periodicals In-County	7	-0.290	0.367	0.030	0.030	-2.920	0.080	0.356	0.162	0.171	0.029	0.026	0.000	0.288	-0.871	-1.040
Periodicals Outside-County	8	0.225	0.279	0.017	0.018	0.004	-1.549	0.265	0.113	0.114	0.017	0.014	0.000	0.157	-0.142	-0.811
Standard non-Carrier Route Lrs, Flats & Pcls	9	0.178	0.212	0.011	0.013	0.002	0.033	-1.131	0.083	0.083	0.012	0.009	0.000	0.113	-0.251	-0.467
Standard Carrier-Route Lts, Flats & Pcls	10	0.193	0.232	0.013	0.015	0.003	0.039	0.217	-1.441	0.094	0.014	0.011	0.000	0.126	-0.338	-0.543
Parcel Post & Parcel Select	11	0.199	0.241	0.014	0.016	0.003	0.041	0.226	0.097	-3.516	0.015	0.012	0.000	0.133	-2.364	0.045
Bound Printed Matter	12	0.238	0.290	0.020	0.022	0.005	0.057	0.276	0.125	0.131	-2.013	0.017	0.000	0.171	-0.454	-0.316
Media & Library Mail	13	0.269	0.336	0.026	0.027	0.006	0.070	0.324	0.147	0.155	0.026	-3.549	0.000	0.205	-1.709	-19.60
Penalty, Franked, and Free Mail	14	0.275	0.343	0.028	0.028	0.007	0.074	0.330	0.153	0.162	0.027	0.024	0.000	0.212	1.920	2.334
Domestic Mail Services ex Evps & Box Rents	15	0.197	0.239	0.013	0.015	0.003	0.040	0.224	0.095	0.095	0.014	0.011	0.000	-1.548	-0.452	0.782

masks the true own-price elasticity of each postal product. To see this effect one need only examine the sums of own-price and cross-price elasticities in the next to the last column of Table 4. These sums resemble conventional own-price elasticities. The sum for First-Class Single-Piece Letters, Flats and Parcels, -0.285, is not much different from the USPS estimate of -0.189. The USPS underestimate of the own-price elasticity is approximately equal to the combined cross price elasticities of First-Class Single-Piece Letters, Flats and Parcels with respect to the prices of all other categories of mail. Our estimates suggest that conventional methods have seriously underestimated virtually all of the own-price elasticities for U.S. postal services.

The cross-price elasticity estimates in Table 4 reflect sensible substitution patterns amongst the products. For First-Class Single-Piece Letters, Flats, and Cards, the cross-price elasticity with respect to the price of First-Class Presort Letters, Flats, and Cards is positive and small, 0.147, suggesting that these goods are substitutes. Similarly, the cross-price elasticity with respect to Standard non-Carrier-Route Letters, Flats, and Parcels is 0.134. However, due to content restrictions for Periodicals mail, it would be a near impossibility for a First-Class Single-Piece letter to be sent as an In-Class Periodical, and indeed the associated cross-price elasticity, 0.001, is virtually nonexistent. Likewise, it would be nearly impossible for a piece of In-County Periodical mail to be diverted to the First-Class Single-Piece Cards subclass, and indeed, this estimated cross-price elasticity, 0.030, is negligible. Conversely, the cross-price elasticity for In-County Periodical subclass with respect to First-Class presort is 0.367 and with respect to Standard non-Carrier-Route mail is 0.356. The cross-price elasticity with respect to First-Class single-piece is 0.290 and with respect to Standard Carrier-Route Letters, Flats, and Parcels is 0.162. For the In-County Periodicals subclass, these cross-price elasticities reflect the most-likely substitute mail sub-classes. Due to mail preparation requirements and distribution densities, an In-County Periodical is much more likely to convert to presort First-Class or regular Standard.

Finally, based on the estimates seen in the last two columns of Table 4, we make the observation that the elasticities with respect to the FWI are smaller in magnitude than are the elasticities with respect to the RPP. The mathematical relationship between the elasticities that underlies this conclusion is

$$\frac{\partial \text{Volume}}{\partial \text{RPP}}\frac{\text{RPP}}{\text{Volume}} = \frac{\frac{\partial \text{Volume}}{\partial \text{FWI}}\frac{\text{FWI}}{\text{Volume}}}{\frac{\partial \text{RPP}}{\partial \text{FWI}}\frac{\text{FWI}}{\text{RPP}}}$$

When the elasticity of RPP with respect to the FWI price is less than one, the demand elasticity with respect to RPP exceeds the demand elasticity with respect to the FWI price.

This confirms and extends an earlier finding in Pearsall (2005) that revenues per piece are less than unit elastic with respect to the U.S. postal tariff as represented by the FWI prices. USPS tariffs that apply to broadly-defined mail categories are actually quite complex. Consequently, when the tariff changes, mailers are able to re-optimize the structure of their mailings, either by reducing content or by otherwise adjusting shapes, weights, and/or worksharing. In the face of increased rates this usually results in an increase in RPP that is smaller than the increase in the FWI price. This less-than-unit-elastic relationship between RPP and FWI helps to explain why both the PRC and USPS tend to over-estimate the changes in postal revenues from higher rates.

3.6 Further Research

This application to postal services of our Random-Coefficients Discrete-Choice Normal model and our method of estimation can be further refined. For example, we specified the model using mail class definitions chosen to ease the use of postal data assembled by PFY from 1972 to 2011. Alternatively, the same model could be fit using quarterly data and the post-2006 definitions of mail classes that arose from the Postal Accountability and Enhancement Act (PAEA).

Our finding that conventional models underestimate postal price elasticities depends very much on the selection of product categories for our model. Our division of postal traffic into 14 mail and one service categories is not particularly fine. In fact it was chosen to provide a convenient example for the model and estimation methodology. USPS accounting supports much finer divisions of both mail volumes and postal ancillary services. As the mail stream and service transactions are disaggregated we would expect to find that our own-price elasticities will increase in magnitude. This should happen because disaggregation will tend to introduce products that are ever closer substitutes. Ideally, our model should be refit using product definitions that reflect the level of aggregation found in postal price decisions. This level is much finer than the 15 products we have used in our initial research.

It may be desirable to include a broader set of demographic variables and/or harness a suitable household-level sample to better estimate the variance-covariance matrix calculate the principal components. We have also employed only a subset of the hedonic properties found underlying the U.S. tariff by Fenster et al (2007. Further explorations may suggest some extensions to the subset that we chose. Also, the low t-values of many of the estimates of the coefficients included in the vectors $\gamma_1, ..., \gamma_J$ indicate that the model can be fit just about as well using a shorter list of exogenous market effects.

The effect of the regulatory environment on rates and fees is an important aspect of our research that needs further study. To simplify the method of estimation, we omitted the use of instrumental variables and assumed that all postal prices are exogenous.[6] Between 1970 and 2006 the nominal rates were predetermined by a regulatory process; since 2006, they have been linked to the Consumer Price Index under a formula stipulated by Congress. All econometric demand studies of U.S. postal volumes to date have treated postal rates as error-free. The Generalized Method of Moments is an estimation method that avoids this probably-incorrect assumption. It can be applied to our model, provided a set of suitable instrumental variables can be identified. Possible data that could be used as effective instruments include unit costs, productivity measurements, and contract labor rates.

