Regulations in Nursing Home Markets:
Estimation of a Competitive Model

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December 28, 2006

Abstract:

The nursing home industry has been thought to face many problems: low quality, high price, and limited access. This industry is heavily regulated by state governments. Supply is restricted by the certificate-of-need (CON) laws and Medicaid reimbursement rates are usually set lower than the private-pay prices. The purpose of this paper is to construct a structural model that can examine the effects of these policies on nursing home outcomes. The estimated model suggests that about one fourth of nursing homes used for this study face a binding bed constraint; about 11 percent of Medicaid consumers who demand for nursing home care cannot enter their first-choice nursing homes; about 2 percent of Medicaid consumers who demand for nursing home care do not enter any of the nursing homes.

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1. Introduction

With the substantial growth of the elderly population, it is becoming increasingly important to understand the workings of the nursing home market. This market is widely thought to face some serious problems. One such problem is access to care; many Medicaid patients who qualify for nursing home care have difficulty finding a home with available beds.[1] Another problem is quality of care; in many cases the quality of care has been perceived to be low.[2] This industry is heavily regulated in two important ways. First, many state governments restrict supply so that a certificate of need (CON) is necessary for new nursing homes to enter the market or even the existing ones to increase the number of beds. Second, state governments regulate the price that they pay for a large percentage of nursing home care through Medicaid programs.

There exists a large body of work that studied the effects of regulations on nursing home markets. One group of studies focused on the effect of Medicaid reimbursement, such as how the level of Medicaid reimbursement rates affects nursing home quality of care and whether the difference of reimbursement method—prospective or cost-based payment—affects nursing home outcomes.[3] Another group of studies investigated the effects of the CON laws. Because the CON laws can potentially create excess demand in the market and allow existing nursing homes to establish and preserve market power, some of the studies examined the empirical relationship between excess demand and market outcomes while others examined the effect of market concentration on market outcomes.[4]

We have learned much from this work; however, we cannot use it to answer some important questions, due to its use of a reduced-form model approach. Those questions include: Is Medicaid access improved if the government allows existing nursing homes to increase their number of beds more easily? Does the increased competition lower quality of care because nursing homes tend to compete in prices

[1] Many previous studies found evidence that Medicaid patients face lower access to nursing home care.
[2] See the report to Congress made by Health Care Financing Administration in July 2000.
[3] See, for example, Nyman (1985, 1998, 1994), Gertler (1989, 1992), GAO (1990), Cohen and Spector (1996), and Grabowski (2001).
[4] See, for example, Lee et al. (1983), Nyman (1988a, 1988b, 1994), Gertler (1989, 1992), Cohen and Spector (1996), and Spector et al. (1998).

rather than in quality? Is consumer welfare increased when the Medicaid reimbursement rates are raised? If so, how much will consumer welfare be increased? Previous studies have tried to measure the extent of rationing by using the nursing home occupancy rate as a proxy for rationing. But this approach does not quantify the extent of excess demand because it does not measure the number of patients who prefer to live in a particular nursing home but cannot do so. Most previous studies using a reduced-form model assumed a fixed relationship between price and quality; however, it is possible that price and quality move to the same direction in one case but they move in the opposite direction in another case. Such variation is not allowed in reduced-form models. Furthermore, reduced-form analysis cannot measure consumer welfare.

The goal of this paper is to provide an alternative way to approach the problems—a structural model approach.[5] We construct a structural model that takes into account key institutional features of the nursing home industry and that enables us to simulate counterfactual policy changes. Our model basically follows the structural oligopoly discrete-choice models developed by Berry et al. (1995), but it differs in two ways.

First, we modify their models to account for rationing. It is important to incorporate rationing into the analysis, not just because rationing is a key feature of the industry, but also because this aspect of the industry is obviously heavily influenced by government policies. Our model explicitly takes into account the fact that each nursing home has two different demand functions: one from private-pay patients and one from Medicaid patients.[6] Nursing homes are unconstrained in setting the price for private-pay patients, but face a regulated price for Medicaid. In addition, they are required to set the same quality of care for both kinds of patients. They also cannot change the facility size freely, because of the certificate of need law. Due to these institutional features, some nursing homes face a binding bed constraint, i.e., demand for the nursing home care exceeds its supply. As a result, some patients, especially Medicaid patients, will

[5] A structural model approach has been taken in the recent health economics literature. See, for example Kessler and McClellan (2000), Gowrisankaran and Town (2003), and Gaynor and Vogt (2003).

[6] Medicare and privately insured patients are excluded in this study. The share of privately insured patients in the total patients is less than 1 percent and that of Medicare is less than 10 percent. In addition, Medicare patients become either private-pay or Medicaid patients after 100 days residing in a nursing home, and most of them are discharged fairly soon.

be denied care in such nursing homes. We develop a computational algorithm to carry out this rationing. The structural model approach taken here allows us to estimate the extent of rationing.

The second modification is that nursing homes choose not only prices but also the level of quality, in response to policy variables. It is important to incorporate endogenous quality choice into the analysis, not just because quality of care is a perceived problem in the industry, but also because it is potentially influenced by government policies towards competition and the regulated Medicaid reimbursement rate. A priori, the effects of increased competition on quality are ambiguous. Increased competition may spur nursing homes to raise quality to attract patients. But quality might go down as well, if price is the key dimension upon which firms compete. Given the requirement that nursing homes offer the same quality of care to both private-pay and Medicaid patients, it is clear that the quality of care private-pay patients receive is potentially linked to the regulated Medicaid price. Our structural model of endogenous quality choice explicitly takes into account all of these links. Quality is inferred from consumer choices instead of just measured by inputs, such as staff intensity. Berry et al. (1995) approach enables us to estimate an unobserved (by the econometrician) quality variable, which can lessen the problem of inputs-based quality measures.[7] The approach taken in this paper in measuring quality also lessens the problem of multiple equilibria when simulating a model.

This study uses data from the Wisconsin Annual Survey of Nursing Homes, which contains each nursing home's characteristics and patients' information. Because the patients' information is grouped, estimation of the model is not straightforward. Following Berry et al. (2004) and Petrin (2002), we develop a generalized method of moments estimation strategy that estimates the demand-side parameters exploiting the grouped patient level data, and the nursing home characteristics. In contrast to their estimation strategies, we estimate supply-side parameters separately from demand-side parameters due to endogenous quality assumed in our model.

The estimated model suggests that about one fourth of nursing homes used for this study face a

[7] Other than input-based measures, outcome measures have become more popular in recent years. However outcome measures likely have self-selection problems.

binding bed constraint; about 11 percent of the Medicaid consumers who demand for nursing home care cannot enter their first-choice nursing homes; and about 2 percent of Medicaid consumers who demand for nursing home care do not enter any of the nursing homes. The model is useful not only for counterfactual policy simulations but also for analysis of consumers' substitution patterns or correlation between excess demand/a binding bed constraint and market outcomes. It suggests that consumers' substitution patterns vary by age and sex, and correlation between a binding constraint and market outcomes vary whether excess demand is likely a countywide problem or not.

The rest of the paper is organized as follows. Section 2 summarizes some important regulations in Wisconsin. Section 3 presents the industry model. Section 4 details the data and section 5 presents the estimation procedure. Parameter estimates and their implications are provided in section 6. Finally, section 7 concludes.

2. Regulations in Wisconsin

This section summarizes the regulations in Wisconsin, which affect key institutional features of the nursing home industry.

