Incentivizing Better Quality of Care: The Role of Medicaid and Competition in the Nursing Home Industry *

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May 1st, 2015

Abstract

The quality of care in U.S. nursing homes has been an ongoing concern for several decades and remains an important policy issue as evidenced by the Nursing Home Transparency and Improvement Act as part of the Affordable Care Act (ACA). This paper empirically investigates two mechanisms that can explain why the quality of care may be inefficiently low: regulated prices and market power. Using data from Pennsylvania, I model these mechanisms in an empirical model of demand and supply. My results indicate that the quality of care, measured by the number of skilled nurses per resident, is indeed inefficiently low. In counterfactual experiments, I conduct a “horse race” between two alternative policy strategies that can lead to an increase in the skilled nurse staffing ratios and thereby enhance social welfare. First, I consider the effects of a universal 10 percent increase in the regulated Medicaid reimbursement rates. I find that nursing homes increase the number of skilled nurses per resident by 9 percent and decrease private rates charged to seniors who pay-out-of-pocket by 4 percent on average. This leads to an annual welfare gain of $62 million, 34 percent of the additional Medicaid spending. Second, I find that increasing competition, via additional entry, increases staffing ratios only slightly. On net, the gains from competition fall short of the additional fixed costs of entry, which indicates that entry policies are not a cost-effective instrument to incentivize better quality of care.

*I thank my advisers Steven Berry, Philip Haile, and Amanda Kowalski as well as Nikhil Agarwal, Joe Altonji, Zack Cooper, Camilo Dominguez, Maximiliano Dvorkin, Paul Grieco, Mitsuri Igami, Adam Kapor, Fabian Lange, Costas Meghir, Nora Müller-Alten, Charlie Murry, Christopher Neilson, Peter Newberry, Vincent Pohl, Ted Rosenbaum, and Seth Zimmerman for their thoughtful comments. Jean Roth and Mohan Ramanujan provided invaluable help with the data. Funding from the National Institute of Aging grant #P30 AG012810 is gratefully acknowledged.
1 Introduction

Quality shortfalls in U.S. nursing homes have been an ongoing concern for decades and remain an important policy issue as evidenced by the Nursing Home Transparency and Improvement Act as part of the Affordable Care Act (ACA). Despite various regulatory effort to improve the situation, nurse to resident staffing ratios remain very low (see e.g., Centers for Medicare and Medicaid (2001)), which may harm a particularly vulnerable, frail, and elderly resident population. Understanding why nursing homes lack incentives to improve the quality of care is important for the design of policy instruments and of growing interest as the U.S. population ages and as nursing home spending increases.

In this paper, I empirically investigate two mechanisms that can explain why the quality of care may be inefficiently low. First, prices for nursing home care are largely regulated. Medicaid and Medicare regulate the reimbursement rates for 65 percent and 9 percent of all nursing home stays respectively. Only 26 percent of residents pay the private rate set by the nursing home. If reimbursement rates are set too low, then nursing homes face little incentive to compete for Medicaid or Medicare beneficiaries through better quality of care. Understanding the effect of Medicaid reimbursement rates on the quality of care is particularly important in this context because state regulators frequently reduce Medicaid rates in response to budgetary shortfalls. Second, theory has long held that firm market power can lead to inefficiently low quality levels. Following Spence (1975), the monopoly quality is inefficiently low if the marginal consumer values quality less than the average consumer. Furthermore, in the case of regulated prices, White (1972) shows that the quality set by the monopolist falls short of the quality achieved under perfect competition. Market power arises in this context because of vertical and horizontal product differentiation (in geography) but also because Certificate of Need (CON) laws restrict entry and investment decisions of nursing homes. CON laws may keep the number of competitors particularly low. Motivated by these theoretical considerations, this paper empirically investigates the cost-effectiveness of different policy strategies that either address regulated prices or the lack of competition to achieve better quality of care. Specifically, I consider a “horse race” between a universal increase in regulated Medicaid reimbursement rates and policies that encourage competition between nursing homes using an empirical model of demand and supply.
I investigate these questions using resident and nursing home micro data from Pennsylvania. One important advantage of this empirical context, besides data availability, is that I am able to isolate a source of plausibly exogenous variation in Medicaid reimbursement rates in Pennsylvania. I leverage this variation to provide first direct evidence on the effects of Medicaid rate changes on nurse and therapist to resident ratios, the key inputs for the labor-intensive delivery of care, as well as private rates. The identification strategy takes advantage of the fact that the regulated Medicaid reimbursement rate of each nursing home in Pennsylvania is determined based on previously reported costs of all nursing homes from a facility-size and region-based peer group. Each of these peer group regions spans several counties that are commonly assumed to define locally segmented nursing home markets. I isolate reported cost variation of those nursing homes in the peer group that operate in different nursing home markets. Specifically, I assume that these cost shocks affect staffing and private rate decisions through the reimbursement rule only conditional on a rich set of control variables.

Applying the methodology to the data, I find that nursing homes increase the number of registered and licensed practical nurses per resident, henceforth skilled nurses per resident, in response to an increase in the regulated Medicaid reimbursement rate. I do not find evidence for changes in the number of nursing assistant or physical therapists. I also provide preliminary evidence on the relationship of market structure and markups. Using detailed cost report information from Medicaid cost reports, I am able to calculate the markup for private rates. I find suggestive evidence for larger markups and lower nurse staffing ratios in more concentrated counties.

The preliminary evidence indicates that Medicaid reimbursement rates and the market structure affect skilled nurse staffing and pricing decisions of nursing homes. Yet, to precisely quantify these effects and to understand the effect of counterfactual policies I develop and estimate a static structural model of demand and supply building on the methods developed in Berry, Levinsohn and Pakes (1995) henceforth “BLP” and Fan (2013). On the demand side, I model the choice of a specific nursing home, the intensive margin, and treat the form of long term care as well as the length of stay, the extensive margin, as exogenous. Preferences for a specific nursing home depend most importantly on proximity, the private rate if the senior pays out-of-pocket and, motivated by the preliminary evidence, on the number of skilled nurses per resident. On the supply side, I assume that nursing homes compete for new residents. Nursing homes take the regulated Medicaid and
Medicare reimbursement rates as given and choose private rates and the number of skilled nurses per resident optimally. To estimate the model, I combine nursing home data from annual surveys with micro data from the Minimum Data Set (MDS) on the universe of nursing home residents in Pennsylvania. I construct additional cost moment from Medicaid cost reports, which help identify the key staffing ratio and price elasticities of demand.

The demand parameter estimates support the general quality concerns in this industry: staffing ratios of skilled nurses are inefficiently low in equilibrium. Based on a revealed preference approach that leverages the estimated disutility of higher prices among seniors who pay out-of-pocket, I find that nursing home residents jointly value an additional skilled nurse at $119,000 per year. However, employing an additional skilled nurse costs the nursing home only about $82,000 when considering wage and fringe benefits. Based on a social planner’s problem, I find that on average current staffing standards fall short of the social optimum by about 30 percent. Interestingly, I do not find evidence for inefficiently low staffing ratios in the small fraction of nursing homes that do not accept Medicaid residents. This indicates that low Medicaid reimbursement rates are potentially important in understanding the generally low staffing ratios.

Building on the estimated primitives of the oligopoly model, I am able to conduct a variety of counterfactual experiments that aim to increase the skilled nurse staffing ratios and thereby enhance social welfare. I start with an investigation of a universal 10 percent increase in Medicaid reimbursement rates. I use the model to simulate the counterfactual equilibrium distribution of skilled nurse staffing ratios as well as the private rates. My estimates indicate that the number of skilled nurses per resident increases by 9 percent on average. I also find a smaller average decrease in private rates of 4 percent. Seniors who are partially eligible for Medicaid and partially pay out-of-pocket become more lucrative as Medicaid rates increase which incentivizes nursing homes to lower to their private rates in order to attract these hybrid payers to their facility. This effect outweighs the upward pricing incentive stemming from the increase in the skilled nurse staffing ratios, which raises marginal costs. Interestingly, the increase in skilled nurses is more pronounced in more competitive market environments because of strategic complementarities. With respect to social welfare, I find that the increase in Medicaid rates costs the regulator about $184 million per year but raises nursing home profits by $75 million per year. This indicates that nursing homes pass 60 percent of the Medicaid revenue increase on to their residents through higher skilled nurse
staffing ratios and lower private rates. Based on the revealed preference approach, I find an annual increase in consumer surplus of $170 million. In total, I find a welfare gain of $62 million per year, about 34 percent, of the increase in Medicaid spending. This estimate exceeds common estimates from the public finance literature on the social cost of taxation, which equal about 30 percent. Larger increases in Medicaid reimbursement rates lead to smaller relative welfare gains because of diminishing marginal utilities for the number of skilled nurses per resident. Hence, my findings indicate social welfare gains from small to moderate increases in Medicaid reimbursement rates.

An alternative policy strategy to incentivize the provision of good quality of care is to increase the competition among nursing homes. I evaluate the potential effects in two counterfactual experiments. First, I remove a form of horizontal differentiation amongst nursing homes that can lead to substantial market power: distance. Specifically, I set the distance of potential residents to nursing homes to zero and allow residents to revisit their nursing home choices. This intervention changes the substitution patterns of residents and alters the pricing and staffing incentives of nursing homes. I use the model to calculate the new equilibrium distribution of skilled nurse ratios and private rates. While this experiment does not correspond to a particular policy instrument, I interpret the results as an upper bound of potential welfare gains that can result from a large influx of new nursing homes, ignoring the additional fixed costs of entry and operating the additional facilities. My estimates indicate that nursing homes increase the number of skilled nurses by 8 percent and reduce the private rates by 10 percent. Contrary to the former counterfactual, I find larger staffing and pricing responses in more concentrated rural markets. My normative estimates indicate a loss in provider profits of $105 million per year and an increase in consumer surplus of $186 million per year, evaluated at “zero-distance” preferences. There is a negligible increase in Medicaid spending of $1 million per year, induced by the resorting of residents, which implies a net welfare gain of $80 million per year. If compared to reasonable annual fixed cost estimates, these potential gains appear to be relatively low. Using data on administrative and capital costs from Medicaid cost reports, I estimate fixed costs of about $1.3 million per year for an average sized nursing home. This indicates that the potential gains in social welfare can justify another 80/1.3=62 nursing homes, which corresponds to a 9 percent increase. While entry of additional nursing homes increases the proximity of residents to a nursing homes, it seems implausible that these gains correspond to a complete reduction of distance in nursing home considerations.
To provide a more specific analysis of costs and benefits from an increase in competition, I consider the effects of directed entry in a second counterfactual exercise. Specifically, I consider the costs and benefits of adding an additional nursing home to four different rural markets, where the gains from competition may be largest. This exercise is particularly interesting in the context of existing CON regulations, which restrict the entry and investment decisions of nursing homes in Pennsylvania. In each market, I add an additional nursing home, whose product characteristics and location correspond to a weighted average over the incumbent nursing homes. Again, I use the model to calculate the new equilibrium staffing and private rate distribution. I find that incumbents respond to entry by lowering their private rates and increasing their skilled nurse staffing ratios on average. Interestingly, I find that variable annual profits of the entering nursing homes range between $900,000 and $1.5 million, which equals the annual fixed costs. However, the increase in profits reflects business stealing from incumbents. In fact total industry profits decrease by $200,000 which is consistent with the decrease in private rates and an increase in the number of skilled nurses of local competitors. While consumer surplus increases slightly, social welfare actually decreases when considering the additional fixed costs. Hence, the findings indicate that the additional entry is socially wasteful while profitable from the point of view of the entrant. These findings support current CON regulations.

Taken together, the results from the counterfactual exercises provide supportive evidence for small to moderate increases in Medicaid reimbursement rates to improve nurse staffing ratios in this industry. However, increasing competition by encouraging entry does not appear to be a cost effective policy instrument to improve the quality of health care delivery in this industry.

This paper contributes to several distinct literatures. First, this paper contributes to the literature on the effect of reimbursement regulations and market structure on the quality of care in the nursing home industry. A large number of studies investigated the link between Medicaid reimbursement rates and nurse staffing ratios both theoretically (see Scanlon (1980) as well as Ma (1994); Rogerson (1994)) and empirically (see Nyman (1989a); Gertler (1989); Gertler (1992); Cohen and Spector (1996); Grabowski (2001); Feng et al. (2008); Harrington et al. (2008)). Other studies have investigated the link between measures of concentration and staffing and pricing decisions (see e.g., Nyman (1988)). Most studies lack, however, a clean source of identifying variation in Medicaid reimbursement rates and undertake a reduced-form approach that does not allow for coun-
terfactual experiments. My analysis also relates to studies of nursing home demand. While most studies investigate the demand at the extensive margin (see Grabowski and Gruber (2007); Goda, Golberstein and Grabowski (2011), my demand analysis is closely related to Ching, Hayashi and Wang (2012) who estimate a demand model for nursing homes using data from Wisconsin. Most importantly, my analysis departs from these studies by adding a model of supply, which is integral for the counterfactual analysis.