Finally, the efficiency of our estimation methodology can be improved by adding a second

[6] Vertually everything said here about prices also applies to weights per piece.

stage. The first stage would remain the least-squares methodology described in Cigno et al. (2012). The residuals from the first stage would then be used to estimate the variance-covariance matrix of the mean disturbances. The second stage would be to refit the model with the estimation methodology modified to Generalized Least Squares.

3.7 Conclusion

Our estimates of price elasticities are markedly different from those that are produced by conventional econometric methods. The estimates suggest that U.S. postal products are much more sensitive to selective price changes than conventional demand models predict. Our estimates of own-price elasticities using FWI prices range from -0.8 to -3.5, with most in the elastic range. We have also indirectly confirmed an earlier finding that revenues per piece are generally less than unit elastic with respect to the prices in the U.S. postal tariff. The implications for postal pricing and regulation are potentially significant.

Our estimates should be regarded as the early results of an initial exploration. Nevertheless, they stand as a demonstration that a new and effective method has been found to estimate a full set of own-price and cross-price elasticities for postal services.

APPENDICES

APPENDIX A

Robustness Analyses

Table A.1: Evidence of Balanced Propensity Score

p-values shown in parentheses

	p	**p^2**	**p^3**	**p x M**	**p^2 x M**	**p^3 x M**
Total Time	-711.9	3374.5	-4472.7	106.7	-723.2	830.3
	(0.00)	(0.00)	(0.00)	(0.34)	(0.49)	(0.70)
Discharges	98.2	-46.7	-153.6	6.3	-116.9	366.5
	(0.00)	(0.25)	(0.03)	(0.61)	(0.31)	(0.12)
Medicare Discharge Share	-127.6	509.2	-566.5	2.9	60.8	-339.7
	(0.00)	(0.00)	(0.01)	(0.94)	(0.85)	(0.62)
Market Power	96.0	-2,14.6	72.6	-4.3	0.0	39.9
	(0.00)	(0.00)	(0.54)	(0.83)	(1.00)	(0.92)
HMO Penetration	324.1	-1,801.2	2,540.2	-42.0	291.9	-368.7
	(0.00)	(0.00)	(0.00)	(0.22)	(0.36)	(0.57)
Under 65, No Insurance	-85.1	384.3	-519.6	-4.7	62.4	-144.9
	(0.00)	(0.00)	(0.00)	(0.73)	(0.62)	(0.57)
Urban	20.1	-92.3	116.9	-0.1	-6.5	26.5
	(0.00)	(0.00)	(0.00)	(0.92)	(0.36)	(0.07)
Case Mix Index	5.1	-13.2	16.8	-0.2	3.0	-6.3
	(0.00)	(0.00)	(0.00)	(0.55)	(0.37)	(0.35)
HHI	-7,876.8	38,169.7	-56,241.7	1,634.3	-12,823.0	16,417.3
	(0.00)	(0.00)	(0.00)	(0.56)	(0.62)	(0.76)
For-Profit	1.9	-16.6	26.9	0.2	-5.1	15.2
	(0.00)	(0.00)	(0.00)	(0.81)	(0.50)	(0.32)
Government	-14.3	73.0	-99.3	1.4	-4.9	-5.2
	(0.00)	(0.00)	(0.00)	(0.13)	(0.57)	(0.77)

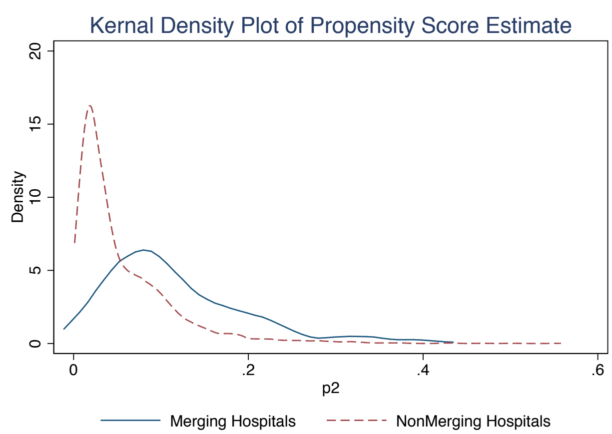

Figure A.1: Evidence supporting the assumption of common support.

Table A.2: Robustness Analysis

Correlation between Estimated Merger Effect and Outcome Net of Controls
(p-value of merger effect shown)

Price

	Correlation Level						
	0.01	**0.02**	**0.03**	**0.04**	**0.05**	**0.06**	**0.07**
6 Years After	0.105	0.131	0.16	0.185	0.205	0.219	0.233
7 Years After	0.116	0.149	0.184	0.215	0.24	0.257	0.274
8 Years After	0.077	0.101	0.128	0.153	0.173	0.186	0.2
9 + Years After	0.036	0.048	0.063	0.077	0.088	0.096	0.105
Joint F-Test	0.308	0.373	0.438	0.490	0.528	0.553	0.577

Net Income

	Correlation Level								
	0.05	**0.10**	**0.15**	**0.20**	**0.25**	**0.30**	**0.35**	**0.40**	**0.45**
6 Years After	0.063	0.081	0.09	0.096	0.099	0.101	0.103	0.106	0.108
7 Years After	0.014	0.02	0.023	0.024	0.025	0.026	0.026	0.027	0.028
8 Years After	0.32	0.382	0.408	0.421	0.426	0.428	0.429	0.428	0.428
9 Years Plus After	0.022	0.031	0.035	0.038	0.039	0.04	0.04	0.041	0.042
Joint F-Test	0.046	0.063	0.071	0.077	0.081	0.084	0.088	0.095	0.100