Medicaid Reimbursement

In Wisconsin, a prospective payment method is used for setting Medicaid reimbursement, based on a facility-specific rate. A facility-specific rate for the 1998 fiscal year is based on the facility's actual allowable expense in 1996 and other factors such as inflation, its case-mix and its own occupancy rate. The actual allowable expenses are divided into seven categories, direct care, support services, administration, fuel and utilities, property tax, capital, and over-the-counter drugs; the expense of each category is calculated separately. When the facility's actual allowable expense in 1996 exceeds the maximum set by the state, which is adjusted regionally, the facility specific rate is calculated based on the state-set maximum. Wisconsin does not allow these rates to be adjusted during a fiscal year.

Certificate-of-Need

Wisconsin has used a CON law for nursing homes since 1980. The purpose of this policy in Wisconsin is clearly written in the state statutes, stating that "*it exists* in order to enable the state to budget accurately for medical assistance and to allocate fiscal resources most appropriately,…" (Wisconsin Statutes Chapter 150). Wisconsin has a statewide bed limit, which was 51,795 in 1998. Although there are no countywide bed limits, the state limits the number of beds in each county by allowing only nursing homes within a county to redistribute beds as a result of a nursing home closure within that county. The review criteria and standards for applications include a need for additional beds in the health planning area, sufficient funds availability, and satisfactory quality care to be provided. As shown in Table 1, occupancy rates vary from county to county. Although the occupancy rate in some counties is close to 100 percent, there were no nursing home CON applications in 1998.[8]

TABLE 1: County Level Occupancy Rate in 1998

County Level Occupancy Rate	Number of Counties
95-100%	5
90-94.9%	18
85-88.9%	31
80-84.9%	13
Less than 80%	4
Total	71

Quality of Care

Each nursing home can set its quality level freely, but it is required that nursing homes offer the same quality of care to all patients regardless of the source of a patient's payment or amount of payment. The state regulation prohibits discriminatory treatment based on the payment sources.[9]

3. Model

3.1 Basic Assumptions

We develop an oligopolistic supply-side model in combination with a discrete-choice demand-side model considering a nursing home as a differentiated product oligopoly. Since our goal is to construct a

[8] A state official mentioned unofficially that they know some counties have a bed shortage and that even if some applications had

structural model accounting for institutional features of this industry, we make assumptions specific to nursing home markets.

First, nursing homes are assumed to face two different demands: one is private-pay and the other is Medicaid. Since private-pay patients have to pay the price of the nursing home by themselves, their preferences are affected by prices. On the other hand, Medicaid patients do not pay for themselves; the government pays for them. Therefore, nursing home prices have no effect on their preferences.

Second, we assume each nursing home has a bed constraint, that is, bed supply in each nursing home is fixed in the model, because the CON law restricts an increase in beds in existing nursing homes. This assumption affects both demand and supply behaviors. Since freely determined private-prices are usually higher than Medicaid reimbursement rates which are set by the government in advance and quality of care is required to be common to all patients in a given nursing home, a profit maximizing nursing home provides beds to private-pay patients first, then fills Medicaid patients as residuals.[10] A Medicaid patient who seeks care from a nursing home with a binding bed constraint, therefore, may not be able to enter the nursing home. In the model, such Medicaid patients are assumed to choose other nursing homes that give them the highest utility among nursing homes with available beds. We develop a computational algorithm to obtain aggregate Medicaid demand. For the supply side, the profit function depends on whether the nursing home's bed constraint is binding or not. This in turn affects nursing homes' reaction functions.

Lastly, a nursing home is assumed to set not only its price but also its quality level in equilibrium. Quality depends on a variety of factors, such as staff intensity, services provided, and technology used by a nursing home. To simplify the model, we assume that each consumer evaluates nursing home quality by constructing a quality index from these factors and that the function they use to construct the quality index is common to all consumers. This implies that all consumers have the same quality index for a given nursing home. It is also assumed that each nursing home knows how consumers evaluate its quality,

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been submitted in 1998, they would not have accepted any of them.
[9] Wisconsin Administration Code Chapter HFS 132.

thus the nursing home controls its quality index. It is possible that quality index consists of not only variables that nursing homes can control but also variables that nursing homes cannot control. We assume that each nursing home can partially control its quality index by choosing its controllable variables, such as number of nurses or other staff members.

3.2 Utility specification

The consumer's utility is defined over nursing home price, quality, and distance between the consumer's residence and the nursing home. We use a multinomial nested logit model with coefficients that can vary across consumer's observed characteristics. Although complete consumer-level data is unavailable, the data used in this paper contains statistics on each nursing home's patients that are categorized by patient characteristics, such as age, sex, payment type, and residence prior to entering the nursing home. A simple logit model with aggregate data has the undesirable property of a fixed substitution pattern. To overcome this problem, most of the previous literature used a random coefficients model approach to introduce individual heterogeneity.[11] This paper does not take a random coefficients model approach but introduces individual heterogeneity from three sources.

Two of them are from the nature of the data set, which contains detailed patient-level information. In the model, consumer's taste for observed nursing home characteristics vary according to consumer's observed attributes, such as age, sex, and payment type. These observed consumer characteristics can be important determinants in the choice of a nursing home. For instance, older consumers might be less price-sensitive than relatively younger consumers, if older consumers are more likely to have poor health conditions or scarce availability of informal care. Another example might be the difference of marginal utility from quality between private-pay patients and Medicaid patients. Private-pay patients might be less quality-sensitive than Medicaid patients if they weight price much more than quality. Or private-pay

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[10] The same assumption was made in Nyman (1985, 1988a, 1994) that also analyzed data from Wisconsin. The state does not have a regulation that requires nursing homes to offer beds 'first come first serve basis.'

[11] See, for example, Berry et al. (1995) and Petrin (2002).

patients, whose families are likely to be better educated, might be more quality-sensitive because they might investigate nursing homes more thoroughly than Medicaid patients.

Information on patients' residence allows us to obtain distance, which is also an important determinant of demand for nursing home care.[12] According to the data, about 80% of patients in a nursing home previously lived in the same county where the nursing home is located.

Third, nested logit error can capture part of the consumer's heterogeneity of demand for nursing home care. The observed substitution patterns, especially the substitution between a nursing home and outside alternatives, cannot be fully explained by the observed consumer attributes. According to the previous literature, demand for nursing home care heavily depends on consumers' health status and/or availability of informal care, which are unobservable from the data used for this study.[13] If two consumers with the same observed characteristics have different health conditions and/or availability of informal care, one is more likely to demand for care from a nursing home than the other. Since the nested logit model allows the variance to differ across the groups, it can capture such taste differences between consumers with the same observed attributes more than a simple logit model can. In the model, it is assumed that a consumer's choice consists of two steps. First, the consumer chooses whether she demands for care from nursing homes or not. If she chose to demand for nursing home care, then she will select one of the nursing homes to enter. Alternatives are grouped into two subgroups: one consists of all nursing homes and the other consists of outside alternatives.

Private-pay consumer i's utility of care from nursing home j is defined as:

$$u_{ij}^{p} = \tilde{\gamma}_i + p_j\alpha + Q_j + D_{ij}\lambda + \zeta_i + (1-\sigma)\varepsilon_{ij}\,, \qquad (1)$$

and Medicaid consumer i's utility of care from nursing home j is defined as:

$$u_{ij}^{m} = \tilde{\gamma}_i + Q_j\beta + D_{ij}\lambda + \zeta_i + (1-\sigma)\varepsilon_{ij}\,, \qquad (2)$$

[12] See Gaynor and Vogt (2003).
[13] See Murtaugh et al. (1997).

with $$\tilde{\gamma}_i = \bar{\gamma} + \sum_r z_{ir}\gamma_r^o, \tag{3}$$

where Q_j, p_j, and D_{ij} are quality, price paid by private-pay consumers, and distance to the nursing home from consumer i's residence, respectively.[14] Quality is defined later in this section. Distance is measured between the center of the county consumer i resides in and the center of the county in which the nursing home is located. By definition, distance is zero if the consumer receives care from the nursing home located in the consumer's residence county. z_{ir} is consumer i's observed characteristic r, such as age, sex, and payment type.