Second, the paper contributes to a growing literature on endogenous product choice (see e.g., Mazzeo (2002); Crawford and Shum (2006); Draganska, Mazzeo and Seim (2009)) and is methodologically closely related to Fan (2013). Endogenizing product characteristics invalidates the typical exclusion restriction employed in the estimation of oligopoly models. For example, BLP treat the product characteristics of competitors as exogenous and use them as instruments to identify price elasticity of demand. To address this concern, I exploit a plausibly exogenous source of variation in Medicaid reimbursement rates as an instrument for nurse staffing decisions and take advantage of detailed cost data, which serve as exogenous cost shifters and additional moments to identify the price and nurse staffing elasticities of demand.

Finally, my counterfactual analysis also relates to the welfare effects of free entry. A theoretical literature has shown that free entry can lead to social inefficiencies (see e.g., Mankiw and Whinston (1986)). Entry may be excessive since entrants don’t internalize the business stealing from competitors, but it may also be inefficiency low when the entrant cannot fully internalize the consumer gains of variety. I am investigating this tradeoff in the context of the nursing home industry, where CON laws aim to avoid excessive entry. However, the latter source of inefficiency may reverse this conclusion as price regulations limit the entrant’s ability to harness the consumer gains from better quality of care and proximity. Hence, my results extend the existing empirical evidence on free entry (see e.g., Berry and Waldogel (1999)) in the context of an important health care industry.

The remainder of this study is organized as follows. In Section 2, I discuss the institutional background before I turn to the data and preliminary evidence in Section 3. In Section 4, I discuss the empirical model. In Section 5, I present the estimation results before I turn to the counterfactual exercises in Section 6. I consider robustness checks in Section 7. Finally, I conclude in Section 8.
2 Institutional Background

This section discusses important regulatory features of the nursing home industry. The goal of this section is to provide relevant background information to allow for a discussion of external validity and to motivate the empirical modeling assumptions as well as the counterfactual exercises. The discussion focuses on price regulation, uniform health care quality, and CON laws.

Prices are regulated for the majority of nursing home residents. At a given point in time, Medicaid covers the nursing home stay of about 65 percent of nursing home residents, who meet the state-specific income and asset criteria, see the left panel of Table 1. Medicaid pays the nursing home a regulated capitation payment per Medicaid resident day, the Medicaid reimbursement rate, which should cover the provider’s expenses for health care services as well as room and board. Another 9 percent of residents are covered by Medicare, which only covers up to 100 days of post-acute care following a qualifying hospital stay.\textsuperscript{1} Similar to Medicaid, Medicare also pays the nursing home a regulated Medicare reimbursement rate per Medicare resident day, which is considerably more generous than the Medicaid reimbursement rate. The residual 26 percent of residents generally pay their stay out-of-pocket as only a very small fraction of residents has long term care insurance.\textsuperscript{2}

Nursing homes can set an arbitrary private rate per day, which is on average 20 percent higher than the regulated daily Medicaid reimbursement rate. The majority of residents uses mixed payer sources to pay for their nursing home stay. Only about a third of the residents, when weighted by length of stay, uses the same payer source throughout their nursing home stay, see the diagonal in the right panel of Table 1. For instance, about 52 percent of the residents are initially eligible for Medicare but most stay longer than the number of days covered by Medicare. These residents start paying out-of-pocket for following days unless they are eligible for Medicaid in which case Medicaid pays for the remainder of their stay. Others start paying out-of-pocket on the first day but become eligible for Medicaid during their stay once they have spent down their assets.

Since the daily revenues differ across payer types, nursing homes may have an incentive to differentiate the quality of care. However, the regulator requires nursing homes to offer the same quality of care to all payer types within a facility and existing studies have shown that nursing

\textsuperscript{1}Medicare covers, for example, post-acute care in nursing homes, if the nursing home stay starts within 30 days after a hospital stay of weakly more than 3 days. Common conditions include the recovery from a hip fracture or a stroke.

\textsuperscript{2}Data from the annual nursing home survey indicated that only about 2 percent of the resident days in the sample population are paid via private long term care insurance.
Table 1: Payer Types

<table>
<thead>
<tr>
<th>Point in time</th>
<th>Transitions (weighted by length of stay)</th>
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<tbody>
<tr>
<td></td>
<td>Discharge</td>
</tr>
<tr>
<td></td>
<td>Medicaid 65%</td>
</tr>
<tr>
<td></td>
<td>Private 26%</td>
</tr>
<tr>
<td></td>
<td>Medicare 9%</td>
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</tbody>
</table>

Note: The left panel uses nursing home survey information from 2000, weighted by nursing home beds. The right panel uses Minimum data set combined with Medicaid and Medicare claims data for sample of residents, who were admitted between 2000-2002 and discharged by the end of 2005. The right panel compares the resident’s payer source at admission and discharge.

homes appear to comply with the regulation, see Angelleli, Grabowski and Gruber (2008). This may suggest that some nursing homes may only accept some payer types. In fact, a set of nursing homes targets intensive post-acute care residents that are predominantly covered by Medicare. I exclude these rehabilitative care facilities from the analysis assuming that they compete for different resident health profiles. More than 90 percent of the remaining nursing homes accept all payer types leaving only a few providers that focus on Medicare and private pay residents. Motivated by this regulatory requirement, I assume that quality of care is uniform across residents in a given nursing home.

Entry and investment decisions are restricted by CON laws in Pennsylvania. In general, a new potential entrant has to prove excess demand in the respective county in order to open a new nursing home facility, which has oftentimes been rejected in the early and late 1990s. One economic rationale for this legislative barrier to entry is that free entry can lead to excessive entry if fixed costs are high and nursing homes provide substitutes for one another. On the other hand, the existing regulations may be too restrictive such that the number of incumbent nursing homes is inefficiently low. I come back to this consideration in the counterfactual analysis in Section 7, where I evaluate the welfare effects of entry. Motivated, by this regulation I consider a static oligopoly model and abstract from entry, exit and capacity investment decisions in the baseline analysis.
3 Data and Preliminary Evidence

In this section, I discuss the main data sources and provide preliminary evidence on the effects of Medicaid reimbursement rates and market concentration on nurse staffing and pricing decisions. To estimate the structural model of demand and supply, I require data on resident choices and their demographics, to the extent that they matter for demand, as well as nursing home characteristics including the nurse staffing levels, the private rate, and the regulated Medicaid and Medicare reimbursement rates. I obtained resident data from the MDS as well as Medicaid and Medicare claims data. Information on nursing home characteristics are contained in an annual nursing home survey and Medicaid cost reports.

3.1 Data

The MDS is an administrative assessment database that provides as least quarterly information on a variety of health measures for all nursing home residents in Medicaid or Medicare certified nursing homes, about 98 percent of all nursing homes. The MDS becomes increasingly more popular among researchers, who study the health profiles of nursing home residents. However, this is the first study, to the best of my knowledge, which uses the MDS to estimate the demand for nursing home care. The MDS provides information on the zip code of the resident’s former address, which allows me to incorporate the role of distance in the demand model. I select a subset of health measures, evaluated at the resident’s admission to the nursing home, to model potential differences in the seniors’ preferences for nursing home characteristics. For instance, I measure whether the resident was diagnosed for Alzheimer and allow for a particular preference for nursing homes with an Alzheimer unit. I also reduce a large number of health variables to a one-dimensional individual case-mix index (CMI). The CMI is used in reimbursement methodologies and summarizes the expected resource utilization relative to the average resident. I also use information on the admission date and the discharge date to calculate the length of stay. I weight the observations by their length of stay in the demand estimation. One disadvantage of the MDS is that the provided payer type information is not particularly accurate. To this end, I merge the MDS with Medicaid and Medicare claims data at the resident-nursing home stay level. The claims data allow me to specific which days during any stay were covered by Medicaid or Medicare. I assume that the residual days are paid out-of-pocket
given that only a negligible fraction of residents has access to long-term care insurance.

For my baseline analysis, I collapse the observations at the resident nursing home stay level and keep residents that were admitted to a nursing home in Pennsylvania in the years 2000-2002. This reduces the sample population to about 270,000 observations, about 90,000 admissions per year as indicated by the two top rows in Table 2. There is considerable heterogeneity in the resident’s length of stay. While some residents stay for several years about 50 percent are discharged within 1 month. The second indicates that distance to the nursing home is critical for the nursing home choice. The median resident chooses a nursing home within 7km of distance.

Table 2: Summary Statistics 2000-2002

<table>
<thead>
<tr>
<th></th>
<th>N</th>
<th>Mean</th>
<th>10th</th>
<th>50th</th>
<th>90th</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Stay in Days</td>
<td>287,211</td>
<td>223.00</td>
<td>8.00</td>
<td>34.00</td>
<td>872.00</td>
</tr>
<tr>
<td>Distance travelled in 100km</td>
<td>287,211</td>
<td>0.12</td>
<td>0.02</td>
<td>0.07</td>
<td>0.25</td>
</tr>
<tr>
<td>Medicaid Certified</td>
<td>2,091</td>
<td>0.92</td>
<td>1.00</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Publicly Operated NH</td>
<td>2,091</td>
<td>0.06</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>For-Profit NH</td>
<td>2,091</td>
<td>0.46</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
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<tr>
<td>Not-For-Profit NH</td>
<td>2,091</td>
<td>0.49</td>
<td>0.00</td>
<td>0.00</td>
<td>1.00</td>
</tr>
<tr>
<td>Licensed Beds</td>
<td>2,091</td>
<td>131.50</td>
<td>47.00</td>
<td>120.00</td>
<td>210.00</td>
</tr>
<tr>
<td>Licensed Practical Nurses per Res.</td>
<td>2,091</td>
<td>0.14</td>
<td>0.07</td>
<td>0.13</td>
<td>0.21</td>
</tr>
<tr>
<td>Registered Nurses per Res.</td>
<td>2,091</td>
<td>0.13</td>
<td>0.06</td>
<td>0.11</td>
<td>0.21</td>
</tr>
<tr>
<td>Daily Private Rate</td>
<td>2,091</td>
<td>224.32</td>
<td>174.99</td>
<td>211.68</td>
<td>262.71</td>
</tr>
<tr>
<td>Daily Medicaid Rate</td>
<td>1,837</td>
<td>154.54</td>
<td>121.13</td>
<td>152.73</td>
<td>191.65</td>
</tr>
<tr>
<td>Average Variable Costs per Resident Day</td>
<td>1,823</td>
<td>154.54</td>
<td>121.13</td>
<td>152.73</td>
<td>191.65</td>
</tr>
<tr>
<td>Fixed Costs per Year in million dollars</td>
<td>1,785</td>
<td>1.45</td>
<td>0.52</td>
<td>1.28</td>
<td>2.43</td>
</tr>
</tbody>
</table>

Note: The top two rows describe the data from the Minimum Data Set and are based on newly admitted residents between 2000 and 2002. Travel distance is weighted by length of stay. The remaining rows describe the annual nursing home survey data and the annual cost report data for the years 2000-2002.

I combine the MDS with data from annual nursing home surveys, which were provided by the Bureau of Health Statistics of the Pennsylvania Department of Health. The survey provides information on various nursing home characteristics for all licensed nursing homes in Pennsylvania including the Medicaid and Medicare reimbursement rates, the private rates charged to seniors who pay out-of-pocket, the number of full-time and part-time employees by educational background, as well as the number of licensed beds, ownership type, and the mix of resident payer types at a fixed

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3I observe discharge dates up until the end of 2005 and treat the 31st of December as the discharge date for those residents that stay beyond this day.

4The Department specifically disclaims responsibility for any analysis, interpretation of conclusions.
point in time. One advantage of the survey data from Pennsylvania is that it provides information on the private rates, which is important for the estimation of demand and the analysis of nursing home incentives. This information is not provided in national nursing home data sources such as the Online Survey, Certification and Reporting (OSCAR) database. The survey information appears to be very reliable given that the information on the number of residents and the payer type distribution coincides very accurately with the information from the MDS and the Medicaid and Medicare claims data between 2000 and 2002 when aggregated at the yearly level. An advantage of the sample period is that private Medicare advantage plans were not particularly prevalent in Pennsylvania between 2000 and 2002. The Medicare claims data only provide information on traditional fee-for-service plans, but not for Medicare advantage plans, which could lead to measurement error in the underlying payer sources in later years.

I use survey data from 1996-2002 for the preliminary analysis and focus on the years 2000-2002 in the structural estimation. Similar to Feng et al. (2008), I drop nursing homes whose share of Medicare residents exceeds 90 percent at a survey determined point in time of a year, about 10 percent of all nursing homes. I also drop about 2.5 percent of nursing homes who charge a daily private rate of more than $650, which exceeds the median daily rate by more than 7 standard deviations. These nursing homes primarily target expensive, rehabilitative care residents and thereby compete in a different market. Furthermore, I drop 5 percent of nursing homes that cannot be linked between the survey and the MDS, have fewer than 5 admissions per year in the years 2000-2002 or admit more than 85 percent of their residents from other states. This reduces the sample to 5,000 nursing home-year observations including about 2,100 observations for the years 2000-2002, which are summarized in Table 2. About 95 percent of the nursing homes are privately operated and almost as many are Medicaid certified.