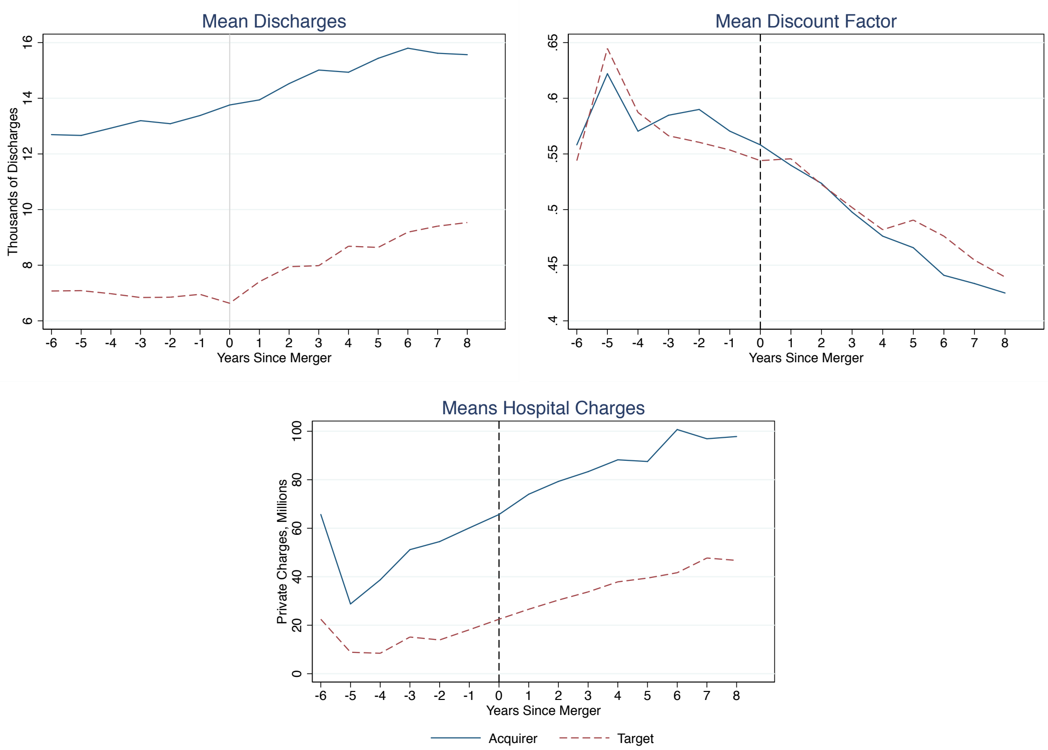

Figure A.2: Target and Acquiring Hospital Price Inputs

APPENDIX B

Generalized Duopoly Equilibrium

B.1 Short Run Analysis

Recall that the short run is defined as the time when a firm can make adjustments to price, but not to quality. This is the second stage of the game, described by the Nash Equilibrium prices. In the case of the duopoly, Tirole (1988) derived this explicitly. From this solution, I simplify the derivation relying on the assumption of unit demand, $\underline{\theta} + 1 = \overline{\theta}$.

Given this transformation, the Nash Equilibrium prices derived from the stage two problem, Eq. (2.3), are

$$p_h^* (q_h, q_l) = c + \frac{1}{3} (2 + \underline{\theta}) (q_h - q_l)$$

and

$$p_l^* (q_h, q_l) = c + \frac{1}{3} (1 - \underline{\theta}) (q_h - q_l)$$

Note here that $\underline{\theta} < 1$ ensures that $p_{l,2}^* \geq 0$.

These Nash equilibrium prices imply the following stage one demand functions

$$D_h^* = \frac{1}{3} (2 + \underline{\theta})$$

and

$$D_l^* = \frac{1}{3}\left(1 - \underline{\theta}\right)$$

B.2 Long Run Homogeneous Analysis

From Eq. (2.8) I derive the equilibrium quality choices of the two firms

$$q_{h,2}^* = \frac{4 + \beta + \underline{\theta}\left(4 + \underline{\theta}\right)}{B}$$

and

$$q_{l,2}^* = \frac{\beta + \underline{\theta}\left(2 - \underline{\theta}\right) - 1}{B}$$

Given equilibrium quality, I can derive equilibrium prices from Eq. (2.4) and Eq. (2.5)

$$p_h^* = c + \frac{10 + \underline{\theta}\left(9 + 2\underline{\theta}\left(3 + \underline{\theta}\right)\right)}{3B}$$

and

$$p_l^* = c + \frac{5 - \underline{\theta}\left(3 + 2\underline{\theta}^2\right)}{3B}$$

Neither of these equilibrium prices depends on β, the quality preference parameter.

B.3 Long Run Heterogeneous Analysis

The duopoly heterogeneous market contains one nonprofit firm $\beta_N \neq 0$ and one for-profit firm $\beta_F = 0$. In this market, the first order conditions are unaltered from the homogeneous market, but there exist two possible outcomes: (1) $q_h^*\left(\beta_F = 0\right), q_l^*\left(\beta_N\right)$ or (2) $q_h^*\left(\beta_N\right), q_l^*\left(\beta_F = 0\right)$.

B.3.1 For-Profit High Quality Firm

In order for the for-profit firm to be highest quality producer, it must be true that:

$$\begin{aligned} q_h^*\left(\beta_F=0\right) &> q_l^*\left(\beta_N\right) \\ \frac{4+\underline{\theta}\left(4+\underline{\theta}\right)}{B} &> \frac{\beta_N+\underline{\theta}\left(2-\underline{\theta}\right)-1}{B} \\ 5+2\underline{\theta}+2\underline{\theta}^2 &> \overline{\beta_N} \end{aligned}$$

This implies that there exists some threshold quality preference below which a nonprofit firm could be the lowest quality producer. In other words, when the nonprofit firm has a low preference for quality, there are multiple equilibria.

B.3.2 For-Profit Low Quality Firm

In the heterogeneous equilibrium, the low quality firm is for-profit, $\beta_l = \beta_{FP} = 0$. In this case, q_h^* is unchanged, but

$$q_{l,2}^* = \frac{\underline{\theta}\left(2-\underline{\theta}\right)-1}{B}$$

At most, $\underline{\theta} = 1$, and in this case, $q_l^* = 0 < \underline{s}$. For any $\underline{\theta} < 1$, $q_l^* < 0 < \underline{s}$. Thus, in the heterogeneous equilibrium, $q_l^* = \underline{s}$ with the following equilibrium prices:

$$p_h^* = c + \left(2+\underline{\theta}\right)\left(\frac{1}{B}\left(4+\beta+\underline{\theta}\left(4+\underline{\theta}\right)\right)-\frac{1}{3}\underline{s}\right)$$

and

$$p_l^* = c + \frac{1}{3}\left(4+\left(1-\underline{\theta}\right)\left(\beta-B\underline{s}\right)-\underline{\theta}^2\left(3+\underline{\theta}\right)\right)$$

Prices are increasing in β, in contrast to the homogeneous market.

B.4 Total Welfare Analysis

I recall the formula for Total Welfare, Eq. (2.2) here:

$$\text{Total Welfare} = \int_{\underline{\theta}}^{\bar{\theta}} (\theta q^* - p^*)\, d\theta + U^H \left(q^*_{h,2}, p^2_{h,2} \right) + U^L \left(q^*_{l,2}, p^*_{l,2} \right)$$

B.4.1 Homogenous Market

Given the equilibrium defined in Appendix B, the total welfare in the homogenous equilibrium is

$$\text{Total Welfare}_2 = \frac{18\underline{\theta}^4 + 36\underline{\theta}^3 + 16\underline{\theta}^2 + 36\underline{\theta}\,(4+\beta) + 45 + 2\beta\,(9+\beta)}{18B} - c$$

From this, it is immediately seen that total welfare is an increasing function of β, the quality taste parameter. Further, for sufficiently small marginal cost, c, total welfare will always be positive.

B.4.2 Heterogeneous Market

Similarly, the total welfare in the heterogeneous duopoly market where the low quality firm is a for-profit firm is

$$\text{Total Welfare}_2 = \frac{9\underline{\theta}^4 + 60\underline{\theta}^3 + 2\underline{\theta}^2\,(72 - 5B\underline{s} + \beta) + 4\underline{\theta}\,(36 + 2B\underline{s} + 7\beta) - B\underline{s}\,(B\underline{s} - 2) + (4+\beta)\,(12+\beta)}{18B}$$

Total welfare in the heterogeneous case will be positive for sufficiently small values of c, and is increasing in β. This is qualitatively the same result that was seen the homogenous market.