The variable ζ_i captures consumer i's preferences for nursing homes and has a distribution function that depends on σ, with $0 \le \sigma < 1$. As σ approaches to zero, the within group correlation of utility level goes to zero. We assume that ε_{ij} is an identically and independently distributed extreme value, then $\zeta + (1-\sigma)\varepsilon$ is also an extreme value random variable. The utility from the outside alternatives is normalized to be

$$u_{i0} = \zeta_{i0} + (1-\sigma)\varepsilon_{i0}. \tag{4}$$

3.3. Quality

Quality is measured by nursing home observable characteristics as well as an unobservable (to the econometrician) variable. Nursing home observable characteristics include input variables, such as nurse intensity and other staff intensity. These characteristics can be controlled by nursing homes and more staff uses reflect the capacity to provide high quality of care. Other observable characteristics are ownership type, facility size, specific services provided by the nursing home, and nursing home location. These characteristics cannot be controlled by nursing homes but may affect technology or efficiency in providing care.

[14] Prices vary in a nursing home according to the patients' severity. To simplify the model, however, we assume a nursing home provides identical services to patients regardless of patients' severity.

Using an unobserved variable with these observed variables could lessen the problems of measures used in the previous literature. Two types of quality measures have been commonly used. One is input-based measure that refers to the inputs used in the provision of care. The other is outcome-based measure that infers quality from patient health outcomes, such as mortality, functional change, presence of bedsore, and so on. Input-based measures cannot distinguish if more resource intensity implies high quality of care or if it implies an inefficient use of resource. Outcome-based measures should be adjusted to reflect the patient risk factor properly; this requires more detailed patient-level information. The unobservable variable, for instance, can capture a nursing home good reputation that may due to the patient better health outcomes in the nursing home. The unobserved quality variable can also be seen as a factor that adjusts between the actual quality the nursing home provides and the average quality that can be produced with the staff intensity the nursing home uses.

Quality is assumed to be evaluated by all consumers in the following way.

$$Q_j = X_{1j}\rho_1 + X_{2j}\rho_2 + \xi_j, \tag{5}$$

where X_{1j}, X_{2j} and ξ_j are, respectively, a vector of nursing home j's observed characteristics that the nursing home *can* control (note that price is not in X_{1j}), a vector of nursing home j's observed characteristics that the nursing home *cannot* control, and an unobserved characteristic. We further assume that X_{1j}, and X_{2j} are mean independent of ξ_j.

3.4. Demand

As mentioned, nursing homes have a financial incentive to provide beds to private-pay patients first and then to fill the remained beds with Medicaid patients. In the model, we assume that private-pay patients enter a nursing home first, and then Medicaid patients can choose a nursing home from nursing homes with available beds. In this demand framework, aggregate private-pay demand is easily obtained. First, each private-pay consumer's probability of choosing a certain nursing home is calculated. The aggregate private-pay demand for the nursing home is then obtained by integrating over all private-pay consumers' probabilities.

Private-pay consumer i's probability of choosing nursing home j is given by:

$$\Pr(j \mid X, i) = \frac{\exp[\{Q_j + p_j\alpha + \bar{\gamma} + \sum_r z_{ir}\gamma_r^o + D_{ij}\lambda\}/(1-\sigma)]}{E_i^{\sigma}(1 + E_i^{1-\sigma})}, \tag{6}$$

where $E_i = \sum_l \exp[\{Q_l + p_l\alpha + \bar{\gamma} + \sum_r z_{ir}\gamma_r^o + D_{ij}\lambda\}/(1-\sigma)]$ and X is a matrix of observed nursing home characteristics. This yields aggregate private-pay demand for nursing home j, n_j^p, which obtains from integration over i, or

$$n_j^p = M^P \int_i \Pr(j \mid X, i) dF_i \,, \tag{7}$$

where F_i is the distribution and M^P is the market size of private-pay consumers.

Medicaid demand is not as simple as the private-pay demand, because of rationing. That is, Medicaid patients have the possibility of not entering the nursing homes that give them the highest utility. If that is the case, they must look for another nursing home in which beds are still available. We assume that potential Medicaid patients are randomly ordered to choose a nursing home among nursing homes with available beds. The first Medicaid consumer chosen at random will enter the nursing home that gives her the highest utility from all nursing homes. After the first Medicaid consumer has entered the nursing home or has chosen an outside alternative, the second Medicaid consumer chosen randomly will enter a nursing home that gives her the highest utility from all nursing homes with available beds. This means that if the first Medicaid consumer took a nursing home's last bed, the second Medicaid consumer cannot demand that nursing home's care even though it gives her the highest utility. After the second consumer has made a decision, the third Medicaid consumer enters a nursing home. This process continues until all potential Medicaid consumers chose a nursing home or outside alternatives.

The nested logit assumption and the assumption of randomly ordered Medicaid consumers, however, make Medicaid demand computation easier. The Medicaid population is divided into small groups, $\{M_1^M, M_2^M, \ldots, M_G^M\}$, whose distribution is identical to the entire Medicaid population. M_1^M is the measure of the population who can choose a nursing home from all nursing homes. M_2^M is the measure of the population who can choose a nursing home from all but the one nursing home whose last bed is taken by the first population. M_g^M is the measure of the population who cannot choose g-1 nursing homes whose beds are already fully occupied by the first g-1 groups. Therefore, the aggregate Medicaid demand is calculated as:

$$n_j^m = \sum_g M_g^M \int_i \Pr_g^m(j \mid X, i) dF_i^m , \tag{8}$$

where $\Pr_g^m(j \mid X, i)$ is the probability that consumer i who is in group g enters nursing home j and F_i^m is the distribution of Medicaid consumers. Let J_g be the set of nursing homes whose beds are available when people in group g make a decision. If nursing home j has some beds available when consumer i belonging to group g chooses, i.e., $j \in J_g$, the probability can be written as:

$$\Pr_g^m(j \mid X, i) = \frac{\exp[\{Q_j \beta + \bar{\gamma} + \sum_r z_{ir} \gamma_r^o + D_{ij} \lambda\} / (1-\sigma)]}{E_{g,i}^{\sigma}(1 + E_{g,i}^{1-\sigma})}, \tag{9}$$

where $E_{g,i} = \sum_{l \in J_g} \exp[\{Q_l \beta + \bar{\gamma} + \sum_r z_{ir} \gamma_r^o + D_{il} \lambda\} / (1-\sigma)]$. If nursing home j has no beds left, i.e., $j \notin J_g$, the probability of choosing it is zero.

$$\Pr_g^m(j \mid X, i) = 0 . \tag{10}$$

Not all nursing homes face a binding bed constraint. From the data, we identify which nursing homes *potentially* face a binding bed constraint. Two criteria are used: If a nursing home has its occupancy rate higher than 95 percent and/or its number of unoccupied beds less than seven, then the nursing home is identified to *potentially* face a binding bed constraint. This type of nursing homes can be estimated to *actually* face a binding bed constraint. While estimation process, if estimated demand exceeds capacity in a nursing home that is identified to *potentially* face a binding bed constraint, then this nursing home is estimated to *actually* face a binding bed constraint. In contrast, if a nursing home satisfies neither criterion, then the nursing home is identified not to face a binding bed constraint.