I merge the survey data with cost information from Medicaid cost reports based on nursing home name and location. The cost report data are available at the quarterly level and are used to calculate the nursing home-year specific Medicaid reimbursement rate, which I discuss in the next section. I use the July cost data from the respective year, which are available for all Medicaid certified nursing homes. The cost reports distinguish between resident related care costs, which contain expenses related to the delivery of health care services, and other resident related care costs, which capture expenses related to delivery of room and board services. Most of these expenses are
wage and fringe benefit payments. On average, a nursing home spends about $150 per resident-day on these categories, which I consider as variable costs in the main analysis. The cost reports also indicate administrative and capital costs, which I treat as fixed costs in the analysis. The fixed costs equal about $1.3 million per year, see the last row of Table 2.

3.2 Preliminary Evidence

In this section, I provide preliminary evidence on the effects of regulated Medicaid provider reimbursement rates and local competition on staffing and pricing decisions.

Medicaid, Staffing, and Pricing. To provide first evidence on the effect of Medicaid rates on staffing and pricing decisions, I consider the following empirical specification for Medicaid certified nursing homes:

\[ Y_{jt}^k = \gamma_1^k \log(R_{jt}^{caid}) + \alpha_k X_{jt} + \phi^k_c + \phi^k_t + \epsilon_{jt} \]  

(1)

Here, \( Y_{jt}^k \) denotes the respective outcome measure in nursing home \( j \) in year \( t \). Specifically, \( k \) is either the staffing ratio for skilled nurses, nurse aides, or therapists, or the daily private rate for a semi-private room. \( \log(R_{jt}^{caid}) \) refers to the regulated daily log Medicaid reimbursement rate, \( \phi^k_c \) and \( \phi^k_t \) capture county and year fixed effects, and \( X_{jt} \) contains additional nursing-home specific control variables. The key parameter of interest is \( \gamma_1^k \) which denotes the effect of an increase in log Medicaid reimbursement rate on staffing and pricing decisions.

An empirical challenge to the estimation of the key parameters of interest is the potential correlation between the regulated Medicaid reimbursement rate and the residuum. Medicaid reimbursement rates in Pennsylvania are calculated based on previously reported costs, which introduces an endogeneity problem if cost are serially correlated over time and if costs affect optimal staffing and pricing decision directly. To address this concern, I exploit a source of plausibly exogenous variation in Pennsylvania’s Medicaid reimbursement methodology.

The Medicaid reimbursement rate depends on reported cost from 3-5 years ago of all nursing homes in a facility-size and region-based peer group. Specifically, the regulator distinguishes between small (<120 beds), medium sized (120-269 beds), and large nursing homes (>269 beds) in each of the four reimbursement regions indicated in Figure 1. These regions are defined based on the population size of the Metropolitan Statistical areas (MSAs) and combine several counties that
have commonly been assumed to define separate nursing home markets.

Figure 1: Reimbursement Peer Group Regions in Pennsylvania

The provider-year specific Medicaid reimbursement rate depends on the provider’s previously reported costs as well as the median over the reported costs of all nursing homes in the peer group, see the appendix section 9.1 for details. This implies that the Medicaid reimbursement rate for a nursing home located in Allegheny county (Southwest corner in Figure 1.) depends in parts on previously reported costs of a nursing home located in Bucks county (Southeast corner), if they are of similar size.

To identify the key parameters of interest, I assume that nursing homes compete in locally segmented markets both for new residents and inputs (e.g. nurses). In the presented specifications, I assume that counties define locally segmented markets.\(^5\) This implies that previously reported costs from nursing homes located in different counties don’t affect the optimal staffing and pricing decision directly and are therefore excluded from equation 1. However, previously reported costs from peer-group affiliated nursing located in different counties affect the Medicaid reimbursement rate though the reimbursement formula and are therefore valid instrumental variables. For example,

\(^5\)However, I also consider more conservative market definitions in additional robustness checks, which delivers very similar estimates. These results are available upon request.
the competitiveness of the local market will affect the equilibrium distribution of staffing ratios and private rates and thereby affect the cost distribution of providers in the given county. However, I assume that the local competitiveness does not affect staffing and pricing decisions in different peer-group affiliated counties, conditional on the observed competitiveness in these counties, other than through the reimbursement formula.

In practice, I consider two sets of instrumental variables. In the baseline analysis, I use the reported costs of peer-group affiliated nursing homes located in different markets directly. However, in additional robustness checks I identify a set of observable cost shifters including the number of licensed beds, the ownership type, the Herfindahl index, and measures of the elderly county population. I construct predicted reported costs based on these variables and use the predicted costs as instrumental variables controlling for the same set of statistics of the nursing home of interest. Specifically, I include them in the set of control variables $X_{jt}$. This approach exploits observable differences in facility and market characteristics between peer-group affiliated counties, see the appendix section for details. All specifications control for a flexible polynomial in the number of beds, county and year fixed effects to address cross-sectional differences between nursing homes and common state-wide demand and cost shocks.

To use the large number of instrumental variables most effectively, I employ a simulated instrument approach. This method increases statistical power by exploiting knowledge of the functional relationship between instruments and the endogenous regressor (see Currie and Gruber (1996a); Currie and Gruber (1996b) and Shan (2010) for a more recent application). To apply this method, I use the exact reimbursement formula but simulate an analogue Medicaid reimbursement rate that only varies in exogenous cost components, cost from peer-group affiliated nursing homes located in different counties. Intuitively, I numerically integrate out the endogenous cost components from the given county by sampling these costs from the population of nursing homes and taking the mean over a large number of sample draws, see the appendix section 9.2 for details.

The top panel of Table 3 presents the regression results. The first column shows the first stage parameter estimate, which indicates that a 1 percent increase in the simulated reimbursement rate raises the endogenous Medicaid reimbursement rate by 0.86 percent. The point estimate is statistically significant at the 1 percent level with an F statistic of 20 and is statistically indistinguishable from 1.
Columns 2-4 present the second stage effects of a 1 percent change in the Medicaid reimbursement rate on the log staffing ratio for skilled nurses, nursing aides, and therapists. The estimates indicate an economically and statistically significant effect for skilled nurses. The point estimate suggests that nursing homes increase the number of skilled nurses per resident by 1.9 percent in response to a 1 percent increase in the Medicaid reimbursement rate. To put this effect into perspective, I assume that a full time skilled nurse works 2,080 hours per year, which corresponds to 52 40-hour weeks. The number of skilled nurses per resident equals 0.24 on average, which corresponds to 2,080 \times 0.24/365 = 1.35 hours per resident and day. This suggests that a 10 percent increase in Medicaid rates raises the time a skilled nurse spends per resident and day by about 15 minutes on average. However, I do not find evidence for systematic changes in the number of nurse aides or therapists following a plausibly exogenous increase in Medicaid rates. Finally, I investigate the effect on private rates in column 5. The partial effect is negative but not statistically significant.
Overall, the preliminary results indicate that nursing homes predominantly adjust the number of skilled nurses per resident in response to exogenous changes in the regulated Medicaid reimbursement rate. This assessment is further supported by additional robustness specifications that investigate the effect of Medicaid rate changes on nursing home costs. Nursing home costs summarize all potential staffing and input decisions. The results from these specifications indicate that vast majority in cost changes can be explained by the observed changes in the number of skilled nurses.

**Market Structure, Staffing, and Pricing.**—To investigate the effect of local competition on staffing and pricing decisions, I consider the following empirical specification:

\[
Y_{jt}^k = \gamma^k HHI_{ct} + \phi^k_t + \alpha^k X_{jt} + \epsilon_{jt}^k
\]

where \(Y_{jt}^k\) denotes the respective outcome measure. Specifically, \(k\) is either the log private rate markup over marginal costs, or the log number of skilled nurses per resident. To quantify marginal costs, I simply use the information on average variable costs from the Medicaid cost reports, see Table 2. \(HHI_{ct}\) denotes the Herfindahl Index in county \(c\) and year \(t\), a commonly used measure of market concentration that equals 0 in case of perfect competition and 1 in case of monopoly. The second panel of Table 3 presents the ordinary least squares regression results. The findings indicate higher markups and lower staffing ratios in more concentrated counties, measured by the Herfindahl index. However, the point estimate for markups is not statistically significant. I revisit the analysis in columns 3 and 4 where I only consider nursing homes located the 25 percent most and least concentrated counties. I replace the Herfindahl index on the right hand side by an indicator variable that turns on in the concentrated markets. The results indicate higher markups and lower staffing ratios in the most concentrated counties, when compared to the least concentrated counties.

Overall, the preliminary evidence suggests that nursing homes adjust the number of skilled nurses per residents in response to changes in Medicaid rates. The findings also indicate that nursing homes located in more concentrated counties charge higher markups and choose lower skilled nurse staffing ratios. This suggests that both Medicaid reimbursement rates as well as the local market structure are potentially important determinants for the provision of good quality of care.
4 Empirical Model

In this section, I derive the empirical model of demand and supply. The demand model addresses the intensive margin, the choice of a particular nursing home, but treats the extensive margin, the form of care in the long term care spectrum as well as the length of stay as exogenous. The supply side model is static and endogenizes the nursing home’s optimal private rate, charged to elderly people who pay out-of-pocket, as well as the skilled nurse staffing decisions. Motivated by steadily falling occupancy rates in this industry over the last decades, I abstract from potentially binding capacity constraints in the baseline analysis. I revisit this assumption in the robustness check section 7.2.

4.1 Demand

In each period $t$, a new cohort of elderly people chooses a specific nursing home. I assume that person $i$ with payer type $\tau$ chooses the nursing home which maximizes her daily indirect conditional utility given by

$$u_{i\tau jt} = \beta_1^d * D_{ij} + \beta_2^d * D_{ij}^2 + \beta_3^{sn} * \log(SN_{jt}^{Res}) + \sum_x \beta_x^X X_{jt} - \beta_p^p * P_{jt} + \xi_{\taujt} + \epsilon_{ijt}.$$  

Here, $D_{ij}$ measures the distance between the senior’s former residence and nursing home $j$. $\log(SN_{jt}^{Res})$ denotes the number of skilled nurses divided by the average number of residents in the facility. $X_{jt}$ captures facility characteristics that are valued by consumers but remain exogenous in the empirical analysis. These include, for example, an Alzheimer unit. $P_{jt}$ captures the daily private rate charged to elderly people, who pay out-of-pocket. $\xi_{\taujt}$ denotes facility characteristics which are observed by person $i$ but remain unobserved to the econometrician, including for example the values or the atmosphere in the nursing home. Finally, $\epsilon_{ijt}$ refers to an i.i.d. extreme value taste shock.

In model heterogeneity in preferences based on the former address, observable differences in the resident’s health profiles (at admission) and payer type. I distinguish between elderly people who

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6 Lack of data on the extensive margin motivate this modeling assumption, which I revisit in the robustness check section 7.1.

7 Similar to Goolsbee and Petrin (2004), I do not model random coefficients since they cannot be nested in the proposed estimation strategy. The inclusion of random coefficients would require a method of moments strategy a la Berry, Levinsohn and Pakes (2004), which introduces other disadvantages. I will come back to this point in the
pay the entire stay out-of-pocket, elderly people who are covered by Medicaid or Medicare for the entire stay, and elderly people who are partially covered but also pay some days of their stay out-of-pocket. I refer to these payer types as private, public, and hybrid payers respectively. I allow the price coefficients in equation 3 to differ between private \((-\beta^P_{\text{priv}} = -\beta^P)\) and hybrid payers \((-\beta^P_{\text{hybrid}} = -\beta^P \cdot \nu^p_{\text{hybrid}})\), where \(\nu^p_{\text{hybrid}}\) captures an adjustment factor. Intuitively, one would expect that hybrid payers to respond to private rates but presumably not as elastically as private payers, suggesting an adjustment factor between 0 and 1. Finally, I assume that public payers do not respond to private rates and set their price parameter to zero. This is equivalent to setting their price to zero. I also allow for differences in preferences over the unobserved characteristics, captured by \(\xi_{r,j}\).8

Combining the modeling assumptions, I can express the nursing home choice probability for senior \(i\) as follows:

\[
 s_{ijt} = \frac{\exp(\beta^d_{1} D_{ij} + \beta^d_{2} D_{ij}^2 + \beta^s_{1} \log(SN_{Res}^{jt}) + \sum_x \beta^x_i X_{jt} - \beta^p_t P_{jt} + \xi_{rjt})}{\sum_{k \in CS_i} \exp(\beta^d_{1} D_{ik} + \beta^d_{2} D_{ik}^2 + \beta^s_{1} \log(SN_{Res}^{kt}) + \sum_x \beta^x_k X_{kt} - \beta^p_t P_{kt} + \xi_{rkt})} .
\]

Here, \(CS_i\) denotes senior \(i\)'s choice set, which includes all nursing homes in a 50 km radius around the senior’s former address. I impose this choice set restriction for computational reasons.9 In practice, less than 2 percent of the seniors choose a nursing home that is further away. This choice set formulation implies that nursing homes may compete with other nursing homes throughout the entire state if there is a sequence of seniors with mutually overlapping choice sets. In practice, however, these “indirect” strategic connections between nursing homes do not turn out to be quantitatively important in the counterfactual exercises.