APPENDIX C

Three Firm Oligopoly Equilibrium Outcome

C.1 Short Run Analysis

To derive the demand functions for each of the high, medium, and low quality firms, I first identify the critical consumer for each good. In particular, consumers between U and θ_{hm} will buy the high quality good, consumers between θ_{hm} and θ_{ml} purchase the medium quality good, and, assuming the market is covered, all consumers with taste for quality below θ_{ml} will buy the low quality good.

Indifferent Consumer:	$\theta_{hm}q_h - p_h = \theta_{hm}q_m - p_m$	$\theta_{ml}q_m - p_m = \theta_{ml}p_l - p_l$	
Demand	$D_h = \overline{\theta} - \frac{p_h - p_m}{q_h - q_m}$	$D_m = \frac{p_h - p_m}{q_h - q_m} - \frac{p_m - p_l}{q_m - q_l}$	$D_l = \frac{p_m - p_l}{q_m - q_l} - \underline{\theta}$

In the short run, where quality levels are fixed, each firm selects p_i to maximize Eq. (2.3) subject to the demand functions described above. Then for fixed levels of quality, the firm's best response functions can be derived from the first order condition for the utility maximization problem for the firm: This will yield the following price best response functions:

$$p_{h,3}(p_m, p_l) = \frac{\overline{\theta}(q_h - q_m) + p_m}{2} + \frac{c}{2}$$

$$p_{m,3}(p_h, p_l) = \frac{p_h(q_m - q_l) + p_l(q_h - q_m)}{2(q_h - q_l)} + \frac{c}{2}$$

$$p_{l,3}(p_h, p_m) = \frac{p_m - \underline{\theta}\,(q_m - q_l)}{2} + \frac{c}{2}$$

The Nash Equilibrium prices are derived from the intersection of the first order conditions for all three firms, and are shown below

$$p^*_{h,3} = c + \frac{(q_h - q_m)\,(q_m - q_l)}{6\,(q_h - q_l)} + \frac{\overline{\theta}\,(q_h - q_m)}{2}$$

$$p^*_{m,3} = c + \frac{(q_h - q_m)\,(q_m - q_l)}{3\,(q_h - q_l)}$$

$$p^*_{l,3} = c + \frac{(q_h - q_m)\,(q_m - q_l)}{6\,(q_h - q_l)} - \frac{\underline{\theta}\,(q_m - q_l)}{2}$$

I now use the Nash Equilibrium prices to derive long run (first stage) demand. This defines the profit maximization problem for each firm in the first stage. Plugging the Nash Equilibrium prices into the demand functions for each firm yields the follow first stage demand functions:

$$D_h = \frac{1}{2}\overline{\theta} + \left(\frac{q_m - q_l}{q_h - q_l}\right)\left(\frac{1}{6}\right)$$

$$D_m = \frac{1}{3}$$

$$D_l = \left(\frac{q_h - q_m}{q_h - q_l}\right)\left(\frac{1}{6}\right) - \frac{1}{2}\underline{\theta}$$

The short run analysis solves the second stage optimal prices. Via backwards induction, I next solve for stage one optimal quality choices, where each firm maximizes Eq. (2.3) given Eq. (2.13), Eq. (2.14), and Eq. (2.15).

C.2 Long Run Homogenous Equilibrium

Because low quality must be greater than $\underline{s}$, I redefine the quality choice to be $q_i = x_i + \underline{s}$ where $x_l = \lambda$, $x_m = \mu\chi + \lambda$, $x_h = \chi + \lambda$, $\lambda, \chi > 0$, and $\mu \in (0, 1]$. This enforces the constraints on the choice of quality so that $\underline{s} \leq q_l \leq q_m \leq q_h$. I will use these substitution forms, x_i to simplify the first order conditions, $\frac{\partial \Pi_i}{\partial q_i}$

C.2.1 Interior solution

The first order condition for the low quality firm is

$$\frac{1}{36}\left((1-\mu)^2(2\mu-1) - 4B(\chi+\underline{s}) + 4\beta + 6\underline{\theta}(\mu-1)^2 - 9\underline{\theta}^2\right) = 0 \tag{C.1}$$

The first order condition for the medium quality firm is

$$\frac{1}{9}\left(1 - 2\mu - B(\lambda + \chi\mu + \underline{s}) + \beta\right) = 0 \tag{C.2}$$

Finally, the first order condition for the high quality firm is

$$\frac{1}{36}\left(9 + \mu^2(5+2\mu) - 4B(\chi+\lambda+\underline{s}) + 4\beta + 6\underline{\theta}\left(3+\mu^2\right) + 9\underline{\theta}^2\right) = 0 \tag{C.3}$$

Simultaneously solving the above first order conditions reduces to the following third order polynomial condition in μ:

$$-12\mu^3 + \mu^2\left(9 - 18\underline{\theta}\right) - \mu\left(22 + 18\underline{\theta}^2\right) + 5 - 6\underline{\theta} + 9\underline{\theta}^2 \tag{C.4}$$

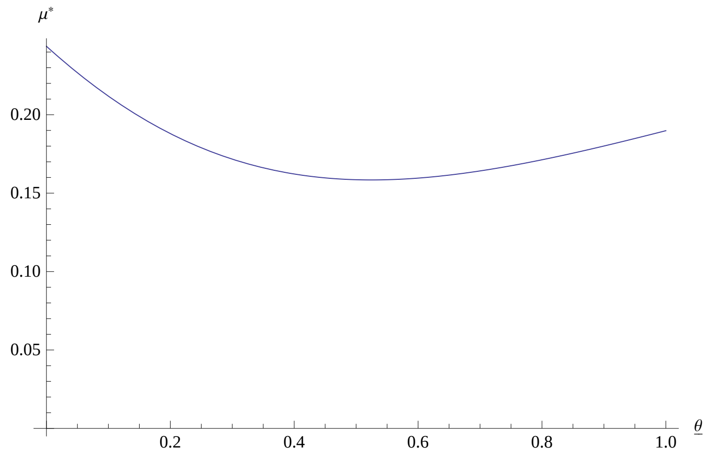

Figure C.1: Optimal μ^* as a function of $\underline{\theta}$

This third order polynomial has only one real root, $\mu^*(\underline{\theta})$, and for a particular value of $\underline{\theta}$, this root will define the equilibrium quality choice for all three firms. The root of the polynomial, $\mu^*(\underline{\theta})$ is shown in Fig. C.1.

For example, $\underline{\theta} = 0.05$ implies that $\mu^* \approx 0.227$ and defines the three interior quality choices as functions of μ^* itself:

$$q^*_{h,3}(\mu^*) = \left[\chi(\mu^*) + \lambda(\mu^*)\right] + \underline{s} \approx \frac{2.554 + \beta}{B} \tag{C.5}$$

$$q^*_{m,3}(\mu^*) = \left[\chi(\mu^*)\,\mu^* + \lambda(\mu^*)\right] + \underline{s} \approx \frac{0.546 + \beta}{B} \tag{C.6}$$

$$q^*_{l,3}(\mu^*) = \left[\lambda(\mu^*)\right] + \underline{s} \approx \frac{\beta - 0.042}{B} \tag{C.7}$$

These are the numerical interior equilibria for the 3 firm homogenous market case that are described in the body of the text.