3.5. Supply side

Nursing homes are assumed to be price- and quality-setting oligopolists, and market outcomes are derived from an assumption of Nash equilibrium in prices as well as levels of quality. All nursing homes are assumed to maximize their profits.[15] Since the state of Wisconsin, from which the data comes, uses a prospective payment system, Medicaid reimbursement rates are set by the government. A nursing home knows its reimbursement rate in advance and cannot alter this amount.[16] Each nursing home sets a price for private-pay patients and quality of care that is common to both private-pay and Medicaid patients in the nursing home. When consumers evaluate quality of nursing homes, they construct quality index. The quality index consists of not only variables that nursing homes can control but also variables that nursing homes cannot control (see equation 5). Let us define:

$$q_j = X_{1j}\rho_1, \tag{11}$$

where X_{1j} is a vector of nursing home j's controllable variables. We assume that nursing home j chooses a combination of its controllable variables X_{1j} to control q_j, which affects its quality index Q_j. This assumption lessens the potential problems we would have in the policy simulation.[17]

[15] This assumption might be too strong, because the nursing home industry is noted as one of the industries which are occupied by not-for-profit firms with great percentage, and some previous studies suggested that not-for-profit firms behave differently from for-profit firms. However, allowing cost function varies according to ownership type, first-order condition(s) for profit maximization can also be the first-order condition(s) that maximizes the objective function of not-for-profit firms. See Lakdawalla and Phillipson (1998) and Gaynor and Vogt (2003).

[16] Cost-based reimbursement, on the other hand, sets a rate based on the actual costs incurred in providing care in the present period. Therefore a nursing home can control the reimbursement rate by changing its quality, which affects its cost.

[17] Controlling quality index lessens the computational burden when finding an equilibrium. Without this assumption, all first-order conditions with respect to input variables should be satisfied simultaneously in the simulation. The number of first-order equations is the number of control variables of a nursing home, which is one (for price) plus the number of input variables, times

Costs for a nursing home likely depend on its quality, its number of patients, and exogenous variables, such as facility size, ownership type, location, etc., in a complicated manner. We assume the marginal cost of providing care to an additional patient is constant in any nursing home, given a partial quality index, q_j, and other exogenous variables. In order to achieve a given level of q_j, nursing home j chooses its controllable variables so as to minimize the cost. It is natural to assume that the higher the (partial) quality index, the higher the marginal cost. Exogenous variables, such as facility size, ownership type, and location (i.e., rural, urban, and Milwaukee), likely affect marginal costs. For example, production technology used in large nursing homes might be different from that used in small nursing homes. Production efficiency may vary by ownership type. The location of the nursing home would also affect the cost, because the input prices in urban areas could be higher than the input prices in rural areas.

Nursing home j's total cost function, TC_j can be written as:

$$TC_j = c_j(q_j, W_j, \omega_j; \kappa) \times N_j + \overline{C}_j, \tag{12}$$

where c_j is a variable cost per patient, $\overline{C}_j$ is a fixed cost which is not affected by quantity (the number of patients) or quality, N_j is the total number of patients in the nursing home, q_j is a partial quality index, W_j is a vector of exogenous variables which would affect cost, ω_j is a vector of unobserved variables, and κ is a vector of supply parameters.

To utilize both price- and quality-setting equations, the marginal cost function is assumed as follows:

$$c_j(q_j, W_j, \omega_j; \kappa) = (W_{1j}\kappa_1 + \omega_{1j})q_j + W_{2j}\kappa_2 + \omega_{2j}, \tag{13}$$

where W_{1j} is the set of exogenous variables which interact with quality and W_{2j} contains the rest of the exogenous variables.

Profit function for nursing home j depends on whether the nursing home has a binding bed

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400. However, with this assumption, the number of first-order equations is about eight hundred.

constraint or not. The profit for nursing home j with a binding bed constraint can be written as

$$\pi_j(p, X, \xi, D, W_j, \omega_j; \theta) = p_j n_j^p(p, X, \xi, D; \theta_d) + r_j\{\overline{N}_j - n_j^p(p, X, \xi, D; \theta_d)\} \\ - TC_j(\overline{N}_j, q_j, W_j, \omega_j; \kappa), \tag{14}$$

where $\theta = (\theta_d, \kappa)$, θ_d is a vector of demand parameters, r_j is the Medicaid reimbursement rate, and $\overline{N}_j$ is facility size. Note that the number of Medicaid patients in the nursing home with a binding bed constraint is not equal to (true) Medicaid demand but is equal to the bed residuals after private-pay patients entering the nursing home. The profit for nursing home j without a binding bed constraint can be written as

$$\pi_j(p, X, \xi, D, W_j, \omega_j; \theta) = p_j n_j^p(p, X, \xi, D; \theta_d) + r_j n_j^m(X, \xi, D; \theta_d) \\ - TC_j(n_j^p + n_j^m, q_j, W_j, \omega_j; \kappa). \tag{15}$$

Since a nursing home's price- and quality-setting equations are derived from its profit function, they also depend on whether the nursing home's bed constraint is binding or not. Per patient cost cannot be obtained from either price- or quality-setting equation when nursing homes have a binding bed constraint. It can be obtained from the price-setting equation of nursing homes that do not have a binding bed constraint.

$$c_j = p_j + \frac{n_j^p}{\partial n_j^p / \partial p_j} = (W_{1j}\kappa_1 + \omega_{1j})q_j + W_{2j}\kappa_2 + \omega_{2j}. \tag{16}$$

From the quality-setting equation, the derivative of the marginal cost with respect to quality, $\partial c_j / \partial q_j$, is derived. When nursing home j has a binding bed constraint,

$$\partial c_j / \partial q_j = \frac{(p_j - r_j)\partial n_j^p / \partial q_j}{\overline{N}_j} = W_{1j}\kappa_1 + \omega_1. \tag{17}$$

When nursing home j does not have a binding bed constraint, it follows from the first order condition and equation 16 that:

$$\partial c_j / \partial q_j = \frac{-n_j^p \, \partial n_j^p \big/ \partial q_j + (r_j - p_j - n_j^p \, \partial n_j^m \big/ \partial q_j)}{(n_j^p + n_j^m) \, \partial n_j^p \big/ \partial p_j} = W_{1j} \kappa_1 + \omega_1 \, . \tag{18}$$

4. Data

Two data sources are used for this study. One is the 1998 Wisconsin Annual Survey of Nursing Homes and the other is the 1990 Census of Population and Housing: Special Tabulation on Aging.[18, 19]

The Annual Survey contains information from all 463 Wisconsin licensed nursing homes. Since the paper focuses on the demand by the elderly population, nursing homes for the developmentally disabled and those with mental disease are excluded, because most of the patients in these nursing homes are fairly young. Nursing homes whose patients consist of only Medicare patients are also excluded. This leaves us with 407 nursing homes. We use information of private-pay and Medicaid patients aged 65 or over who reside in these 407 nursing homes.

The Annual Survey provides each of the nursing home characteristics, such as prices, staff intensities, ownership, facility size, certificate level, location, provided services, and so on. It also provides patient information for each nursing home. It does not contain the complete characteristics of each patient; that is, we cannot observe each patient's age, sex, payment type, and residence altogether. However, it contains the number of patients by categories, such as the number of patients by age group-sex pair, the number of patients by payment type-sex pair, and the number of patients by residence. This information allows us to construct micro moments so that we can estimate the coefficients for interactive terms between nursing home observed characteristics and patient observed attributes.