### 4.2 Supply

I consider a static oligopoly model. Each year, nursing homes compete in private rates and the number of skilled nurses per resident over a new cohort of nursing home residents that begin a

---

8This may capture differences in access to a private room. Medicare beneficiaries or private payers are potentially more likely to end up with a private room than Medicaid beneficiaries. This is contained in the unobserved in the unobserved characteristic, since room type is difficult to track in the data.

9This assumption reduces the data memory requirements considerably since I only need to store nursing home-resident match specific information for nursing homes within 50 km of reach.
nursing home stay in the given year. To deal with nursing home stays that overlap multiple years, I
assume that nursing homes commit to the cohort-specific staffing ratio and private rate throughout
the entire stay.

I assume that nursing homes operate under constant marginal costs, which depend on the skilled
nurse staffing ratio and an unobserved cost shifter \( \omega_{jt} \):

\[
C_{jt} = MC_{jt} \sum_{i \in NH_{jt}} LOS_i = (\omega_{jt} + r_{jt} \cdot SN_{jt}^{res}) \sum_{i \in NH_{jt}} LOS_i + FC_{jt}.
\]

Here, \( LOS_i \) denotes resident \( i \)’s length of stay measured in days, \( NH_{jt} \) is the set of residents of
cohort \( t \) that chooses nursing home \( j \), \( r_{jt} \) measures the salary of a skilled nurse per calendar day,
and \( FC_{jt} \) denotes fixed costs. Since nursing homes choose the number of skilled nurses \textit{per resident},
total skilled nurse salaries, and consequently variable costs, are proportional to the total number
resident days.\(^{10}\)

Combining demand and costs, I can express nursing home profits as follows:

\[
\Pi_{jt} = \sum_{i \in NH_{jt}} s_{ijt} \cdot (P_{jt} \cdot Days_{i}^{priv} + R_{jt}^{mcaid} \cdot Days_{i}^{mcaid} + R_{jt}^{mcare} \cdot Days_{i}^{mcare}) - C_{jt}
\]

\[
= \sum_{i \in NH_{jt}} s_{ijt} \cdot LOS_i \cdot (\bar{R}_{ijt} - MC_{jt}) - FC_{jt}.
\]

Here \( Days_{priv} \) refer to days paid out-of-pocket and \( Days_{mcaid}^{mcaid} \) and \( Days_{mcare}^{mcare} \) denote days reim-
bursed by Medicaid and Medicare respectively. \( \bar{R}_{ijt} \) captures the average daily revenue rate over the
nursing home stay of the elderly \( i \). I assume that nursing homes maximize profits and choose private
rates charged to the non-insured elderly and the number of skilled nurses per resident optimally.
I come back to this assumption in the result and the robustness check section 7.4. Furthermore,
I assume that nursing homes choose private rates and staffing levels simultaneously, which implies
the following first order conditions:

\(^{10}\)It is a simple accounting exercise to show that the equation is cost equivalent to the sum of annual skilled nurse
salaries and the unobserved cost shifter multiplied by the total number if resident days.
\[
\frac{\partial \Pi_{jt}}{\partial P_{jt}} = \sum_{i \in NH_{jt}} s_{ijt} \cdot Days_i^{priv} + \sum_{i \in NH_{jt}} \frac{\partial s_{ijt}}{\partial P_{jt}} \cdot LOS_i \cdot (\bar{R}_{ijt} - MC_{jt}) = 0
\]

\[
\frac{\partial \Pi_{jt}}{\partial S_{N_{res}}^{jt}} = \sum_{i \in NH_{jt}} s_{ijt} \cdot \frac{\partial s_{ijt}}{\partial S_{N_{res}}^{jt}} \cdot (\bar{R}_{ijt} - MC_{jt}) \cdot LOS_i - r_{jt} \sum_{i \in NH_{jt}} s_{ijt} \cdot LOS_i = 0
\]

Rewriting the first order conditions yields the following expressions:

\[
MC_{jt} = \frac{\sum_{i \in NH_{jt}} s_{ijt} \cdot Days_i^{priv} + \sum_{i \in NH_{jt}} \frac{\partial s_{ijt}}{\partial P_{jt}} \cdot \bar{R}_{ijt} \cdot LOS_i}{\sum_{i \in NH_{jt}} s_{ijt} \cdot LOS_i} \tag{4}
\]

\[
r_{jt} = \frac{\sum_{i \in NH_{jt}} s_{ijt} \cdot \frac{\partial s_{ijt}}{\partial S_{N_{res}}^{jt}} \cdot (\bar{R}_{ijt} - MC_{jt}) \cdot LOS_i}{\sum_{i \in NH_{jt}} s_{ijt} \cdot LOS_i} \tag{5}
\]

### 4.3 Estimation and Identification

To estimate the structural preference and cost parameters, I proceed in two steps following the approach in Goolsbee and Petrin (2004). First, I use a Maximum likelihood approach to estimate the nonlinear preference parameters and the mean utilities. The nonlinear preference parameters include the preference parameters for proximity (\(\beta_1^d\) and \(\beta_2^d\)) as well as heterogeneity in preferences in observable resident characteristics. Specifically, I recover the taste heterogeneity net of average tastes in the resident population denoted by \(\tilde{\beta}_i = \beta_i - \beta\). The mean utilities vary at the product-payer type-year level and combine the remaining preference components from the indirect utility function ignoring the logit taste shock:

\[
\delta_{jt} = \begin{cases} 
\beta^{sn} \log(SN_{res}^{jt}) + \sum_x \beta^x X_{jt} - \beta^p \cdot P_{jt} + \zeta_{jt}^{private} & \text{if } \#Private \ Days = \#Days \\
\beta^{sn} \log(SN_{res}^{jt}) + \sum_x \beta^x X_{jt} - \beta^p \cdot v_{hybrid}^{p} \cdot P_{jt} + \zeta_{jt}^{hybrid} & \text{if } 0 < \#Private \ Days < \#Days \\
\beta^{sn} \log(SN_{res}^{jt}) + \sum_x \beta^x X_{jt} + \zeta_{jt}^{public} & \text{if } \#Private \ Days = 0 
\end{cases}
\]

(6)

Weighting the observations by their length of stay delivers the following likelihood function:
\[ L = \prod_{i=1}^{N} \prod_{j \in CS_i} \left( \frac{\exp(\delta_{\tau_{jt}} + \beta^d_1 * D_{ij} + \beta^d_2 * D^2_{ij} + \sum_x \beta^x_i * X_{jt} + \beta^{sn}_i * \log(SN_{jt}^{res}))}{\sum_{k \in CS_i} \exp(\delta_{\tau_{kt}} + \beta^d_1 * D_{ik} + \beta^d_2 * D^2_{ik} + \sum_x \beta^x_i * X_{kt} + \beta^{sn}_i * \log(SN_{kt}^{res}))} \right)^{1(C_i = j) * LOS_i} \]

Hence, the first step solves

\[ \arg \min_{\delta_{\tau_{jt}}, \beta^d_1, \beta^d_2, \beta^x_i, \beta^{sn}_i} - \log(L) . \]

To improve the computational performance of the Maximum likelihood estimator I provide the analytic gradient and hessian. The gradient with respect to the mean utilities equals the difference between the predicted and the observed (weighted) market shares for each payer type and year. Therefore, predicted and observed market shares equal in the optimum just as they do in BLP.

One computational advantage of this estimator, compared to the contraction mapping approach used in BLP, is that the predicted and observed market shares need not coincide in each iteration. This reduces the computation time considerably.\(^1\) Another advantage of the proposed Maximum likelihood estimator is that it uses the micro data on about 270,000 admissions efficiently. A disadvantage of this approach is that it cannot nest random coefficients on endogenous product characteristics since they are not separately identified from the mean utilities in this first step.\(^2\)

Yet, I show in section 5.2 that the modeled preference heterogeneity based on distance, health profiles, and payer types is rich enough to explain variation in markups between nursing homes.

In the second step, I decompose the mean utilities into preferences over observable and unobservable characteristics. However, in order to identify the average tastes for skilled staffing ratios and private rates in the resident population, I need to address their endogeneity. Both, private rates and skilled nurse staffing ratios, are chosen optimally by the nursing home and will therefore be correlated with the unobserved product characteristics \(\xi_{\tau_{jt}}\).

To this end, I use instrumental variables as well as cost data from the Medicaid cost reports combined with the first order conditions. Instrumental variable techniques are commonly used in the industrial organization literature, which aim to exploit exogenous variation in private rates and skilled nurse staffing ratios, exogenous with respect to unobserved preference shocks contained in \(\xi_{\tau_{jt}}\). I use the simulated Medicaid reimbursement rate as an instrument for the skilled nurse

\[^1\]This property is shared with the MPEC approach proposed by Su and Judd (2012).

\[^2\]The identification of random coefficients on endogenous product characteristics requires exclusion restrictions, which are introduced in the second step (but not in the first step) to identify the mean preference parameters.
staffing ratios. I have established the validity of the first stage in Table 3 and I assume that the identifying cost variation (stemming from nursing homes located in different markets) is orthogonal to unobserved preference shocks in the given nursing home market. I use information on region specific price indexes interacted with the payer type as instruments for the private rates. Higher input prices raise marginal costs and lead nursing home to charge higher private rates in equilibrium, which establishes the first stage. A common assumption in the industrial organization literature is that these marginal cost shifters are orthogonal to local preference shocks, which allows me to exclude them from equation 6. Furthermore, I use observable and exogenous product characteristics of local competitors as additional instrumental variables, which are commonly referred to as “BLP” instruments. These characteristics are excluded from equation 6 because rival’s product characteristics do not affect the indirect conditional utility function directly. However, a given nursing home may adjust staffing and pricing decisions based on the characteristics of competing nursing homes, which establishes the first stage. In practice, I use the distance-weighted number of licensed beds, and ownership type of competing nursing homes. Mathematically, the instruments define a set of demand moments, which identify the remaining mean preference parameters. These moment conditions can be written as

$$E[\xi_{tj}|Z_{tj}] = \tilde{\xi}_{rt}$$

where $\tilde{\xi}_{rt}$ only varies at the payer-type-year level. $Z$ contains the set of instruments discussed above.

To further increase the precision of the point estimates, I match the cost predictions form the first order conditions, see equations 4 and 5, with cost data from Medicaid cost reports. Specifically, I construct average variable costs from Medicaid cost reports by subtracting administrative and capital costs from total costs and by diving the remainder by the reported number of resident days. Following the assumption of constant marginal cost, this estimate corresponds to the nursing homes marginal cost, $mc_{jt}$. To construct the daily earnings, $r_{jt}$, I add data on annual salary fringe benefits for skilled nurses from more detailed cost report information and divide the total by 365. This information is available for the year 2002. Next, I construct additional moment conditions

---

13While the geographic market definition used for the simulated instrument contradicts the choice set specification discussed in the demand model, it is important to emphasize that less than 10 percent of residents choose a nursing home located in a different county. Therefore, this conceptual inconsistency does not appear to be important in the empirical analysis. Furthermore, I consider robustness to this specification by considering a more conservative market definition: the metropolitan statistical area.
that relate the predicted marginal costs, $\hat{mc}_{jt}(\theta)$, and the predicted daily earnings, $\hat{r}_{jt}(\theta)$, from the first order conditions to the observed costs in the Medicaid cost reports:

$$\frac{1}{J} \sum_{j \in J_{caid}^{2002}} \hat{r}_{j2002}(\theta) = \frac{1}{J} \sum_{j \in J_{caid}^{2002}} r_{j2002}$$

$$\text{var}(\hat{r}_{j2002}(\theta)) = \text{var}(r_{j2002})$$

$$\frac{1}{J} \sum_{j \in J_{caid}^{2002}} \hat{mc}_{jt}(\theta) = \frac{1}{J} \sum_{j \in J_{caid}^{2002}} mc_{jt}$$

$$\text{var}(\hat{mc}_{jt}(\theta)) = \text{var}(mc_{jt})$$

where $J_{caid}$ and $J_{caid}^{2002}$ denote set Medicaid certified nursing homes for all years and the year 2002 respectively. The cost information is particularly useful for the estimation of the price and staffing preference parameters. Intuitively, the cost information specifies the markup, which is directly related to the price elasticity of demand though the Lerner index. Similarly, the wage information is informative about the demand elasticity with respect to nurses. I discuss the effect of adding the additional cost moments in the next section. Finally, I minimize the weighted sum of the squared moments in a method of moments approach:

$$\hat{\theta} = \text{argmin}_{\theta} g(\theta)' * W * g(\theta)$$

where $W$ is a weighting matrix and $g(\theta)$ is the vector of moment conditions presented in equation 7 and 8.

5 Results

In this section, I discuss the estimation results. I first present the parameter estimates before I evaluate the goodness of the fit and provide a normative interpretation of the demand estimates.