Finally, having solved for the interior equilibrium quality choices, I can now plug these into the Nash Equilibrium prices derived in the first stage, Eq. (2.13) Eq. (2.14), and Eq. (2.15) to solve for the equilibrium prices in the homogeneous market:

$$p_{h,3}^{*}\left(\mu^{*}\right)\approx\frac{1.130}{B}+c$$

$$p_{m,3}^{*}\left(\mu^{*}\right)=\frac{0.152}{B}+c$$

$$p_{l,3}^{*}\left(\mu^{*}\right)=\frac{0.061}{B}+c$$

C.2.2 Corner Solution

In the case where $\lambda^{*}<0$, the equilibrium outcome of the market is a corner solution: $\lambda^{*}=0 \implies q_{l}^{*}=\underline{s}$. This does not alter the first-order conditions for the medium or high quality firm. It does, however, alter the polynomial that determines the equilibrium solution:

$$-2\mu^{4}-\mu^{3}\left(5+6\underline{\theta}\right)-\mu\left(17+4\beta+18\underline{\theta}+9\underline{\theta}^{2}-4B\underline{s}\right)+\left(4+4\beta-4B\underline{s}\right)$$

When $B\underline{s}\in(0,1]$, there is one positive real root for this quartic polynomial, seen in Fig. C.2. Having solved for this root, the algorithm for defining equilibrium price and quantity is as in the homogeneous interior solution concept.

C.3 Long Run Heterogenous Equilibrium, 2 Nonprofit and 1 For-Profit (2NF)

This heterogenous market is defined by $\beta_{l}=\beta_{FP}=0$ and $\beta_{m}=\beta_{h}=\beta_{NP}=\beta$. As in the two firm case, I proceed by assuming that the for-profit firm is the lowest quality firm.

As in the homogeneous market, I redefine the quality choice to be $q_{i}=x_{i}+\underline{s}$ where $x_{l}=\lambda$, $x_{m}=\mu\chi+\lambda$ and $x_{h}=\chi+\lambda$, $\lambda\geq 0$, and $\mu\in(0,1]$. This enforces the constraints on the choice of quality so that $\underline{s}\leq q_{l}\leq q_{m}\leq q_{h}$. I use these substitution forms, x_{i} to simplify the first order conditions, $\frac{\partial\Pi_{i}}{\partial q_{i}}$

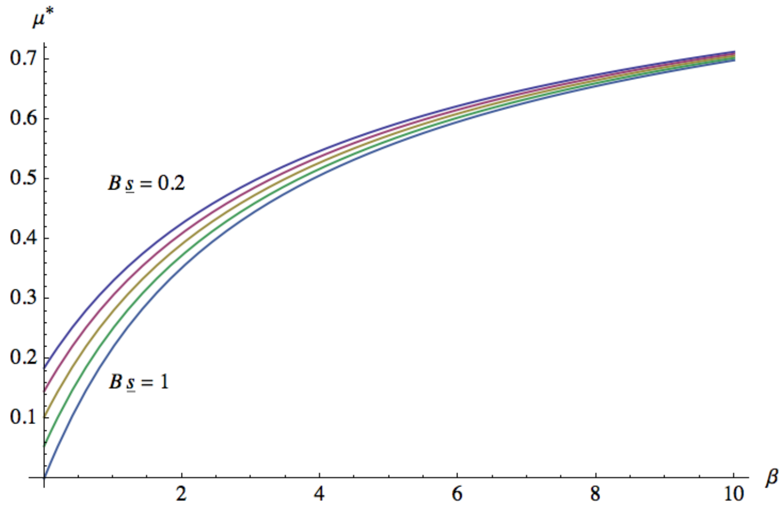

Figure C.2: Homogeneous Constrained Market: μ_{2N}^* as a function of β

C.3.1 Interior Solution

In heterogeneous two nonprofit market, the first order condition for the high (Eq. (C.3)) and medium firm (Eq. (C.2)) will be unchanged from the homogeneous market. However, $\beta_l = 0$ for the for-profit firm, affecting the first-order condition for the low-quality firm.

$$\partial\lambda : \frac{1}{36}\left((1-\mu)^2(2\mu-1) - 4B(\lambda+\underline{s}) + 6\underline{\theta}(1-\mu)^2 - 9\underline{\theta}^2\right) = 0 \tag{C.8}$$

Simultaneously solving all 3 first order conditions yields the following third order polynomial condition, the real root of which defines the equilibrium quality choices:

$$-12\mu^3 + \mu^2(9-18\underline{\theta}) - \mu\left(22+4\beta+18\underline{\theta}^2\right) + 5 + 4\beta - 6\underline{\theta} + 9\underline{\theta}^2 = 0 \tag{C.9}$$

The roots of this polynomial depend on two parameters, $\mu_{2N}^*(\underline{\theta}, \beta)$, and the singular real root is shown in Fig. C.3. This polynomial has one positive root that is increasing in β and is less than one for all valid parameter values.

To determine whether an interior solution exists, I examine when $\lambda^* < 0$, or from Eq.

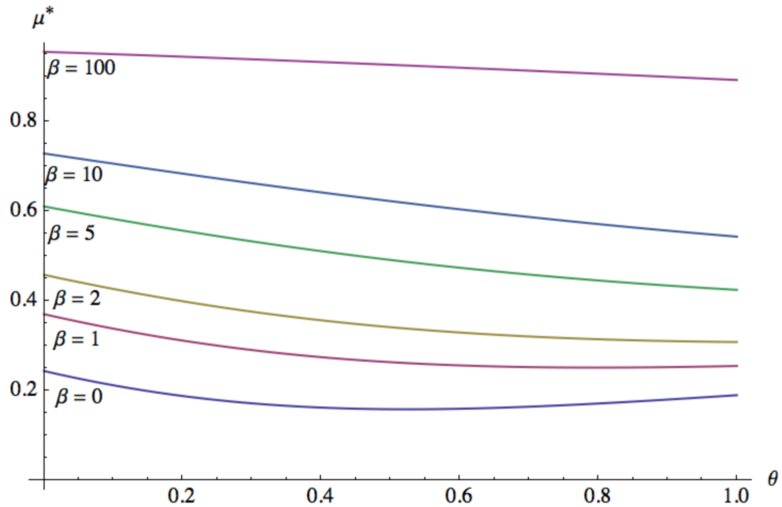

Figure C.3: 2 Nonprofit 1 For Profit Unconstrained Market: μ^* as a function of $\underline{\theta}$

(C.8):

$$\left(1-\mu^*\right)^2\left(2\mu^*-1\right)-4B\underline{s}+6\underline{\theta}\left(1-\mu^*\right)^2-9\underline{\theta}^2<0 \tag{C.10}$$

Because μ_{2N}^* depends on $\underline{\theta}$ and β, the sign of λ^* depends on 3 parameters: $\underline{\theta}, \beta, B\underline{s}$. When $\underline{\theta} = 0.05$, the maximum possible range of μ_{2N}^* is approximately from 0.226 to 1 (seen in Fig. C.4), and for this range the sign of λ^* is always negative (seen in Fig. C.5), indicating that the equilibrium solution is always constrained.

