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## The impact of structural and strategic competition on hospital quality

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Christiane Wuckel

**The Impact of Structural and Strategic  
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# Imprint

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Christiane Wuckel<sup>1</sup>

# The Impact of Structural and Strategic Competition on Hospital Quality

## Abstract

*Many health care systems aim to enhance hospital quality by encouraging competition. However, evidence on the relationship between quality and competition is inconclusive. My contribution to this literature is two-fold. Analyzing the relationship between competition and quality for the German hospital market can give valuable insights about the nature of the relationship in a market with regulated prices that is characterized by a high number of hospitals and a diverse ownership structure. While most studies look at competition as market structure, I distinguish effects of market structure from effects of strategic behavior. I find evidence for a significant, non-linear relationship between market structure and care quality. Additionally, I find evidence for strategic behavior.*

*JEL-Codes: C21, I11, L11*

*Keywords: Hospitals; quality; competition; spatial econometrics*

*July 2022*

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## 1. Introduction

Competition in the health care sector and its consequences for welfare have been subject to an enormous debate during the last decades. Particularly in the hospital sector, market-based reforms were undertaken to improve health care quality despite weak evidence of the link between competition and hospital care quality (Gaynor 2006). Neither the theoretical nor the empirical body of literature can offer unambiguous evidence on the nature of the relationship between competition and hospital quality.

While basic microeconomic models of organization would predict that increasing competition leads to an improved provision of goods or services, the characteristics of the hospital market differ strongly from assumptions of the common market, for example, concerning information asymmetries or price setting behavior (see e.g. Arrow 1963). Theoretical models that consider a fixed price system (like the German hospital market) find a generally positive relationship between competition and quality in the absence of competition on prices (e.g. Brekke et al. 2006). However, incentives to provide quality might not just depend on the level of competition but also on the level and range of quality provided by competitors (Montefiori 2005). Even beyond, the ownership of the hospitals and of its competitors might shape the relationship in relevant ways (Sanjo 2009, Herr 2011). Furthermore, Brekke et al. (2010) suggest that considering adaption of quality as static rather than as an adaptive process overestimates the impact of competition on quality. If modeled dynamically, the benefits of competition on quality become considerably smaller. Brekke et al. (2011) introduce the aspect of altruism respectively semi-altruism into theoretical models of the health care market. They show that, given semi-altruistic behavior and a convex cost structure, the relationship between competition and quality can become negative. Those results, in line with Herr (2011) and Sanjo (2009), suggest that the nature of the relationship is strongly influenced by the particular composition of the health care market. Further, the amount of patient choice appears to influence the relationship between competition and quality (e.g. Brekke et al. 2014).

Regarding the ambiguous results of the theoretical considerations, it is not surprising that the large existing body of empirical evidence on the topic is similarly inconclusive. There is neither

consensus concerning the direction nor the magnitude of the relationship between competition and hospital quality. As there are various approaches to measure competition (as shown by Wong et al. 2005), the choice of measure clearly also adds to the wide range of results. The empirical approaches can be roughly summarized into the following categories.

A common approach to assess hospital competition is to analyze the impact of hospital closures or mergers on quality. Using that approach, Hayford (2012) finds a negative immediate impact of hospital consolidation on mortality rates for California (USA). In line, Avdic (2016) finds decreasing survival rates of patients with acute myocardial infarcts after hospital closures in Sweden. However, those initial negative effects vanish quickly, suggesting a fast adaption of impacted hospitals. Similarly, Herr (2009) finds initial negative impacts of closures on infant mortality in California (USA), but only very limited long run effects. In contrast, Bloom et al. (2015) find, for the UK, that hospital closures improved patient and staff outcomes as well as managerial quality.