5.1 Demand Parameter Estimates

Table 4 presents relevant demand parameter estimates. Columns 3 and 4 present the baseline estimates that employ the demand and cost moments in the second step of the empirical strategy.
The estimate in the first row indicates that residents value higher skilled nurse staffing ratios. Sicker residents as indicated by a higher CMI value the staffing ratio by more than their healthier peers as evidenced by the second row. Residents dislike paying higher private rates if they pay at least partly out-of-pocket, see rows 3 and 4. Not surprisingly private payers have a higher disutility for private rates than hybrid payers since they pay the private rate on all days as opposed to only on some days of the stay. Consistent with the suggestive evidence from Table 2, I find that residents value proximity measured in 100km to the former residence, see rows 5 and 6. The marginal disutility of traveling further is always negative in the relevant 50km radius. Finally, I find additional evidence for taste heterogeneity based on observable resident characteristics. For example, residents with a stay of less than 100 days have a higher valuation for the number of therapists per resident if they are assigned a larger number of rehabilitative care minutes, see row 9. Also, residents with a diagnosed Alzheimer disease value nursing homes that offer an Alzheimer unit.

### Table 4: Demand Parameters

<table>
<thead>
<tr>
<th>Demand and Cost Moments</th>
<th>Demand Moments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>SE</td>
</tr>
<tr>
<td>$\beta_{sn}$: log(SN/Resident)</td>
<td>1.176***</td>
</tr>
<tr>
<td>$\beta_{cmi}$: log(SN/Resident)*CMI</td>
<td>0.254***</td>
</tr>
<tr>
<td>$-\beta_{p} * \upsilon_{hybrid}$: Price*Hybrid</td>
<td>-0.0088***</td>
</tr>
<tr>
<td>$-\beta_{p}$: Price*Private</td>
<td>-0.0153***</td>
</tr>
<tr>
<td>$\beta_{d1}$: Distance</td>
<td>-25.73***</td>
</tr>
<tr>
<td>$\beta_{d2}$: Distance$^2$</td>
<td>22.34***</td>
</tr>
<tr>
<td>$\beta_{rehab}$: Therapist/Res*Rehabmin</td>
<td>-0.129***</td>
</tr>
<tr>
<td>$\beta_{rehab,short}$: Therapist/Res<em>Rehabmin</em>Short-Stay</td>
<td>0.304***</td>
</tr>
<tr>
<td>$\beta_{a1}$: Alzheimer*Alzheimer Unit</td>
<td>0.440***</td>
</tr>
<tr>
<td>Average Benefit per SN/year</td>
<td>$119,355***$</td>
</tr>
<tr>
<td>Average Wage+Fringe Benefits per SN</td>
<td>$82,000$</td>
</tr>
<tr>
<td>Benefit-Cost</td>
<td>$37,355***$</td>
</tr>
</tbody>
</table>

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

I revisit the point estimates in column 5, which presents analogues results that only exploit the more traditional demand moments in the second step of the empirical strategy. This leaves the point estimates of the nonlinear preference parameters unchanged since I have not changed the first step in the estimation algorithm. Therefore, I focus the discussion on the mean parameter estimates listed in the first, the third, and the fourth row. The point estimates increase slightly in absolute

---

The marginal utility of distance is given by $-25.73 + 2 \times 22.34 \times \text{Distance}$, which is bounded from above by $-25.73 + 2 \times 22.34 \times 0.5 = -3.39$ in the 50km choice set.
magnitude, both for private rates and the skilled nurse staffing, but remain relatively similar in general. In fact, the ratio of the parameters remains almost identical, which is important for the normative implications discussed below. However, we see a substantial increase in the standard errors for the skilled nurse parameter in particular. In that sense, adding the additional moments primarily increases the precision of the point estimates.

5.2 Cost Results and Goodness of Fit

Figure 2 contrasts the predicted marginal cost, predicted by the model, on the horizontal axis with the observed average variable costs from the Medicaid cost reports on the vertical axis for privately operated nursing homes in 2002.\textsuperscript{15} On average, predicted marginal costs coincide closely with observed average variable costs at about $150 per day. While the difference between the marginal costs marks a moment condition in the empirical analysis, it is important to say that the predicted marginal cost are very similar when I exclude the cost moments in the analysis.\textsuperscript{16} More importantly, the model is able to predict the heterogeneity in observed average variable costs, which has not been imposed in the estimation strategy. The slope of the linear regression line equals 0.6 indicating that a $1 increase in the predicted marginal costs is associated with $0.6 increase in the observed average variable costs. The data seem to support the demand and supply modeling assumptions that form the predictions of the first order conditions including profit maximization of privately operated nursing homes, as well as parametric demand and cost restrictions.

Figure 3 presents analogous evidence for predicted and observed average annual salaries for skilled nurses in 2002 at the county level.\textsuperscript{17} Each observation compares the average predicted salary (horizontal axis) to the observed Average annual salary (vertical axis). On average, predicted and observed annual salaries coincide at about $82,000 even when I exclude the cost moment in the empirical analysis. There is also a positive albeit less pronounced relationship between the two measures, which indicates that the model is able to explain some of the heterogeneity in salaries between counties. Presumably, the relationship is less stark for annual earnings given because of considerable measurement error at the facility and even at the county level. Overall, the presented

\textsuperscript{15}The graph focuses on those 80 percent of nursing homes whose predicted and observed marginal costs fall between $100 and $200 per day.

\textsuperscript{16}The respective cost figures are available upon request.

\textsuperscript{17}I aggregate the observed salary data at the county level in order to mitigate the role of measurement error in the graphical analysis.
evidence provide supportive empirical evidence for the empirical modeling assumptions that are necessary for a structural analysis.

5.3 Normative Implications

In order to assess the quality of care in nursing homes from a normative perspective, I contrast the residents’ marginal benefit of an additional skilled nurse with the marginal cost of employing an additional skilled nurses. The marginal benefit depends, however, on the marginal utility of wealth, which is inherently difficult to quantify for Medicaid and Medicare residents since these beneficiaries do not pay for their nursing home stay. To address this concern, I abstract from wealth effects and extrapolate the estimated price parameter of private payers, residents who pay the entire stay out-of-pocket, to the entire nursing home population. I revisit this assumption in the robustness check section 7.3. It is important to note, however, that this assumption does not affect the positive results in the counterfactual analysis.

\footnote{Private payers have higher wealth levels otherwise they would be eligible for Medicaid.}
To provide first evidence on the magnitude of the total resident benefit of an additional skilled nurse, I simply add individual benefits across days and residents at the nursing home-year level evaluated at the year-specific skilled nurse staffing ratio:

\[
MB_{jt} = \sum_{i} MB_{ijt} = -\frac{M\bar{U}_{SN_{jt}}}{MU_{P}} * 365 * Residents_{jt} = -\frac{M\bar{U}_{SN_{res}}}{MU_{P}} * 365 = \frac{\bar{\beta}_{sn_{jt}}}{\bar{\beta}_{P}} * 365.
\]

Here, \( M\bar{U}_{SN_{jt}} \) and \( M\bar{U}_{SN_{res}} \) denote the average daily marginal utility for an additional skilled nurse and an additional skilled nurse per resident respectively. Similarly, \( \bar{\beta}_{sn_{jt}} \) denotes the average preference coefficient for log skilled nurses per residents among residents in facility \( j \) and year \( t \). Combining the preference parameters in Table and evaluating the marginal benefit at the average skilled nurse staffing ratio 2002 yields a joint marginal benefit of $119,400 per year, see the first row in the lower panel of Table 4. The marginal costs of employing an additional skilled nurse, on the other hand, equal only about $82,000 when considering wages and fringe benefits. This
indicates that marginal benefit exceeds the marginal cost by $37,400 per year. This difference is statistically significant at the 5 percent level. The marginal benefit estimate is almost identical if I only consider the demand moments in the estimation strategy evidenced by the third column of the lower panel. However, the difference between marginal benefits and marginal costs becomes statistically insignificant.

The estimates indicate that skilled nurse staffing ratios are on average inefficiently low. To assess the potential heterogeneity across nursing homes, I calculate the difference between joint marginal benefits and marginal costs at the facility-year level. Figure 4 displays the distribution of these facility-specific wedges in a histogram for the year 2002. Staffing standards are inefficiently low in about 80 percent of the nursing homes as indicated by a positive wedge. However, there are also few nursing homes that have negative wedges. Interestingly, these are predominantly nursing homes that do not accept Medicaid residents, which indicates that low Medicaid reimbursement rates may at least partly lead to inefficiently low staffing levels in Medicaid certified nursing homes.

**Figure 4: Heterogeneity Across Nursing Homes in 2002 (in $1,000)**

![Histogram showing the distribution of the difference between joint marginal benefits and marginal costs at the facility-year level for the year 2002.](image)

**Optimal nurse staffing levels:** To provide first evidence on the difference between observed and optimal skilled nurse staffing ratios, I consider a simple social planner problem. In this problem, the social planner allocates residents to nursing homes and chooses the skilled nurse staffing ratio in order to maximize the sum of consumer surplus and provider profits. To simplify the analysis, I assume that annual earnings for skilled nurses are constant within a county. These assumptions
imply a necessary, not sufficient, optimality condition for the nurse staffing ratios:

\[ AMB_c = \frac{\hat{\beta} s^n}{SN_c} \times 365 = r_c \]

where \( r_c \) indicates earnings for a skilled nurse in the county. This condition states that the earnings for skilled nurse must equal a weighted average over the nursing home specific joint marginal benefits in every county. Intuitively, if this condition does not hold true, then there must be at least one nursing home in the county at which the joint marginal benefit differs from the marginal costs. This, however, cannot be socially optimal. In Figure 5, I test the condition in Philadelphia county. The horizontal line indicates the marginal cost of employing an additional skilled nurse, which is simply the nurse salary of about $100,000 in Philadelphia county. The horizontal line also indicates a perfectly elastic labor supply curve. Nursing homes employ only a small fraction of skilled nurses in the local labor market, which is why I abstract from general equilibrium effects on wages when nursing homes increase the number of skilled nurses on staff. The downward sloping curve indicates the average joint marginal benefit of an additional skilled nurse. The benefit curve depends on the staffing ratio because of diminishing marginal utilities. The optimality condition suggest a nurse staffing ratio of 0.26, which exceeds the observed average staffing ratio by about 30 percent. Both observed and optimal staffing ratios are substantially higher than the regulated minimum staffing ratio of 0.07.

In Table 5, I summarize the difference between the optimal and the observed average staffing ratio for all counties. On average observed staffing ratios fall about 29 percent short of the optimum. Interestingly, the predicted optimal staffing ratios coincide closely with recommendations from industry experts. Harrington et al. (2000) argue that the skilled nurse hours per resident day should at least equal 1.85 hours\(^{19}\), which corresponds to a skilled nurse staffing ratio of about 0.33. This benchmark exceeds the current average by about 37.5 percent.

\(^{19}\)The 1.85 hours recommendation combines 1.15 hours for registered nurses and 0.7 hours for licensed practical nurses, see Table 2 in Harrington et al. (2000).
6 Counterfactuals

In this section, I consider several counterfactual policy experiments that aim to increase nursing home incentives to employ additional skilled nurses. Most importantly, I consider increases in the Medicaid reimbursement rates and increases in local competition. In all counterfactual experiments, I only adjust staffing decisions of privately operated nursing homes. An integral assumption is that nursing home maximize profits which may not be accurate for publicly operated nursing homes. Therefore, I hold staffing and pricing decisions of public nursing homes constant in the counterfactual experiments. I also hold the staffing and pricing decisions constant for another 10 percent of privately operated nursing homes, whose predicted marginal costs or salaries were implausible. Since the empirical model is not able to explain their staffing and pricing decisions, I decide to keep them fixed throughout the analysis.

Medicaid Rates: I first consider the effects of a universal increase in the Medicaid reimbursement
rates of 10 percent. Using the estimated model of demand and supply, I am able to calculate the new equilibrium distribution of skilled nurse staffing ratios as well as private rates, which are indicated in Figure 6. The left figure indicates a noticeable increase in the staffing ratio of about 9.4 percent on average, see the fifth row of the top panel of Table 6. Based on the calculation outlined in section 3.2, this corresponds to an increase of 7.5 skilled nurse minutes per resident and day. The right panel of Figure 6 describes the effect on private rates, which is theoretically ambiguous. The associated increase in skilled nurses raises marginal costs, which encourages nursing homes to raise their private rates. However, an increase in Medicaid rates also raises to profitability of hybrid payer consumers are partially covered by Medicaid but partially pay out-of-pocket and who respond to changes in private rates. The increase in Medicaid rates gives nursing homes an incentive to lower their private rates in order to attract additional hybrid payers to their facility. The results in the second figure indicate that the second effect dominates leading to a reduction of 4.1 percent as indicated by the 6th row in Tables 6.