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[18] The state of Wisconsin requires nursing homes to complete this Annual Survey as part of the annual requirements for Medicaid re-certification.

[19] Special Tabulation on Aging contains aging-related population and housing data from the 1990 census, including sample data weighted to represent the total population, as well as 100 percent counts and unweighted sample counts for total persons and housing units.

TABLE 2: Average Nursing Home Characteristics in Wisconsin, 1998

		Mean	Standard Deviation
Price	Private-pay	$125.09	22.86
	Medicaid	$95.39	8.22
Number of Nurses per 100 beds		35.43	11.86
	Registered	7.61	3.42
	Licensed Practical	4.67	3.46
	Nurse Assistant	23.15	8.77
Number of Therapists per 100 beds		3.77	3.18
Number of Social Workers per 100beds		1.34	0.70
Capacity (Number of Beds)		111.26	75.63
Occupancy Rate		88.36%	10.33
	by Private-Pay Patients	23.48%	14.83
	by Medicaid Patients	57.82%	17.02
Patient Share by 65 years old or over		94.34%	7.76
	By 85 years old or over	52.46%	13.41
	By Female and 65 years old or over	69.75%	1.41
	By Female and 85 years old or over	41.91%	1.55
	By Patients from the same county as NH	80.70%	2.81
Ownership Type	Government	0.13	
	Not-for-Profit	0.37	
Number of Nursing Homes		407	

Table 2 presents a description of the average characteristics of nursing homes. The private price is $125, which is about $30 higher than the Medicaid reimbursement rate. The average number of nurses per 100 beds is 35. The average facility size is 111 beds. The average occupancy rate is 88 percent, with 23 percent by private-pay patients, 58 percent by Medicaid, and 7 percent by Medicare. About 95 percent of the total patients are elderly patients whose age is 65 years old and over and the majority of them, almost 70 percent, are female. More than 80 percent of the patients in a nursing home come from the county of the nursing home. Thirteen percent of nursing homes are government owned facilities and 37 percent of nursing homes are not-for-profit facilities.

The 1990 Census of Population and Housing: Special Tabulation on Aging specifically collects information on the elderly population. It contains county level data on demographic and economic variables. Using demographic variables, the distribution of nursing home potential patients characterized by age group, sex, and county of residence is constructed. The population should be further characterized by payment type: private-pay or Medicaid. Although whether patients are eligible for Medicaid or not depends on the state policies, all states are required to offer Medicaid to Supplemental Security Income (SSI) recipients.[20] Therefore, we use income information to divide the population into potential private-pay and Medicaid patients.

TABLE 3: Nursing Home Utilization Rates in Wisconsin, 1998

	Per 100 Population
Total (65 years old or over)	4.3
Male 65-84 years old	1.7
Male 85 years old or over	21.1
Female 65-84 years old	2.4
Female 85 years old or over	35.3
Male Medicaid	16.1
Male Private-pay	1.2
Female Medicaid	28.3
Female Private-pay	2.1

Based on authors' calculation

Table 3 shows the nursing home utilization rates per 100 population in Wisconsin. Approximately, four percent of the total number of elderly people aged 65 or over reside in nursing homes. The utilization rates are higher for older people and for females. Also the payment type affects the utilization rate: utilization rates per 100 Medicaid eligible population is much higher than that of private-pay population for both sexes.

[20] Most states supplement the basic SSI payments made to individuals by the federal government. States can further broaden eligibility for Medicaid via the medically needy classification, which includes persons whose medical bills are large enough to reduce their disposable income to the SSI level. In Wisconsin, eligibility for medically needy status has criteria based on assets. Both the categorically needy and medically needy classifications have different income standards for institutionalized persons and for non-institutionalized persons. Income standards for institutionalized persons are more generous than for non-institutionalized persons.

5. Estimation

Our estimation consists of two steps. First, we estimate the demand-side parameter values. Then, by utilizing the estimates of demand-side parameters, we estimate the supply-side parameter values. Our basic estimation strategy for the first part follows Berry et al. (2004) and Petrin (2002). We use Generalized Method of Moments (GMM). Similar to Petrin (2002), three sets of moment restrictions are imposed. One is related to market share, one is related to the market level disturbances, and one is micro moments. For the second part, parameters for the marginal costs and for derivatives of the marginal cost with respect to quality are jointly estimated.

5.1 Demand-side estimation

Demand-side parameters, θ, can be divided into three groups: the first group includes parameters that affect utility of private-pay consumers $\theta_1 = (\alpha, \gamma_{old}, \gamma_{female}, \lambda, \sigma)$, the second group includes parameters that only affect utility of Medicaid consumers $\theta_2 = (\beta, \gamma_{medicaid})$, and the third group includes parameters of quality index $\theta_3 = (\rho_1, \rho_2)$.

Private-pay market share

Most of the previous work matches the model's market share predictions to observed market share. In this study, however, since nursing home markets have two different demands and Medicaid demand may exceed observed supply, only private-pay market share can be used to match the model predictions to observed data.

At the true parameter values, $\theta^0 = (\theta_1^0, \theta_2^0, \theta_3^0)$, the model predictions for nursing home j's share, including outside alternatives, in the private-pay market, $s_j^p\ (Q(\theta_1^0),\ \theta_1^0)$, is restricted to match the actual observed share in the private-pay market, $\mathrm{s}_\mathrm{j}^\mathrm{P} = \mathrm{n}_\mathrm{j}^\mathrm{P} / M^P$, where M^P is the private-pay market size. The restriction is written as

$$\mathrm{s}_\mathrm{j}^\mathrm{P} - s_j^p\ (Q(\theta_1^0),\ \theta_1^0) = 0, \qquad j = 1, ..., J \tag{19}$$

This moment matching is equivalent to solving for each nursing home's quality index $Q_j(\theta_1^0)$. Given θ_1, $Q(\theta_1)$ is solved by using a contraction mapping, which is defined in Appendix.

Micro moments

The second set of restrictions relates to micro moments. Given θ_1 and θ_2, after solving for $Q(\theta_1)$, Medicaid demand is calculated considering the possibility that some nursing homes face a binding bed constraint and as a result some Medicaid patients are rationed out. The calculation procedure is explained in subsection 3.4.[21] We choose θ_1 and θ_2 to match the three sets of micro moments, which are constructed from each nursing home's patient information. The first matches the number of patients characterized by age-sex pair (4 moments), the second matches the number of patients characterized by payment type-sex pair (4 moments), and the third matches the number of patients characterized by county of residence—whether they came from the same county of the nursing home or not (2 moments). We define the disturbance ς_{jm} (m=1,2,...,M indexes the moments) as, for example,

$$\varsigma_{jm}(\theta_1,\theta_2) = \mathrm{n}^{\mathrm{m}}_{\mathrm{j}\ (male)} - n^{m}_{j(male)}(\theta_1,\theta_2)\,, \tag{20}$$

the difference between the realized number of Medicaid male patients and the model prediction given θ_1 and θ_2. At the true parameter value,

$$E[\varsigma_{jm}(\theta_1^0,\theta_2^0)] = 0\,. \tag{21}$$

Market-level disturbances

The final set of restrictions relates to the market level disturbances, $\xi_j(\theta_1,\theta_3)$. To obtain the residuals for each nursing home, we project $Q(\theta_1)$ onto the space of nursing home characteristics, X_j, which determine quality. The unobserved demand disturbances for any nursing home j are assumed to be

[21] See also Appendix A1 for details.

uncorrelated with observed demand-side variables of all nursing homes. (Note that demand-side vector X_j does not include price.). At the true parameter value, the following should be satisfied.

$$E[\xi_j(\theta_1^0, \theta_3^0) \mid X] = 0\,. \tag{22}$$

GMM criterion function

Following Petrin (2002), two sets of moments enter the GMM criterion function. $G_1(\theta)$ is the moments associated with the market disturbances, and $G_2(\theta)$ is the micro moments. At the true parameter value, θ^0, the moment conditions are assumed to be zero, or

$$E[G(\theta^0)] = E\begin{bmatrix} G_1(\theta^0) \\ G_2(\theta^0) \end{bmatrix} = 0\,. \tag{23}$$

Following Hansen (1982), the criterion function to be minimized is defined by $[\hat{G}(\theta)' A^{-1} \hat{G}(\theta)]$, where $\hat{G}(\cdot)$ is the sample analogue to $G(\cdot)$, and A is the asymptotic covariance matrix of the vector sample moments $\hat{G}(\theta)$.