C.3.2 Corner Solution

In a corner solution, the quality constraint binds for the for-profit firm. In this case, I simplify the substitution form in the following way: $x_l = 0, x_m = \mu\chi, x_h = \chi$ where $\mu \in [0,1]$. Given this substitution form, $q_l = \underline{s}, q_m = \mu\chi + \underline{s}, q_h = \chi + \underline{s}$. The first order conditions for the medium and high quality firm remain as in the interior case.

Simultaneously solving these two first order conditions implies the same fourth-order polynomial as was seen in the constrained homogeneous case :

$$-2\mu^4-\mu^3\left(5+6\underline{\theta}\right)-\mu\left(17+4\beta+18\underline{\theta}+9\underline{\theta}^2-4B\underline{s}\right)+\left(4+4\beta-4B\underline{s}\right)$$

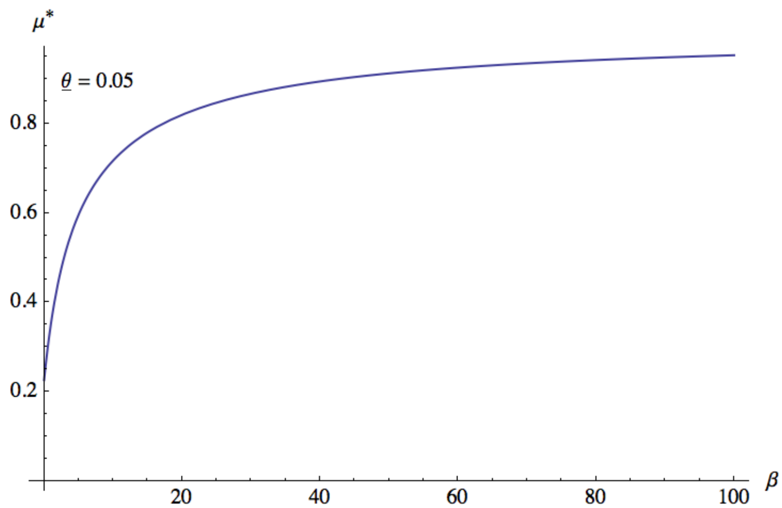

Figure C.4: 2 Nonprofit 1 For-Profit Unconstrained Market: μ^* as a function of β when $\underline{\theta} = 0.05$

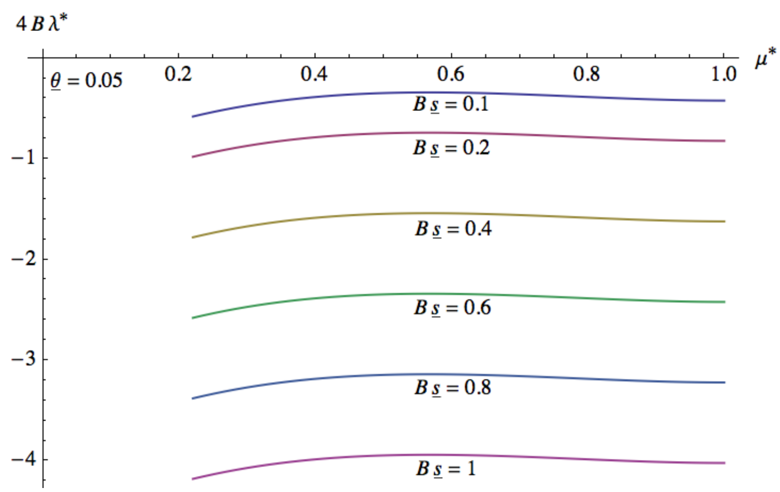

Figure C.5: Sign of λ^* when $\underline{\theta} = 0.05$ showing an always constrained solution

Having solved for this root, seen in Fig. C.2, the algorithm for defining equilibrium price and quantity is as in the homogeneous interior solution concept.

C.4 Long Run Heterogeneous Equilibrium, 1 Nonprofit , 2 For-Profit (N2F)

This heterogenous market is defined by $\beta_l = \beta_m = \beta_{FP} = 0$ and $\beta_h = \beta_{NP} = \beta$. As in the duopoly case, I proceed by assuming that the FP firms are going to be the lowest and medium quality firms. The first stage first order conditions for the high quality firm, which has a positive taste for quality, β, is unchanged from the homogeneous market: Eq. (C.3). However, because $\beta_L = \beta_M = 0$, the first order condition for the medium and low-quality firm will be altered from the homogeneous market.

As in the three firm homogeneous solution, I redefine the quality choice to be $q_i = x_i + \underline{s}$ where $x_l = \lambda$, $x_m = \mu\chi + \lambda$ and $x_h = \chi + \lambda$, $\lambda > 0$, and $\mu \in (0, 1]$. This enforces the constraints on the choice of quality so that $\underline{s} \leq q_l \leq q_m \leq q_h$. I use these substitution forms, x_i to simplify the first order conditions, $\frac{\partial \Pi_i}{\partial q_i}$

C.4.1 Interior solution

The high and low quality first-order conditions are unchanged from the 2NF market, Eq. (C.3) and Eq. (C.8) respectively. However, unlike the heterogeneous two nonprofit market, the medium quality firm now has no taste for quality, $\beta_m = 0$,which implies the following first-order condition for the medium quality firm:

$$\partial\mu : \frac{1}{9}\left(1 - 2\mu - B\left(\lambda + \mu\chi + \underline{s}\right)\right) = 0 \tag{C.11}$$

Substituting Eq. (C.3) and Eq. (C.8) into the above first-order condition for the medium

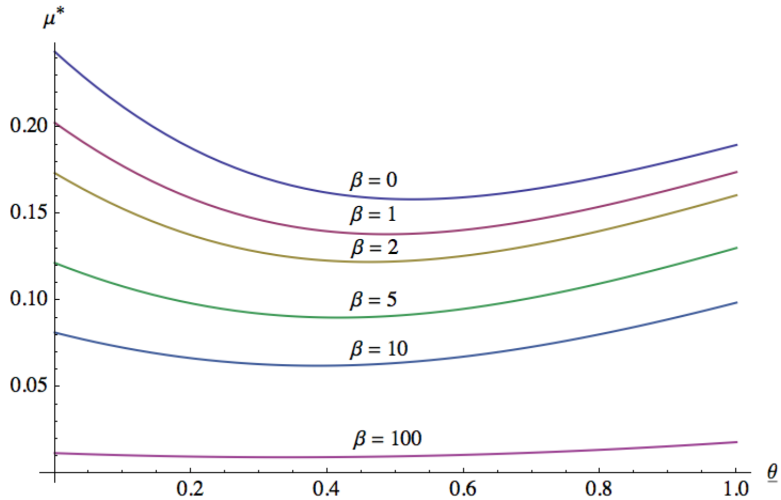

Figure C.6: 1 Nonprofit 2 For Profit Unconstrained Market: μ^* as a function of $\underline{\theta}$

quality firm leads to the following polynomial

$$-12\mu^3 + \mu^2 (9 - 18\underline{\theta}) - \mu \left(22 + 4\beta + 18\underline{\theta}^2\right) + 5 - 6\underline{\theta} + 9\underline{\theta}^2 = 0 \qquad \text{(C.12)}$$

The roots of this polynomial depend on two parameters, $\mu^*_{2N}(\underline{\theta}, \beta)$, and the singular real root is shown in Fig. C.6. This polynomial has one positive root that is decreasing in β and is less than one for all valid parameter values.