Next, I consider heterogeneity in effects based on market structure. Specifically, I separately consider the effects for nursing homes that are located in counties with weakly more or less than 10 nursing homes. Figure 7 shows the different effects on the staffing and the private rate distribution. The findings indicate that that effects are larger in larger markets. The number of skilled nurses increase by 9.4 percent in larger counties but only by 7.8 percent in smaller counties, see row 5 in columns 3 and 4 of the top panel of Table 6. These differences may stem from strategic complementarities. In larger and more competitive market, increases in staffing levels will have a larger positive effects on staffing levels in competing nursing homes. This conclusion is, however, not supported by the effects on private rates, which decrease slightly more in less competitive, smaller counties.

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20 I proof strategic complementarity for this application in the appendix section 9.3.
To evaluate the welfare implications of the increase in Medicaid reimbursement rates, I extrapolate the price coefficient of private payers to the entire nursing home population. I find that the increase in Medicaid reimbursement rates raises annual Medicaid spending by $184 million, see the third row of the top panel of Table 6. Nursing homes take advantage of the increase in Medicaid rates as profits increase by $75 million, about 41 percent of the increase in Medicaid spending. That means that nursing homes pass about 59 percent on to residents through lower private rates and higher nurse staffing ratios. These changes raise consumer surplus by about $170 million per year. Combining the increase in consumer surplus and provider profits I find a welfare gain of $62 million, net of the increase in Medicaid spending. The gain equals about 34 percent of the increase in Medicaid spending, which exceeds the general distortionary cost of taxation of 30 percent, which is required in order to raise Medicaid spending. This indicates that small increases in Medicaid reimbursement rates can be welfare improving even when taking the distortionary effects of taxation into account. I also revisit the entire analysis for a larger increase in Medicaid rates of 30 percent. The findings are generally very similar. However, I find smaller welfare gains because of
Table 6: Counterfactual: Universal Increase in Medicaid Rates

<table>
<thead>
<tr>
<th></th>
<th>10% Medicaid</th>
<th>Large Markets</th>
<th>Small Markets</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Absolute</td>
<td>%∆ Spending</td>
<td>92.8%</td>
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<tr>
<td>Δ CS</td>
<td>170.3</td>
<td>40.7%</td>
<td>38.4%</td>
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<tr>
<td>Δ PS</td>
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<td>100.0%</td>
</tr>
<tr>
<td>Δ Spending</td>
<td>183.5</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Δ Welfare</td>
<td>61.5</td>
<td>33.5%</td>
<td>33.7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>30% Medicaid</th>
<th>Large Markets</th>
<th>Small Markets</th>
</tr>
</thead>
<tbody>
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<td>%∆ Spending</td>
<td>89.0%</td>
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<tr>
<td>Δ CS</td>
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<td>40.5%</td>
<td>38.4%</td>
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<td>Δ PS</td>
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</tr>
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<td>Δ Spending</td>
<td>568.5</td>
<td>100.0%</td>
<td>100.0%</td>
</tr>
<tr>
<td>Δ Welfare</td>
<td>156.1</td>
<td>27.5%</td>
<td>27.4%</td>
</tr>
</tbody>
</table>

Removing Distance: Next, I turn to the effects of increasing local competition. In a first experiment I set the distance of to nursing homes (within the 50km choice set) to zero. Removing a source of horizontal differentiation may raise the competition among nursing homes are thereby lead them to lower their markups either through increasing their staffing ratios and or by lowering their private rates. In practice, a reduction in distance can be achieved by the entry of new nursing homes. In that sense, I consider the effects from removing distance as an upper bound on the welfare gains from additional entry. This ignores the additional fixed costs of new entrant which I consider in a second step. Setting the distance to nursing homes to zero leads to relatively small increases in the number of skilled nurses per resident but slight slightly larger reductions in private rates when compared to the effects of a modest increase in Medicaid reimbursement rates, see Figure 8. Quantitatively, the number of skilled nurses increases by 7.8 percent, about 6 minutes per resident and day, and private rates decrease by 10 percent on average, see the top panel of Table 7. The right picture of Figure 8 indicates however, that some nursing home reduce their
private rates quite substantially.

In Figure 9, I investigate heterogeneous responses by market size. I find that nursing homes respond more elastically to the distance removal in rural counties with a smaller number of nursing homes. The number of skilled nurses increases by 12.8 percent compared to only 6.2 percent in large markets and private rates decrease by 18.2 percent compared to only 7.3 percent in large counties, see the top panel of Table 7. This pattern stands in contrast to the policy responses for increases in Medicaid reimbursement rate but are very intuitive. The potential effects on competition may not be as large in counties with multiple nursing homes as residents already have access to a variety of nursing homes within a few kilometer of distance. In rural counties, however, removing distance may have substantial effects on the local competition as various more distant nursing homes now become close substitutes. To provide a normative assessment of the removal of distance I evaluate changes in consumer surplus at new preferences, which do not depend on the distance to the nursing home.\(^\text{21}\) I find a small increase in Medicaid spending that result from a resoring of residents to

\(^{21}\) An alternative approach would be to evaluate at old distances. This would lead to a net reduction in consumer surplus because some residents travel very far in the counterfactual despite their true disutility over distance. The
nursing homes with higher daily Medicaid reimbursement rates. More importantly, I find that the reductions in private rates and the increases in staffing ratios reduce nursing home profits by $105 million but raise consumer surplus by $186.1 million. This results in a net welfare gain of $80 million not counting the fixed costs. As expected, the welfare effects are disproportionately larger in smaller counties. While nursing homes in small markets account for only 20 percent of all nursing homes, their welfare effects account for about 35 percent of the total welfare gain.

To put these gains into perspective, I calculate the necessary fixed costs of operating an additional nursing home. Considering administrative and capital costs from the cost reports, I find fixed costs equal of about $1.3 million per year ignoring additional sunk costs from entry, see Table 2. That means, however, that even in the more effective rural markets the additional welfare gains can justify the entry of about $28/1.3=21.5$ nursing homes, less than one nursing home per rural county. It seems highly implausible, however, that the competitive effects of an additional nursing home equal the gains from a complete removal of distance. Hence, the evidence indicates that current specification is therefore an upper bound on potential welfare gains and thereby in line with the general exercise.
<table>
<thead>
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<tr>
<td></td>
<td>Absolute</td>
<td>Large Markets</td>
<td>Small Markets</td>
<td></td>
</tr>
<tr>
<td>Δ CS</td>
<td>186.1</td>
<td>114.4</td>
<td>71.7</td>
<td></td>
</tr>
<tr>
<td>Δ PS</td>
<td>-105.3</td>
<td>-65.5</td>
<td>-39.8</td>
<td></td>
</tr>
<tr>
<td>Δ Spending</td>
<td>1.0</td>
<td>-2.8</td>
<td>3.8</td>
<td></td>
</tr>
<tr>
<td>Δ Welfare</td>
<td>79.8</td>
<td>51.7</td>
<td>28.1</td>
<td></td>
</tr>
</tbody>
</table>

|                  |          |          |
| Avg Δ SN/Res     | 7.8%     | 6.2%     | 12.9%      |
| Avg Δ P          | -10.0%   | -7.3%    | -18.2%     |

|                  | Staffing Floor                      |          |          |
|                  | Absolute | Large Markets | Small Markets |
| Δ CS             | 14.3     | 14.1         | 0.2         |
| Δ PS             | -13.1    | -13.0        | -0.1        |
| Δ Spending       | -0.3     | -0.2         | -0.1        |
| Δ Welfare        | 1.5      | 1.5          | 0.0         |

| Avg Δ SN/Res     | 0.6%     | 0.6%     | 0.0%       |
| Avg Δ P          | 1.1%     | 1.3%     | 0.0%       |

policies that aim to increase the local competition via entry may not be particularly cost-effective.

*Entry Analysis*: The former evidence indicates that the welfare gains from a more competitive market structure are relatively small when compared to realistic fixed cost estimates of additional entrants. Yet, it remains difficult to draw specific policy recommendations from these findings because removing the role of distance in the senior’s choice problem does not correspond to a specific policy instrument. To this end, I now evaluate the welfare effects of a more specific policy experiment: the entry of an additional nursing home. As mentioned earlier, CON regulations restrict the entry decisions of nursing homes which may keep the number of incumbent nursing homes inefficiently low. Conversely, CON laws may also prevent excessive entry that can result when products are substitutable and average costs are downward sloping (see e.g., Mankiw and Whinston (1986)). Both conditions are satisfied in this context, the latter because of fixed cost and constant marginal costs, which implies that whether additional entry lowers or raises social welfare is ultimately an empirical question.

In this exercise, I evaluate the effects of adding an additional nursing home in each of four different rural counties on the private rate and skilled nurse staffing ratio distribution as well as
social welfare. Motivated, by the evidence from Table 7, I consider the entry effects in rural counties where the effects on local competition may be largest. Specifically, I consider entry in Northumberland, Lycoming, Monroe and Centre county as evidenced by the left picture of Figure 10. The incumbents are marked by X and the new entrant is marked by O. To define the entry location of the new nursing home, I simply calculate the weighted average longitude and latitude over incumbent nursing homes in the respective county, weighted by the number of licensed beds. Similarly, I construct weighted averages over observable and unobservable product characteristics and assign these to the new nursing home. Next, I use the structural model to calculate the private rate and staffing ratio distribution in the new equilibrium, holding the staffing and private of the new entrant fixed. The right picture of Figure 10 presents the county specific results in a private rate (horizontal axis) and skilled nurse staffing ratio (vertical axis) diagram. The red dot corresponds to the post-entry private rate and staffing decisions of incumbent nursing homes. The thin line connects the pre-entry and the post-entry staffing and pricing bundle. Finally, the green dot refers to the staffing ratio and the private rate of the new entrant. On average, competitors
decrease their private rates and increase their skilled nurse staffing ratios in response to entry. This is particularly evident in Monroe county. Interestingly, competitors appear to respond more elastically to entrants when they are relatively close in private rate space, which may serve as an overall summary statistic for observed and unobserved facility characteristics.\footnote{Overall, strategic responses of competitors are only noticeable within the same county, staffing ratios and private rates remain basically unchanged in counties that do not experience entry. This indicates that markets are locally segmented and that indirect strategic connections between nursing homes via mutually overlapping choice sets of residents do not appear to be important in practice.}

![Figure 10: Counterfactual: Entry in Four Rural Counties](image)

I also consider the effects on consumer surplus, provider profits, and public spending assuming an additional fixed cost of 1.3 million for the entering nursing homes. The entry decisions are individually just profitable on average. The annual variable profits range between $0.9 and $1.5 million, which equals the annual fixed costs on average. However, the additional entry reduces profits for competing nursing homes largely because of “stolen” business. Overall variable industry profits decrease by $200,000, including the variable profits of the four new entrants. The business stealing aspect is particularly stark in this context, because I hold the extensive margin, the length of stay and the number of residents, fixed. The decrease in private rates, the increase in skilled nurse staffing ratios, and the increase in nursing home variety raise consumer surplus by $250,000 per year. On net, however, the additional fixed costs of $5.2 million (4 * $1.3 million) outweigh the...
small benefits from competition and product variety, which implies a reduction in social welfare. This indicates that the CON law may successfully prevent socially wasteful entry. Entry decisions seem to be profitable from the point of view of the entrant, who does not internalize the business stealing effect from competitors, but not from the point of view of society.

Staffing Floor: Finally, I consider the effects of raising the minimum skilled nurse staffing ratio to 0.2. In the counterfactual experiment, I assume full compliance and add this lower bound as an additional constraint to the nursing home’s profit maximization problem. The minimum staffing requirement affects 21 percent of nursing homes directly who choose lower staffing ratios in the absence of this refinement. The competitive spillover effects are relatively small which may be because of considerable vertical differentiation. Nursing homes with higher nurse staffing ratios may compete for different nursing home residents on the margin, which can explain why their staffing and pricing decisions remain largely unchanged. The regulation leads to a moderate increase in social welfare of $1.5 million per year, see the lower panel of Table 6, because staffing ratios are generally inefficiently low to begin with.

7 Robustness

In this section, I first revisit the demand for nursing home care at the extensive margin. Next, I test whether capacity constraints are binding in this context and how this might affect the main empirical findings. Next, I test for wealth effects among nursing home residents and how this might affect the normative implications of the analysis. Finally, I revisit the counterfactual analysis of Medicaid rate changes using an alternative empirical approach to the estimation of supply. This approach rests on different modeling assumptions and provides an interesting benchmark for the baseline estimates.

7.1 Extensive Margin

In the baseline analysis, I assume that the form of long term of care, as well as the length of stay, is primarily determined by the consumer’s health profile and the family background and not by prices and nurse staffing levels chosen by nursing home providers. Specifically, I assume that the total demand for nursing home care services remains unchanged in the counterfactual analysis following
moderate changes in private rates and skilled nurse staffing ratios. This assumption is supported by anecdotal and empirical evidence. Grabowski and Gruber (2007) investigate the effect of Medicaid regulations on the demand for institutional nursing home care and find that more generous asset protection rules as well more generous reimbursement regulations, which may raise the quality of care in nursing homes as shown here, have only very small effects on the demand for nursing home care at the extensive margin. This indicates that the demand at the extensive margin is relatively inelastic with respect to out-of-pocket payments and the quality of care.