5.2 Supply-side estimation

To estimate supply-side parameter values, we need to solve for the marginal cost and for the derivative of the marginal cost with respect to quality. From equations 16, 17, and 18, these require the derivatives of private-pay market share function with respect to price and quality and the derivative of Medicaid market share function with respect to quality. Equations 6 and 9 imply that these derivatives can be solved for closed forms. For example, the derivative of private-pay market share with respect to price can be computed as:

$$\frac{\partial s_j^p}{\partial p_j} = \int_i \alpha \Pr(j \mid i)\{\frac{\Pr(j \mid i)}{\sum_l \Pr(l \mid i)} - \Pr(j \mid i) + \frac{1 - \Pr(j \mid i)}{1 - \sigma}\} dF_i\,. \tag{24}$$

While the derivative of the marginal cost with respect to quality, $\partial c_j / \partial q_j$, is obtained from all nursing home, the marginal cost, c_j, is only obtained from nursing homes without a binding bed constraint. Therefore, we only utilize information on nursing homes without a binding bed constraint to estimate marginal costs. Let q^{NED} denote a vector of (partial) quality index that includes only nursing homes without a binding bed constraint. Similarly, W_1^{NED} and W_2^{NED} are matrices of exogenous variables of nursing homes without a binding bed constraint that interact with quality and do not interact with quality, respectively. Supply-side parameters in equation 25 are estimated by using the generalized least square (GLS) method.

$$\begin{bmatrix} c \\ \partial c / \partial q \end{bmatrix} = \begin{bmatrix} q^{NED} \otimes W_1^{NED} & W_2^{NED} \\ W_1 & 0 \end{bmatrix} \begin{bmatrix} \kappa_1 \\ \kappa_2 \end{bmatrix} + \begin{bmatrix} \omega \\ \omega_1 \end{bmatrix}, \qquad (25)$$

We assume $E(\omega_1) = E(\omega_2) = 0$, and $Var(\omega_1) = \upsilon_1^2$ and $Var(\omega_2) = \upsilon_2^2$ By definition, $\omega = q \otimes \omega_1 + \omega_2$, and we assume $E(\omega) = 0$ and $Var(\omega) = \upsilon^2$.

6. Results

6.1. Parameter Estimates

The results of estimating the demand-side equations are presented in table 4. The coefficient estimates for the utility function are as expected. The coefficient on the impact of distance on nursing home choice is negative and significantly different from zero. The coefficient on price is also negative and significantly different from zero. The coefficient on quality for private-pay patients is standardized as 1 and that for Medicaid patients is estimated to be 0.32. This implies that Medicaid patients' responsiveness for quality is less than that of private-pay patients, although the coefficient is not statistically significant. The intercept term can interpret the attractiveness of any nursing home in comparison to that of outside alternatives. We normalize the base intercept term, $\bar{\gamma}$, to be zero, but allow the intercept term to vary according to patient observed characteristics, such as age, sex, and payment type.[22] As we can expect, older people tend to value nursing home care more than younger people do, just as females tend to value it more than males.

TABLE 4: Results of Demand-Side Equations

	Dependent Variable		Parameter Estimate	Standard Error
Market Share	Distance		-3.1577**	1.8772
	Price		-1.7868**	0.7608
	Quality	Medicaid	0.3208	1.2489
	Constant	Medicaid	-1.0098	3.9091
		Old	2.3311**	0.6693
		Female	0.6034**	0.0592
	Correlation		0.5136*	0.2862
Quality				
	Constant		-5.4471**	0.3734
	Registered Nurses/Nurses		1.3022**	0.4102
	Nurse Assistants/Nurses		0.4995*	0.3436
	Nurses/Beds		0.2022	0.2192
	Therapists/Beds		0.0839	0.7969
	Social Workers/Beds		2.8126	3.3914
	Other (non-medical) Staff/Beds		0.8504**	0.2797
	Log(Beds)		0.3561**	0.0438
	Milwaukee		-0.7940**	0.0785
	Rural		0.2208**	0.0563
	Not-for-profit		0.1554*	0.0817
	For-profit		-0.0499	0.0818
	Wand (utilizes formal wandering precautions)		0.1169*	0.0860
	CBRF (community-based residential facility)		0.1556**	0.0680
	Hospital (operated with a hospital)		0.0262	0.0885
	JCAHO (Joint Commission on Accreditation of Health Care Organizations)		0.0219	0.0710
	HMO (operated with a HMO)		0.0502	0.0573
	Lock (has a lock unit)		-0.0733	0.1175
	Hospice (offers hospice services)		0.0517	0.0529
	Alzheimer (units for Alzheimer patients)		-0.0186	0.0499

Notes:
* - t-statistics > 1
** - t-statistics > 2

[22] The constant term of quality index can interpret the "base" attractiveness of any nursing home in comparison to that of outside alternatives.

TABLE 5: Results of Supply-Side Equations

Dependent Variable	Parameter Estimate	Standard Error
Q	0.3701*	0.2235
*q**Milwaukee	-0.0079	0.0782
*q**Rural	-0.0604*	0.0545
*q**Not-for-profit	0.0244	0.0775
*q**For-profit	-0.0348	0.0752
*q**Log (Beds)	-0.0550*	0.0429
Constant	0.1039	0.2413
Milwaukee	0.1651**	0.0818
Rural	-0.0811*	0.0571
Not-for-profit	-0.0032	0.0786
For-profit	0.1017*	0.0753
Log (Beds)	0.1709*	0.0464

Notes:
* - t-statistics > 1
** - t-statistics > 2

Table 5 presents supply-side parameter estimates. Most of the parameters have expected signs. The coefficients on quality imply that the marginal cost increases as quality level becomes higher. Nursing homes located in Milwaukee have higher marginal costs than those located in rural areas. For-profit nursing homes tend to have higher marginal costs than nursing homes of any other ownership type. Facility size also affects marginal costs: however, whether larger nursing homes have higher marginal costs depends on the partial quality index, q .

6.2. Implication of the Parameter Estimates

This subsection discusses implications of the estimation results by answering the following questions: How many nursing homes are estimated to have a binding bed constraint? What is the extent of rationing? How is excess demand or a binding bed constraint related with market outcomes, such as price and quality? How do price and quality changes affect private-pay demand and Medicaid demand?

As mentioned in subsection 3.4, we identified which nursing homes *potentially* have a binding bed constraint. From data, 189 nursing homes *potentially* have a binding bed constraint.[23] Among them,

[23] This implies 218 nursing homes cannot have its estimated demand that exceeds capacity. 40 nursing homes are estimated to have its demand that exceeds capacity.