Because the first-order condition for the low-quality firm is unaltered from the 2NF market, the optimal choice of λ^* is functionally equivalent to Eq. (C.10), but $\mu^*_{2F} \neq \mu^*_{2N}$. In fact, as is seen when comparing the N2F roots in Fig. C.6, with those from the 2NF market in Fig. C.3, $\mu^*_{2F} < \mu^*_{2N} \forall \beta$. In the N2F market when $\underline{\theta} = 0.05$, the possible range of μ^*_{2F} is from approximately 0.226 to 0, seen in Fig. C.7. For this range, the sign of λ^* is always negative (seen in Fig. C.8), indicating that the equilibrium solution is always constrained.

C.4.2 Corner Solution

In a corner solution, he quality constraint binds for the for-profit firm. In this case, I simplify the substitution form in the following way: $x_l = 0, x_m = \mu\chi, x_h = \chi$ where $\mu \in [0, 1]$.

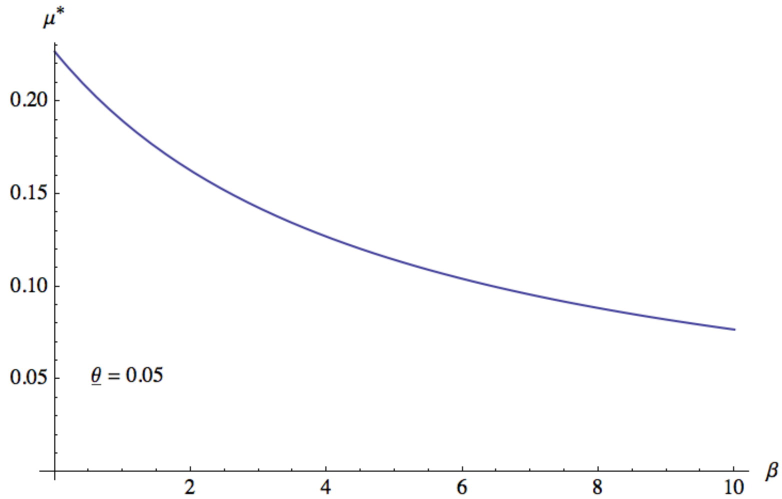

Figure C.7: 1 Nonprofit 2 For-Profit Unconstrained Market: μ^* as a function of β when $\underline{\theta} = 0.05$

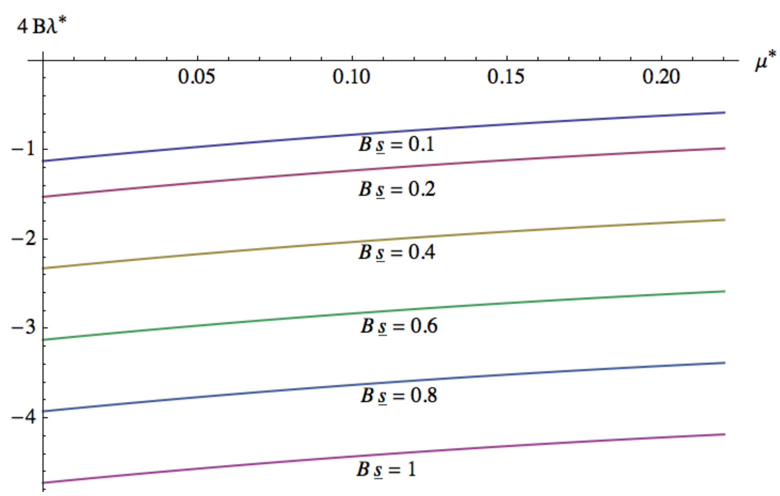

Figure C.8: Sign of λ^* when $\underline{\theta} = 0.05$ showing an always constrained solution

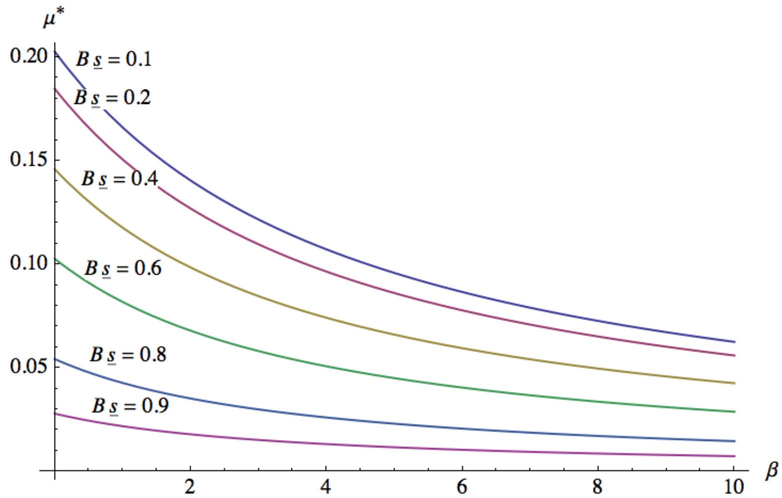

Figure C.9: 1 Nonprofit 2 For Profit Constrained Market: μ^* as a function of β

Given this substitution form, $q_l = \underline{s}, q_m = \mu\chi + \underline{s}, q_h = \chi + \underline{s}$.

Simultaneously solving the medium and the high firm's first order conditions, Eq. (C.11) and Eq. (C.3) respectively, yields the following fourth-order polynomial, the solution of which defines the equilibrium:

$$-2\mu^4 - \mu^3 (5 + 6\underline{\theta}) - \mu \left(17 + 4\beta + 18\underline{\theta} + 9\underline{\theta}^2 - 4B\underline{s}\right) + (4 - 4B\underline{s})$$

The singular positive real root of this polynomial, $\mu^*_{2F} (\underline{\theta}, \beta, B\underline{s})$ is seen in Fig. C.9. Having solved for this root, the algorithm for defining equilibrium price and quantity is as in the homogeneous interior solution concept.

APPENDIX D

Short Run Merger Analysis

D.1 Merger Between High and Medium Quality Firm

In this case, with fixed quality levels $\bar{q}_h, \bar{q}_m$ and $\bar{q}_l$, the problem facing the merged firm is:

$$\max \left(\Pi_h + \beta \overline{q}_h\right) + \left(\Pi_m + \beta \overline{q}_m\right)$$

$$\max_{p_h, p_m} \left(\left(\overline{\theta} - \frac{p_h - p_m}{\overline{q}_h - \overline{q}_m} \right) (p_h - c) - \left(\frac{B}{18} \right) \overline{q}_h^2 + \beta \left(\frac{1}{3} \right)^2 \overline{q}_h \right) + \left(\left(\frac{p_h - p_m}{\overline{q}_h - \overline{q}_m} - \frac{p_m - p_l}{\overline{q}_m - \overline{q}_l} \right) (p_m - c) - \left(\frac{B}{18} \right) \overline{q}_m^2 + \beta \left(\frac{1}{3} \right.$$