To investigate the demand at the extensive margin further, I analyze the demand responses to a discontinues price change amongst Medicare beneficiaries. Medicare covers up to 100 days of a nursing home stay but requires a copay rate of about $157.50 per day starting on the 21st day of the stay.\(^2\) The copay does not depend on the specific nursing home identity. Hence, Medicare beneficiaries witness a substantial $150 price change on the 21st day of their stay, which corresponds to about 2.5 standard deviations of the private rate variation at the intensive margin. If residents are price elastic on the extensive margin, then one would expect a considerable amount of bunching in the length of stay distribution prior to the 21st day of the stay. I investigate the length of stay distribution in Figure 11, where I compare residents that are initially covered by Medicare in the top panel to a control group of residents who either pay out-of-pocket or are covered Medicaid on the first day of their stay in the lower panel. I focus on stays with a length of less than 60 days. Overall, the distributions look very similar. There is small spike in the length of stay distribution for Medicare beneficiaries on day 20, which is consistent with bunching, but the effect appears to be very small. This indicates that Medicare beneficiaries are not particularly price sensitive on the extensive margin.

Based on the evidence from the literature and the presented empirical evidence, I conclude that nursing home demand appears to be relatively inelastic at the extensive margin with respect to prices and the quality of care. This suggests that the main findings are robust with respect to treating the extensive margin as exogenous.

7.2 Rationing

A potential concern for the empirical analysis is the role of binding capacities as a result of CON laws, which restrict entry and investment decisions. Binding capacity constraints may bias the demand elasticities downward. The baseline estimation strategy interprets limited observed demand responses to changes in private rates and staffing ratios as evidence for small preference parameters as opposed to limited access to nursing homes. To assess the role of binding capacities in this context, I revisit the evidence from the literature, discuss evidence on nursing home occupancy rates in the sample population, and re-estimate demand in an alternative framework that incorporates capacity constraints. In this model, constrained nursing homes admit residents on a first-come-first-serve basis.

An earlier literature argues that excess demand, induced by CON laws, has been a prevailing characteristic of the nursing home industry in the 1970 and early 1980, see Scanlon (1980) and Nyman (1989b). Over the last decades, however, occupancy rates in nursing homes have been falling steadily at least in part because various states have implemented policies supporting alternative
forms of long-term care that allow seniors to stay longer in their community. Consequently, a more recent literature finds that capacity constraints are less likely to induce excess demand (e.g., Bishop (1999); Nyman (1993); Grabowski (2001)).

Consistent with the more recent literature, I find that (using admission and discharge information on all residents) less than 4 percent of nursing homes in the sample population operate at their physical capacity limit on a given day. Furthermore, several nursing home residents have very short stays indicating that new beds open up very quickly. This indicates that binding capacities only affect a small number of nursing homes, predominantly located in urban areas, leaving residents sufficiently many accessible alternatives to choose from. Therefore, it seems unlikely that capacity constraints introduce a large bias for the key demand elasticity estimates. This assessment is further supported by the fact the estimated demand parameters imply reasonable marginal cost estimates. As indicated in Section 5.2, predicted marginal costs and salaries coincide closely with observed costs from external cost reports, even when the cost moments are not included the moment conditions. It is also implausible that capacity constraints introduce a large bias to the key findings from the two main counterfactual experiments. With respect to the entry analysis in four rural counties, it is important to emphasize that the highest occupancy rate in any of the incumbent nursing homes equals 98 percent, indicating that none of them reaches their physical capacity limit. With respect to the analysis of increases in Medicaid reimbursement rates, I find that the predicted changes in skilled nurse staffing ratios match closely with the suggestive evidence presented in Section 3.2. The suggestive evidence exploits a plausibly exogenous source of variation in Medicaid reimbursement rates and does not depend on an accurate specification of senior choice sets. I also do not find evidence for heterogeneous nursing home responses based on their occupancy ratios. I extend the suggestive analysis in the next section, where I describe the equilibrium play of nursing homes via estimated policy functions. Using this alternative approach, I find slightly larger staffing responses to a universal increase in Medicaid reimbursement rates, which leaves the qualitative policy conclusions unchanged.

Finally, I revisit the potential effects of rationing in an alternative demand specification that models the capacity constraints directly. Combining the admission and discharge data on the universe of nursing residents with the observed number of licensed beds, I am able to calculate

\[24\] The baseline model, on the other hand, abstract from rationing, which is consistent with wait listing.
the number of open beds on each day in the sample period. In contrast to the baseline model, I assume that residents are admitted on a first-come-first-serve basis. Consequently, I leave only those nursing homes in the senior’s choice set that have at least one open bed on the day the resident was admitted to any nursing home. Using the revised choice set, I estimate the preference parameters excluding the cost moments in the second step. The parameter results are very similar to the estimates presented in Table 4 and imply a wedge between the marginal benefit and marginal costs of about $30,000 per year.

Overall, the presented evidence indicates that capacity constraints are unlikely to have a meaningful impact on the main empirical estimates and policy conclusions.

### 7.3 Wealth Effects

The normative interpretations rely on a revealed preference approach that extrapolates the estimated marginal utility of wealth for private payers onto the entire nursing home population. This approach may overstate the marginal benefit of an additional skilled nurse if the actual marginal utility of wealth for Medicaid beneficiaries is larger than the marginal utility of wealthier private payers.

To test for the potential role of wealth effects, I take advantage of observed asset spend-down patterns in the data. Based on Medicare and Medicaid claims data, I can identify the number of days paid out-of-pocket before the senior becomes eligible for Medicaid. I multiply the number of days with daily private rate to quantify the amount of tangible assets that are not protected under Medicaid and have to be spent down before the senior becomes eligible. Unfortunately, tangible assets are censored since there is a subset of senior who are never eligible for Medicaid during their nursing home stay. To address this concern, I assume that tangible assets follow an exponential distribution, whose mean depends on observable resident characteristics including age, gender, race and zip code. I estimate the respective mean asset levels using the censored and non-censored observations and draw tangible assets levels for the censored observations from the respective distribution. I display the respective asset distribution in the left picture of Figure 12 which indicates a median tangible wealth level of $100,000 prior to the admission to the nursing home for private payers. There is a large number of residents with zero assets, who are eligible for

25 They can be included, require however a supply side model that that takes rationing into account.
Medicaid on first day of their nursing home stay.

Figure 12: Wealth Effects

In a second step, I interact the recovered tangible wealth level with the private rate in the resident’s indirect conditional utility function. This approach allows me to quantify different marginal utilities for wealth amongst residents with different tangible wealth levels. I also add a second interaction term that turns on for residents with tangible wealth levels of more than $120,000 the mean wealth level in the population. The second interaction allows for differential wealth effects for particularly wealthy residents. However, I also re-estimate preferences without this second interaction effect. The right picture of Figure 12 summarizes the estimated marginal utility of wealth for different tangible wealth levels. Interestingly, I do not find evidence for positive wealth effects between 0 and $120,000 of tangible wealth. If anything, the estimates indicate that residents with lower wealth levels have a smaller marginal utility of wealth which suggests the opposite. Since the baseline estimates extrapolate the price coefficient from an average private payer, this suggests that I am slightly overstating the marginal utility of wealth of Medicaid beneficiaries and thereby understate the marginal benefit of additional skilled nurse. However, the evidence indicates that wealth effects exist for richer private payers. Amongst residents with tangible wealth levels of more than $120,000 I find decreasing marginal utilities in wealth.

In summary, I do not find evidence for wealth effects over the relevant support in the extrapolation exercise. Furthermore, the normative implications are highly consistent with the assessments of industry experts, which suggest that possible biases stemming from wealth effects are potentially
small.

7.4 Equilibrium Strategies

In this section, I consider an alternative empirical approach to estimate the supply side behavior, which allows me to revisit some counterfactual exercises. In this approach, I first estimate the equilibrium staffing and pricing strategies directly from the data, similar to the first step estimation in Bajari, Benkard and Levin (2007) and the counterfactual analysis in Goolsbee and Petrin (2004). These equilibrium strategies correspond to the solutions of the first order conditions when solved for the optimal staffing and pricing decisions and depend on a potentially large set of state variables. Second, I use the estimated equilibrium strategies to consider the counterfactual effects of a change in an important state variable: the Medicaid reimbursement rate.

Specifically, I estimate equilibrium strategies of the following form:

\[ Y_{kj}^* = \gamma_1^k * MA_{jt} * \log(R_{caid}^{med}) + \gamma_2^k * \log\left(\frac{1}{J} \sum_{l \in J} R_{caid}^{med}\right) + \alpha^k X_{jt} + \phi_I^MA * MA_{jt} + \phi_I + \phi_c + \epsilon_{kj}^*. \] (9)

where \( Y_{kj}^* \) either refers to the skilled nurse staffing ratio or the private rate charged by nursing home \( j \). The right hand side lists the relevant set of state variables including the Medicaid reimbursement rate, other observable nursing home and county-specific demand and cost characteristics contained in \( X \), year and county fixed effects. I also allow for unobserved state variables contained in epsilon. The main difference relative to the preliminary analysis is that I allow non-Medicaid and Medicaid certified nursing homes, \( MA=1 \), to respond differently to changes in Medicaid reimbursement rates. Certified nursing homes respond to the own rate whereas all nursing home respond to the average Medicaid rate in the market because of competitive spillover effects, captured by the parameter \( \gamma_2 \).

As mentioned earlier, I use instrumental variables to address the potential correlation between Medicaid reimbursement rates and unobserved state variables contained in epsilon. To instrument for the average Medicaid reimbursement rate in the market, I take advantage of the fact that competing nursing homes in a different size group also belong to a different peer group. Therefore, I can use variation in costs from other nursing homes, which are located in different markets but belong to the same peer group of competing nursing homes in different size groups, as additional instruments. The IV regression results are presented in Table 8.
Table 8: Evidence on Staffing and Pricing from Equilibrium Strategies

<table>
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<th>(1) log(SN^{Res})</th>
<th>(2) log(P)</th>
</tr>
</thead>
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<td>$\gamma^k_1$: MA x Log $R_{jt}$</td>
<td>0.83$^*$</td>
<td>-0.51</td>
</tr>
<tr>
<td></td>
<td>[-0.01,1.68]</td>
<td>[-1.58,0.57]</td>
</tr>
<tr>
<td>$\gamma^k_2$: Log Avg. $R_{jt}$</td>
<td>1.97$^*$</td>
<td></td>
</tr>
<tr>
<td></td>
<td>[-0.29,4.24]</td>
<td>[-0.65,1.45]</td>
</tr>
</tbody>
</table>

p-val: $\gamma_{1sn} + \gamma_{2sn} = 0$

N

95% confidence interval in brackets. $^*p<0.10$ $^{**}p<0.05$ $^{***}p<0.01$

Note: All specifications control for year and county fixed effects, ownership type, whether the provider has an Alzheimer unit, and a fourth order polynomial in size. Standard errors are clustered at the county level.

Column 1 of Table 8 presents the equilibrium effects for the number of skilled nurses per resident. The estimates suggest that Medicaid certified nursing homes increase the skilled nurse ratio by $\gamma_{1sn} + \gamma_{2sn} = 2.8$ percent following a universal increase in Medicaid rates of 1 percent. Non-certified nursing homes respond less elastically and increase the skilled nurse ratio by 2 percent because of competitive spillover effects. The equilibrium responses exceed the estimates from the baseline model, notice however that I can not statistically reject the hypothesis that the effects for either group is larger than 1 percent. The estimates do not provide clear evidence in favor of changes in private rates. The point estimates are negative, which is consistent with the evidence from the baseline model but they imprecisely estimated.

The presented estimates indicate even larger welfare gains from an increase in Medicaid in reimbursement rates since nursing homes may increase their staffing ratios even further. This corroborates a main conclusion from the baseline analysis: moderate increases in Medicaid reimbursement rates can raise social welfare.

8 Conclusion

Quality shortfalls in U.S. nursing homes have been an ongoing concern for several decades. Despite various regulatory effort to improve the situation, several policy reports still emphasize that current direct care nurse staffing ratios are too low, which are the key input for the production of health care services for a particularly vulnerable, frail, and elderly resident population. This paper investigates
the incentives faced by nursing home providers to provide better quality of care which are an integral to the design of policy instruments that can address these shortfalls.

Specifically, I empirically investigate two mechanisms that can explain why the quality of care may not be socially optimal. First, prices for nursing home care are largely regulated. If reimbursement rates are set too low, then nursing homes face little incentive to compete for Medicaid or Medicare beneficiaries through better quality of care. Second, theory has long held that firm market power can lead to inefficiently low quality levels. Market power arises in this context because seniors typically only consider nursing homes within a few kilometers from their former residence but also because CON laws restrict entry and investment decisions of nursing homes, which may keep the number of competitors particularly low. Motivated by these theoretical considerations, I quantify the effects of different policy instruments on the quality of care, consumer surplus, producer profits, and social welfare, which either raise the competition amongst providers or increase the generosity of Medicaid reimbursement rates.