109 nursing homes are estimated to *actually* have a binding bed constraint.

The model estimates not only the number of Medicaid patients who would reside in nursing homes but also the number of Medicaid consumers who would demand for nursing home care, which is unobservable from the data. With the estimated parameter value, 22,753 Medicaid patients would reside in nursing homes and 23,213 Medicaid consumers would demand for nursing home care. This implies approximately 2 percent of Medicaid consumers who demand for nursing home care do not enter any of the nursing homes eventually. The model also estimates that 2,461 Medicaid consumers cannot enter their first-choice nursing homes, that is, about 11 percent of the Medicaid consumers who demand for nursing home care cannot enter their first-choice nursing homes.

Previous literature investigated relationship between excess demand or a binding bed constraint and market outcomes. It is possible that higher quality of a nursing home induces more demand and as a result the nursing home has a binding bed constraint. It is also possible that excess demand created by the CON law allows nursing homes to provide lower quality. How a binding constraint and private-pay price are correlated is also a question. If nursing homes are competing, low quality may imply low price. However, if nursing homes with a binding bed constraint maintain market power, they can have low quality as well as high price. We examine the relationship between a binding bed constraint and market outcomes by using a simple correlation analysis.

TABLE 6: Correlation between a Binding Bed Constraint and Quality/Price

	All	Loose	Intermediate	Tight
Quality (Q)	0.083 (0.096)	0.170 (0.043)	-0.026 (0.743)	-0.064 (0.506)
Private-pay price	0.040 (0.421)	0.257 (0.002)	0.011 (0.895)	-0.177 (0.066)

Notes: ( ) p-value

Table 6 shows Pearson correlation coefficients between a binding bed constraint dummy (if a nursing home has a binding bed constraint, then the dummy variable is 1, otherwise it is 0) and quality index, Q, and between a constraint dummy and private-pay price. The first column includes all nursing homes. The next three columns include nursing homes located in “loose”, “intermediate”, and “tight” counties, respectively. A "tight" county is a county where the estimated total number of patients in the county accounts for more than 90 percent of the total number of beds in the county. In an "intermediate" county, the estimated total number of patients accounts for 85 to 90 percent of the total number of beds. The remaining counties are "loose" counties. From the first column, nursing homes with a binding bed constraint seem to have high quality and high price. However, this is not necessarily true if we grouped nursing homes according to the county level occupancy rate. In "loose" counties, the binding bed constraint is significantly positively correlated with quality or with price: nursing homes with a binding bed constraint provide higher quality with higher price than those without a constraint. In "intermediate" counties, nursing homes with a binding bed constraint tend to have lower quality and higher price, but these correlations are not statistically significant. In "tight" counties, nursing homes with a binding bed constraint tend to have lower quality and lower price. These correlations are not statistically significant; however, p-values improve significantly compared with those in "intermediate" counties.

Above correlation analysis suggests that in counties where excess demand is not a countywide phenomenon, a nursing home's higher quality results in the nursing home's facing a binding bed constraint. In contrast, in counties where excess demand is likely a countywide problem, a nursing home's facing a binding bed constraint may cause the nursing home's low quality.

TABLE 7: Effects of Price Changes on Private-Pay Demand

	Own	All other homes	Other homes in the same county
All	-4.23 (0.89)	2.11 (0.70)	1.50 (0.60)
Male 65-84 years old	-4.26 (0.88)	1.78 (0.73)	1.32 (0.51)
Male 85 years old or over	-4.22 (0.90)	2.21 (0.70)	1.55 (0.63)
Female 65-84 years old	-4.26 (0.88)	1.83 (0.71)	1.34 (0.53)
Female 85 years old or over	-4.21 (0.90)	2.48 (0.70)	1.70 (0.70)

Notes: ( ) standard deviations

Table 7 presents the effects of price changes on private-pay demand. In column 1, the average own-price elasticity of private-pay demand and of private-pay demand by age-sex groups are reported. The model estimates imply that a 1 percent increase in price of a nursing home would lead to about a 4 percent fall in private-pay demand for the nursing home. Own-price elasticity varies little across age-sex groups.

The second column shows how many patients in other nursing homes in the entire market increases relative to the number of patients in the nursing home whose price increases by 1 percent. The model predicts that about 2 percent of private-pay patients in the nursing home that increases price would move to one of the other nursing homes in the entire market. This implies that about a half of the patients who do not demand for a certain nursing home's care because of its price increase would choose care from other nursing homes. The substitution patterns vary by age-sex groups: Female patients are more likely to move other nursing homes than male patients; older patients are more likely to move other nursing homes.

The last column shows how many patients in other nursing homes located in the same county as the nursing home whose price increases changes relative to the number of patients in the nursing home. About 1.5 percent of private-pay patients in the nursing home that increases price would move to one of the nursing homes within the county. This implies approximately 71 percent of patients who would move to other nursing homes choose nursing homes within the county. Young and male patients are more likely to stay in the same county.

TABLE 8: Effects of Quality Changes on Private-Pay Demand

	Own	All other homes	Other homes in the same county
All	14.85 (1.18)	-8.68 (1.36)	-5.26 (1.85)
Male 65-84 years old	14.96 (1.12)	-7.77 (1.31)	-4.65 (1.57)
Male 85 years old or over	14.80 (1.25)	-8.98 (1.40)	-5.46 (1.95)
Female 65-84 years old	14.95 (1.12)	-7.91 (1.27)	-4.73 (1.63)
Female 85 years old or over	14.73 (1.25)	-9.76 (1.38)	-5.94 (2.15)

Notes: ( ) standard deviations

Table 8 presents the effects of quality changes on private-pay demand. We increase a partial quality index, q, by 1 percent, instead of changing quality index, Q, because nursing homes can control only input variables. Similar to table 7, table 8 has three columns. Column 1 shows the average own-quality elasticity of private-pay demand. When a nursing home increases its partial quality index by 1 percent, private-pay demand would increase by about 15 percent. From column 2, approximately 60 percent of the new private-pay patients would come from the other nursing homes. The substitution patterns vary by age-sex group: New female patients are more likely to come from the other nursing homes; while male patients' substitution patterns do not vary by age, among female patients older patients are more likely to come from the other nursing homes. The last column implies that about 35 percent of new private-pay patients would come from nursing homes within the same county.

TABLE 9: Effects of Quality Changes on the Number of Medicaid Patients

	All homes	Homes without a binding constraint	Homes with a binding constraint
All	-0.23 (8.75)	3.86 (2.20)	-10.92 (7.48)
Male 65-84 years old	-0.02 (8.72)	4.03 (2.22)	-10.61 (7.42)
Male 85 years old or over	-0.26 (8.77)	3.85 (2.20)	-11.00 (7.49)
Female 65-84 years old	-0.09 (8.73)	3.97 (2.21)	-10.72 (7.44)
Female 85 years old or over	-0.33 (8.77)	3.78 (2.19)	-11.08 (7.51)

Notes: ( ) standard deviations

The effects of quality changes on the number of Medicaid patients in nursing homes are shown in table 9. Because in the model Medicaid patients cannot enter nursing homes if the beds are fully occupied by private-pay patients and other Medicaid patients, the effects greatly depend on whether the nursing home faces a binding bed constraint or not. All columns present the average percent changes in the number of Medicaid patients of the nursing home whose partial quality index increases by 1 percent. The first column shows the average of all nursing homes, the second column shows the average among nursing homes without a binding bed constraint, and the third column shows the average among nursing homes with a binding bed constraint. Not surprisingly, the percentage change in the number of Medicaid patients in nursing homes with a binding bed constraint is negative and that in nursing homes without a binding bed constraint is positive. When a nursing home raises it partial quality index, more private-pay patients would enter the nursing home. If the nursing home faces a capacity constraint, the number of Medicaid in the nursing home needs to be reduced as a result of more private-pay patients. If the nursing home does not face a constraint, then the number of Medicaid patients also increases. Compared with private-pay demand, own-quality elasticity of Medicaid demand is much smaller. This is because Medicaid patients' responsiveness for quality is less than that of private-pay patients, and the number of Medicaid patients in a nursing home is typically much greater than that of private-pay patients.