This will yield the following first order conditions:

$$\partial p_h : \overline{\theta} - 2 \left(\frac{p_h - p_m}{\overline{q}_m - \overline{q}_l} \right) = 0$$

$$\partial p_m : \frac{2(p_h - p_m)}{\overline{q}_m - \overline{q}_l} + \frac{c - (2p_m - p_l)}{(\overline{q}_m - \overline{q}_l)} = 0$$

The non-merged firm (the low quality firm) faces the traditional stage 2 problem, which yields the following first order condition:

$$\partial p_l : \frac{c + p_m - 2p_l}{\overline{q}_m - \overline{q}_l} - \underline{\theta}$$

Then these three first order conditions will yield the following short run Nash equilibrium prices:

$$p_h^{SR} = c + \frac{1}{6}\left(\overline{\theta} - 2\underline{\theta}\right)(\overline{q}_m - \overline{q}_l) + \frac{\overline{\theta}}{2}(\overline{q}_h - \overline{q}_l)$$

$$p_m^{SR} = c + \frac{1}{3}\left(2\overline{\theta} - \underline{\theta}\right)(\overline{q}_m - \overline{q}_l)$$

$$p_l^{SR} = c + \frac{1}{3}\left(\overline{\theta} - 2\underline{\theta}\right)(\overline{q}_m - \overline{q}_l)$$

I compare p_h^{SR} to Eq. (2.13), the Nash equilibrium price with 3 un-merged firms, and show that $p_h^{SR} > p_h^*$. This implies that the price level of the highest quality firm rises immediately post merger.

$$\begin{aligned}
p_h^{SR} &> p_h^* \\
c + \frac{1}{6}\left(\overline{\theta} - 2\underline{\theta}\right)(\overline{q}_m - \overline{q}_l) + \frac{\overline{\theta}}{2}(\overline{q}_h - \overline{q}_l) &> c + \frac{(q_h - q_m)(q_m - q_l)}{6(q_h - q_l)} + \frac{\overline{\theta}}{2}(q_h - q_m) \\
\frac{1}{6}\left(\overline{\theta} - 2\underline{\theta}\right)(\overline{q}_m - \overline{q}_l) + \frac{\overline{\theta}}{2}(\overline{q}_m - \overline{q}_l) &> \frac{(q_h - q_m)(q_m - q_l)}{6(q_h - q_l)} \\
\left(\overline{\theta} - 2\underline{\theta}\right)(\overline{q}_m - \overline{q}_l) + 3\overline{\theta}(\overline{q}_m - \overline{q}_l) &> \frac{(q_h - q_m)(q_m - q_l)}{(q_h - q_l)} \\
2\left(2\overline{\theta} - \underline{\theta}\right)(\overline{q}_m - \overline{q}_l) &> \frac{(q_h - q_m)(q_m - q_l)}{(q_h - q_l)} \\
2\left(2\overline{\theta} - \underline{\theta}\right) &> \frac{(q_h - q_m)}{(q_h - q_l)}
\end{aligned}$$

$\left(2\overline{\theta} - \underline{\theta}\right) > 1$ and $\frac{(q_h - q_m)}{(q_h - q_l)} < 1$. This proves that the post-merger short run price of the highest quality firm will be bigger than the price of the pre-merger three firm oligopoly market.

D.2 Merger Between Medium and Low Quality Firm

In this case, with fixed quality levels $\overline{q}_h, \overline{q}_m$ and $\overline{q}_l$, the problem facing the merged firm is:

$$\max \left(\Pi_m + \beta \left(\frac{1}{3} \right)^2 \overline{q}_m \right) + \left(\Pi_l + \beta \left(\frac{1}{3} \right)^2 \overline{q}_l \right)$$

$$\max_{p_m, p_l} \left(\left(\frac{p_h - p_m}{\overline{q}_h - \overline{q}_m} - \frac{p_m - p_l}{\overline{q}_h - \overline{q}_l} \right) - \left(\frac{B}{18} \right) \overline{q}_m^2 + \beta \left(\frac{1}{3} \right)^2 \overline{q}_m \right) + \left(\left(\frac{p_m - p_l}{\overline{q}_m - \overline{q}_l} \right) (p_l - c) - \left(\frac{B}{18} \right) \overline{q}_l^2 + \beta \left(\frac{1}{3} \right)^2 \overline{q}_l \right)$$

This yields the follow first order conditions

$$\partial p_m : \frac{c + p_h - 2p_m}{\overline{q}_h - \overline{q}_m} - \frac{2(p_m - p_l)}{\overline{q}_m - \overline{q}_l}$$

$$\partial p_l : \frac{2(p_m - p_l)}{\overline{q}_m - \overline{q}_l} - \underline{\theta}$$

The first order condition for the high quality firm will be as it was for the un-merged case:

$$\partial p_h : \overline{\theta} - \frac{2p_h - p_m}{\overline{q}_h - \overline{q}_m}$$

Then these three first order conditions will yield the following short-run Nash equilibrium prices:

$$p_h^{SR} = c + \frac{1}{3} \left(2\overline{\theta} - \underline{\theta} \right) (\overline{q}_h - \overline{q}_m)$$

$$p_m^{SR} = c + \frac{1}{3} \left(\overline{\theta} - 2\underline{\theta} \right) (\overline{q}_h - \overline{q}_m)$$

$$p_l^{SR} = c + \frac{1}{6}\left(2\overline{\theta} - \underline{\theta}\right)(\overline{q}_h - \overline{q}_m) - \frac{1}{2}\underline{\theta}(\overline{q}_h - \overline{q}_l)$$

I compare p_h^{SR} to Eq. (2.13), the nash equilibrium price with 3 un-merged firms, to show that $p_h^{SR} > p_h^*$, or that the short run price of the highest quality firm is larger than price in the three firm oligopoly.

$$\begin{aligned}
p_h^{SR} &> p_h^* \\
c + \frac{1}{3}\left(2\overline{\theta} - \underline{\theta}\right)(\overline{q}_h - \overline{q}_m) &> c + \frac{(\overline{q}_h - \overline{q}_m)(\overline{q}_m - \overline{q}_l)}{6(\overline{q}_h - \overline{q}_l)} + \frac{\overline{\theta}}{2}(\overline{q}_h - \overline{q}_m) \\
2\left(2\overline{\theta} - \underline{\theta}\right)(\overline{q}_h - \overline{q}_m) &> \frac{(\overline{q}_h - \overline{q}_m)(\overline{q}_m - \overline{q}_l)}{(\overline{q}_h - \overline{q}_l)} + 3\overline{\theta}(\overline{q}_h - \overline{q}_m) \\
2\left(2\overline{\theta} - \underline{\theta}\right) &> \frac{(\overline{q}_m - \overline{q}_l)}{(\overline{q}_h - \overline{q}_l)} + 3\overline{\theta} \\
\left(\overline{\theta} - \underline{\theta}\right) &> \frac{(\overline{q}_m - \overline{q}_l)}{(\overline{q}_h - \overline{q}_l)} \\
1 &> \frac{(\overline{q}_m - \overline{q}_l)}{(\overline{q}_h - \overline{q}_l)} \qquad \text{(D.1)}
\end{aligned}$$

The above condition is always less than one, proving that the short-run price of the highest quality firm rises immediately after the merger occurs.

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