Using detailed nursing home and resident micro-data, I estimate a structural industry model that endogenizes the private rate charged to residents who pay out-of-pocket as well as the ratio of skilled nurses per resident, which appears to be the key quality input measures that nursing homes adjust in response to a plausibly exogenous increase in Medicaid reimbursement rates.

My demand estimates indicate that staffing ratios of skilled nurses are inefficiently low in equilibrium. Extrapolating the revealed preferences of seniors who pay out-of-pocket to the entire nursing home population indicates that residents value an additional skilled nurse at $119,000 per year. However, employing an additional skilled nurse costs the nursing home only about $82,000 dollars when counting wage and fringe benefits. Based on a social planner’s problem, I find that current staffing standards fall short of the social optimum by about 30 percent, which is consistent with the evidence from industry reports.

Building on the estimated primitives of the oligopoly model, I am able to conduct a variety of counterfactual experiments that aim to increase the nurse staffing ratios and thereby enhance social welfare. Most importantly, I investigate the effects of a universal increase in Medicaid reimbursement rates, and contrast the findings to the result to increase in competition stemming from additional entry in four rural counties. My findings indicate that nursing homes increase the number of skilled nurses per resident by about 9 percent in response to a universal 10 percent
increase in Medicaid reimbursement rate. Furthermore, nursing homes decrease the private rates by 4 percent. With respect to social welfare, I find that the increase in Medicaid rates costs the regulator about $184 million per year but raises nursing home profits by $75 million per year. This indicates that nursing homes pass 60 percent of the Medicaid revenue increase on to their residents through higher skilled nurse staffing ratios and lower private rates. Based on the revealed preference approach, I find an increase in consumer surplus of $170 million. In total, I find a partial welfare gain of $62 million, about 34 percent, of the increase in Medicaid spending. This estimate exceeds common estimates from the public finance literature on the social cost of taxation, which equal about 30 percent.

I contrast these estimates to the potential gains from competition induced by directed entry. Specifically, I consider the costs and benefits of adding an additional nursing home to four different rural markets, where the gains from competition may be largest. This exercise is particularly interesting in the context of existing CON regulations, which distort the entry and investment decisions of nursing homes in Pennsylvania. In each market, I add another nursing home, whose product characteristics and location correspond to a weighted average over the incumbent nursing homes. Again, I use the model to calculate the new equilibrium staffing and private rate distribution. I find that competing nursing homes increase the number of skilled nurses per resident and lower their private rates in response to additional entry. Interestingly, I find that variable annual profits of the entering nursing homes range between $900,000 and $1.5 million which equal the annual fixed costs. However, the profits reflect business stealing from incumbents. In fact total industry profits decrease by $200,000 which is consistent with the decrease in private rates and an increase in the number of skilled nurses of local competitors. While consumer surplus increases slightly, social welfare actually decreases. Hence, the findings indicate that the additional entry is socially wasteful while profitable from the point of view of the entrant.

Taken together, the results from the counterfactual exercises provide supportive evidence for small to moderate increases in Medicaid reimbursement rates to improve nurse staffing ratios in this industry. However, increasing competition by encouraging entry does not appear to be a cost effective policy instrument to improve the quality of health care delivery in this industry.
References


Grabowski, D, ‘Medicaid Reimbursement and the Quality of Nursing Home Care’, *Journal of Health Economics*, 20 (2001), 549–569.


9 Appendix

9.1 Reimbursement Formula

Each facility within a given peer group reports previous average costs per resident day for different cost categories from typically two, three, and four years ago on a quarterly basis. The different cost categories are resident care costs (rc), which comprise spending on health care related inputs, other resident related care costs (orc), administrative costs (admc), and capital costs (capc). The regulator computes the facility specific arithmetic mean of the reported average costs by category and assigns the peer group and category specific median cost level for all but capital costs to each facility in the peer group. Capital costs are reimbursed directly. The final category specific reimbursement rate for facility \( j \) in year \( t \) depends on the median rate and \( j \)'s previous average costs according to the following formula:

\[
P_{j_t}^{caid} = \min \left\{ \begin{array}{l}
1.17 \times \text{med}\left( \left\{ AC_{rc}^{t-2} \right\}_{P(k)=P(j)} \right), \\
0.3 \times 1.17 \times \text{med}\left( \left\{ AC_{rc}^{t-2} \right\}_{P(k)=P(j)} \right) + 0.7 \times 1.03 \times AC_{rc}^{t-2} \\
\end{array} \right\} \times cmi_{j}^{MA} \\
+ \min \left\{ \begin{array}{l}
1.12 \times \text{med}\left( \left\{ AC_{orc}^{t-2} \right\}_{P(k)=P(j)} \right), \\
0.3 \times 1.12 \times \text{med}\left( \left\{ AC_{orc}^{t-2} \right\}_{P(k)=P(j)} \right) + 0.7 \times 1.03 \times AC_{orc}^{t-2} \\
\end{array} \right\} \\
+ 1.04 \times \text{med}\left( \left\{ AC_{admc}^{t-2} \right\}_{P(k)=P(j)} \right) \\
+ AC_{capc}^{t-2} \\
\right.
\]

(10)

Here, \( AC_{rc}^{t-2} \) denotes the Case Mix Index and inflation corrected average costs for resident care. Average resident related care costs, average administrative costs, and average capital costs (\( AC_{orc}^{t-2}, AC_{admc}^{t-2} \), and \( AC_{capc}^{t-2} \)) are corrected for inflation but not for the Case Mix Index of the residents. Finally, \( cmi_{j}^{MA} \) measures the Case Mix Index of Medicaid patients in facility \( j \) and \( P(j) \in P_1, P_2, \ldots, P_{12} \) refers to facility \( j \)'s peer group, defined by size and geographic region. In words, resident care costs, other related care cost and administrative costs are reimbursed according to a weighted average of own costs and the median cost level in the peer group unless own costs exceed the median cost level. In this case, facilities receive the median cost level. This methodology resembles the “yardstick competition” regulatory scheme in which the regulator uses the costs of comparable firms to...
infer a firm’s attainable cost level.

9.2 Simulated Reimbursement Rate Using Predicted Average Costs

Step 1: The Number of Sampled Facilities:

I replace the set of endogenous average costs of providers located in the county under study with randomly drawn average costs from the sample year population of Pennsylvania. The number of sampled facilities is relevant as the reimbursement formula computes the median resident care cost level. For instance, if I sample too many facilities, then the median rate will reflect the median level in Pennsylvania not the median level in the peer group. This will not bias the parameter estimates but it will clearly reduce the statistical power of the IV strategy. On the other hand, one may not want to replace the endogenous average resident care costs one by one as the number of facilities in the county under study may be endogenous. As a compromise between the two suggestions I compute the predicted number of facilities per county-peer group based on the underlying number elderly residents in the county. Specifically, I first predict the number of nursing facilities in the county via OLS regressions on the number of county residents aged 65 and older by gender. Second, I compute the size group ratio in other counties of the peer group and multiple the predicted number of facilities by this ratio. For instance, if 30 percent of the facilities in other counties have 269 or more beds, then the predicted number of nursing facilities with 269 or more beds in the county under study equals 30 percent times the predicted number of facilities in the county. The predicted number of facilities addresses the endogeneity concern and it is sufficiently close to the observed number of facilities, such that the instruments still have substantial statistical power, see the result section. I address the simulation error in step 3.

Step 2: Simulate the Cost Block Reimbursement Rate:

Using the set of randomly selected and exogenous average costs from other counties, I simulate the cost resident care specific reimbursement rate multiple times such that each of the sampled average cost observations enters the formula once as facility j and otherwise via a competitor in j’s county. As a competitor, the average cost observation affects the reimbursement rate through the median rate only. As facility j, the average cost observation affects the reimbursement rate through the own costs as well.

Step 3: Reduce Simulation Error: Finally, I iterate steps one and two 200 times to minimize
the simulation error and I use the arithmetic mean of these 200 simulated instruments.

9.3 Strategic Complements

In this section, I show that inputs are strategic complements in a simplified framework that abstracts from consumer heterogeneity, pricing decisions and assumes that firms maximize profits.

For simplicity, suppose there are three nursing homes 1, 2, and 3. Each consumer has the same sources of payment and the provider receives an average price of $\bar{P}$ per resident day. To simplify the analysis further, I assume that consumers stay for only one day. Regarding the marginal costs, I assume that they are weakly convex in a one-dimensional input: $\frac{d^2MC_1}{d\theta_1^2} \geq 0$. Finally, suppose the residual demand for provider $j$ equals the market share

$$s_j = \frac{\exp(\delta_j + \beta \log(\theta_j))}{\sum_{k=1,2,3} \exp(\delta_k + \beta \log(\theta_k))} .$$

Firm profits are now given by

$$\pi_j = \left[\bar{P}_j - MC_j\right] * s_j - FC_j .$$

If nursing homes maximize profits, the first order condition w.r.t. the input is given by

$$F_j(\theta_1^*, \theta_2^*, \theta_3^*) = \left[\bar{P}_j - MC_j\right] * \frac{ds_j}{d\theta_j} - s_j * \frac{dMC_j}{d\theta_j} .$$

To show that inputs are strategic complements, I show that

$$\frac{d\theta_j^*}{d\theta_{-j}} = -\frac{dF}{d\theta_{-j}} \geq 0 .$$

Proof. First I show that $\frac{dF}{d\theta_2} > 0$. We have

$$\frac{dF_1}{d\theta_2} = \left[\bar{P}_1 - MC_1\right] * \frac{d^2s_1}{d\theta_1 d\theta_2} - \frac{ds_1}{d\theta_2} * \frac{dMC_1}{d\theta_1}$$

$$= -\left[\bar{P}_1 - MC_1\right] * \frac{\beta_1}{\theta_1} * \frac{\beta_2}{\theta_2} (s_1 s_2 (1 - s_1) - s_1^2 s_2) - \left( -\frac{\beta_1}{\theta_1} s_1 s_2 * \frac{dMC_1}{d\theta_1} \right)$$

$$= \left( -\frac{\beta_1}{\theta_1} s_2 \right) \left( \left[\bar{P}_1 - MC_1\right] \frac{ds_1}{d\theta_1} - \frac{\beta_1}{\theta_1} s_1^2 \right) - s_1 * \frac{dMC_1}{d\theta_1}$$
\[
\begin{aligned}
&= \left( -\frac{\beta}{\theta_2} s_2 \right) \left[ \bar{P}_1 - MC_1 \right] \left( -\frac{\beta}{\theta_1} s_1^2 \right) > 0,
\end{aligned}
\]

where the last step substituted in the first order condition.

Second, I show that \( \frac{dF_1}{d\theta_1} < 0 \). First, we have

\[
\begin{aligned}
\frac{d^2 s_1}{d\theta_1 d\theta_1} &= \frac{d}{d\theta_1} \left( \frac{\beta}{\theta_2} s_1 (1 - s_1) \right) \\
&= -\frac{\beta}{\theta_1^2} s_1 (1 - s_1) + \left( \frac{\beta}{\theta_1} \right)^2 \left( s_1 (1 - s_1)^2 - s_1^2 (1 - s_1) \right).
\end{aligned}
\]

Now we have,

\[
\begin{aligned}
\frac{dF_1}{d\theta_1} &= \left[ \bar{P}_1 - MC_1 \right] \frac{d^2 s_1}{d\theta_1 d\theta_1} - \frac{dMC_1}{d\theta_1} * \frac{ds_1}{d\theta_1} - \frac{dMC_1}{d\theta_1} * \frac{ds_1}{d\theta_1} - \frac{d^2 MC_1}{d\theta_1 d\theta_1} s_1 \\
&\leq \left[ \bar{P}_1 - MC_1 \right] \frac{d^2 s_1}{d\theta_1 d\theta_1} - \frac{dMC_1}{d\theta_1} * \frac{ds_1}{d\theta_1} - \frac{dMC_1}{d\theta_1} * \frac{ds_1}{d\theta_1} \\
&\leq \left[ \bar{P}_1 - MC_1 \right] \frac{d^2 s_1}{d\theta_1 d\theta_1} - \frac{dMC_1}{d\theta_1} * \frac{ds_1}{d\theta_1} \\
&= \frac{\beta}{\theta_1} (1 - s_1) \left( \left[ \bar{P}_1 - MC_1 \right] \left( -\frac{1}{\theta_1} s_1 + \frac{\beta}{\theta_1} s_1 (1 - 2s_1) \right) - \frac{dMC_1}{d\theta_1} s_1 \right) \\
&= \frac{\beta}{\theta_1} (1 - s_1) \left( \left[ \bar{P}_1 - MC_1 \right] \frac{\beta}{\theta_1} s_1 (1 - s_1) - \frac{dMC_1}{d\theta_1} s_1 + \left[ \bar{P}_1 - MC_1 \right] \left( -\frac{1}{\theta_1} s_1 - s_1^2 \frac{\beta}{\theta_1} \right) \right) \\
&= \left[ \bar{P}_1 - MC_1 \right] \left( -\frac{1}{\theta_1} s_1 - s_1^2 \frac{\beta}{\theta_1} \right) < 0
\end{aligned}
\]

where, the last step uses the first order condition again. \( \Box \)