7. Conclusion

In this paper, we have developed a structural model that takes into account key features of the nursing home industry and that enables us to simulate counterfactual policy changes. Although we leave policy simulations for future research, the constructed structural model enables us to answer some of the questions that previous studies tackled with. For example, the model enables us to quantify the rationing, which is impossible with a reduced-form model approach. We also examined the relationship between a binding bed constraint and market outcomes.

There are many possible policy experiments that can use the structural model developed in this paper. For example the model can be used to examine the effects of a change in CON's capacity restriction. Since CON law restricts not only entry but also capacity expansion, there are at least two ways to ease excess demand in the market: one is through new firm entry and the other is through increasing the capacity of existing nursing homes. The policy differences may have different effects on nursing home outcomes. By comparing the results of these two policy simulations the model makes possible, we can evaluate which policy makes consumers better off.

Another example of the model's usefulness is in examining the effects of a change in Medicaid reimbursement rate. There are two competing hypotheses regarding its effect on quality; one is that higher Medicaid reimbursement rates would lower the quality of care in the market where excess demand exists, and the other is that higher Medicaid reimbursement rates would increase the level of quality because low Medicaid reimbursement rates constrain the quality level. Using the model to conduct a policy simulation with higher Medicaid reimbursement rates allows us to examine which of two hypotheses is most supported and likely to occur in the real world.

The experiments mentioned above are certainly not the limit of this model's applicability or usefulness. After all, there are many questions and unknowns in the nursing home industry. The application of this model, however, can help to provide answers to some of those questions and shed light on those unknowns.

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Appendix

A1. Estimating Equilibrium Parameters

The GMM criterion function has to be evaluated at many different values of $\theta = (\theta_1, \theta_2, \theta_3) \in \Theta$ to locate the minimum. The following steps describe this iterative process.

Given a $\theta \in \Theta$:

1) locate the $Q*$ that solves $\text{s}_j^{\text{P}} - s_j^p$ (Q*, $\theta_1) = 0$, where s^{P} is a vector of observed shares in the private-pay market, and s^p ( ) is a vector of predicted shares in the private-pay market,
2) compute Medicaid demand and identify nursing homes with a binding bed constraint and those without,
3) compute moments and the criterion function value.

Step 1: Locate $q*$

Define the function $f(\,.\,)$ by:

$$f(\text{Q}) = Q + (\text{s}^{\text{P}})^{0.1} + (s^P(Q, \theta_1))^{0.1}, \tag{A1}$$

In the following appendix, we show that Equation (A1) is a contraction mapping for any σ below a certain cut-off. Here, we use the private-pay market share to locate $Q*$ that matches observed to predicted market shares. Given θ and an initial guess for Q, say Q^1, by evaluating the right-hand side of (A1) we obtain a new Q^2 as the output of this calculation, substitute Q^2 back into the right-hand side of (A1), and repeat this process until convergence. The contraction property insures that $Q^n \to Q*$.

Step 2: Compute Medicaid demands and identify nursing homes with a binding bed constraint

Given θ_1, θ_2, and $Q*$ obtained in step 1, Medicaid demands are computed in the way that we discussed in subsection 3.4. However, we do not have to find the population of each group, $M_1^M, M_2^M, \ldots, M_G^M$. Instead, we divide the Medicaid population into small groups: each group has small population, say 100, and has identical distribution to the entire Medicaid population. The first group made above can select nursing homes from all nursing homes. After the individuals in this group decide, each nursing home's total number of patients is calculated. Then, we check if one nursing home reaches its maximum capacity or not. If no nursing homes reached their capacities, the second group can also select nursing homes from all nursing homes. We go through the same process again with the second group. If, on the other hand, one nursing home reached its capacity limit, say nursing home A, and if the nursing home is one of the nursing homes that were identified to "potentially" face a binding bed constraint from data, then it is categorized as a nursing home with a binding bed constraint. The second group can choose nursing homes from all but nursing home A. After the individuals in this group choose, we calculate each nursing home's total number of patients and check if another nursing home runs out of its beds or not. We iterate this process until all Medicaid patients choose or all nursing homes are fully occupied.

Step 3: Compute criterion function value

We project $Q*$ onto the space of demand-side characteristics to obtain the residuals for each nursing home. These residuals are interacted with the instruments, H_{ξ} (in this paper, we use X itself as H_{ξ}) to obtain moments. For the micro moments, we calculate the differences between observed and estimated numbers of patients and interact the differences with instruments H_{ζ} (in this paper, we use $1/\overline{N}_j$ as H_{ζ}).

A2. Contraction Mapping

We will show that the equation $f:\Re^J \to \Re^J$ defined as $f(\mathrm{Q}) = Q + (\mathrm{s}^{\mathrm{p}})^{0.1} + (s^p(Q))^{0.1}$ is a contraction by showing that the function satisfies the conditions stated in the theorem in the Appendix of Berry et al. (1995). The important conditions to show are that $f(\mathrm{Q})$ is continuously differentiable, that $\partial f_j(Q)/\partial Q_k \geq 0$ for all *k* and *j*, and that $\sum_{k=1}^{J} \partial f_j(Q)/\partial Q_k < 1$. The function is differentiable by the differentiability of the function $s(Q)$.

First, we will show that $\partial f_j(Q)/\partial Q_j \geq 0$ for any σ below a certain cut-off.

$$\partial f_j(Q)/\partial Q_j = 1 - 0.1(s_j^p)^{-0.9} \int_i \Pr(j \mid i)\{(1 - \frac{\Pr(j \mid i)}{\sum_l \Pr(l \mid i)})/(1-\sigma) + \frac{\Pr(j \mid i)}{\sum_l \Pr(l \mid i)} - \Pr(j \mid i)\} dF_i$$

The above equation is positive when:

$$\sigma < \frac{1 - 0.1(s_j^p)^{-0.9} \int_i \Pr(j \mid i)\{1 - \Pr(j \mid i)\} dF_i}{1 - 0.1(s_j^p)^{-0.9} \int_i \Pr(j \mid i)\{\frac{\Pr(j \mid i)}{\sum_l \Pr(l \mid i)} - \Pr(j \mid i)\} dF_i}.$$

Next, we will show that $\partial f_j(Q)/\partial Q_k \geq 0$ for $k \neq j$.

$$\partial f_j(Q)/\partial Q_k = 0.1(s_j^p)^{-0.9} \int_i \Pr(j \mid i)\{\sigma \frac{\Pr(k \mid i)}{\sum_l \Pr(l \mid i)}/(1-\sigma) + \Pr(k \mid i)\} dF_i \geq 0$$

Lastly, we will show that $\sum_{k=1}^{J} \partial f_j(Q)/\partial Q_k < 1$.

$$\sum_{k=1}^{J} \partial f_j(Q)/\partial Q_k = 1 - 0.1(s_j^p)^{-0.9} \int_i \Pr(j \mid i)\{1 - \sum_l \Pr(l \mid i)\} dF_i < 1.$$