A further approach looks at policy reforms that were implemented to enhance competition and examines the impacts thereof. Volpp et al. (2003) and Volpp et al. (2005) look at a competition enhancing hospital reform in New Jersey (USA) in the 1990s and find increases in mortality rates. Similarly, Propper et al. (2008) look at a set of reforms in the UK during the 1990s that were aimed to introduce competition into the health care market. They find an increasing AMI mortality as well as decreasing waiting times for elective treatments, suggesting that hospitals reacted to increasing competition by shifting focus from unmeasured quality to observable quality aspects. Cooper et al. (2011) use a more recent reform that extends patient choice to enhance competition in the UK. They find a decrease of AMI mortality rates in those regions that adopted more competition. Analyzing the same reform, Gaynor et al. (2013) and Gaynor et al. (2016) also find modest positive effects.

Another approach analyses the topic of competition, measuring the competition intensity in a defined catchment area. Using a measure based on the amount of competitors, Propper et al. (2004) show a negative correlation between competition and quality (measured in AMI mortality rates) for the UK, however rather small in magnitude. For the US, the evidence is very mixed. Some studies find positive correlations (e.g. Kessler and Geppert 2005, Rogowski et al. 2007, Erickson et al. 2018), a few find negative impacts (e.g. Mukamel et al. 2002), others find mixed or no associations (e.g. Mukamel et al. 2001, Mutter et al. 2008).



However, without controlling for the endogenous relationship of competition and quality, estimates are likely to be biased. Endogeneity can arise from selection bias (sicker patients sort into higher quality hospitals) or unobserved heterogeneity in the catchment areas that influences competition levels as well as quality (e.g. population structure). Kessler and McClellan (2000) as well as Gowrisankaran and Town (2003) try to deal with potential endogeneity using IV-approaches for the US. Kessler and McClellan (2000) show a positive impact of competition on quality and costs, looking at elderly patients with heart diseases. However, Gowrisankaran and Town (2003), who apply a similar IV approach but look additionally at patients with pneumonia and include patients from different insurance types, find a negative impact of competition on mortality rates for patients that are covered by Medicare. In case of increased competition among health maintenance organizations (HMO), they find a positive effect on mortality<sup>2</sup>.

A new approach to the topic is the use of spatial econometrics to focus on interactions between hospitals rather than approximating competition by market structure. Gravelle et al. (2014) are the first to look at spatial interactions between hospitals for a range of measures. The model is based on the idea that hospitals are (imperfect) demand substitutes. Patients switch to a hospital if its quality increases. They switch away from the hospital if the quality of a rival hospital increases<sup>3</sup>, decreasing demand for the hospital. Hence, the demand function of a hospital depends on its own quality as well as the rival's quality. The decrease in demand reduces the marginal cost of treatment (incentivizing higher quality) but also lowers cost containing efforts, which leads to higher variable cost and consequently offsets incentives to provide higher quality. The net effect of both effects is determined empirically using a Spatial lag model. Gravelle et al. (2014) apply this Spatial lag estimation for a range of objective and subjective quality indicators in the UK and find mixed results. They find strong evidence for spatial interaction effects for overall mortality, readmissions for knee replacement, as well as patient experience of involvement in decisions and trust in doctors. However, they find no spatial interaction for several others. Those results are in line with the notion of the model

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<sup>2</sup> Being enrolled under Medicare implies a fixed price setting, while health maintenance organizations negotiate rates with hospitals.

<sup>3</sup> The model assumes a fixed price setting.

that it can be optimal for hospitals to adjust their quality in reaction to rival hospitals' quality for some treatments, while it is not optimal for other treatments<sup>4</sup>. They also include the number of competitors in a catchment area, but as control variable that is not further interpreted and very roughly defined. Longo et al. (2017) build on Gravelle et al. (2014) and also find only limited evidence for strategic interaction.

So far, there is no evidence beyond those two papers that apply spatial econometrics to the topic of hospital quality. While Gravelle et al. (2014) include indicators of market structure as control variables, their research question focuses on strategic interaction. Market structure and strategic interaction as different aspects of competition are not discussed and separately estimated.

The models of Gravelle et al. (2014) and Longo et al. (2017) suggest that the existence of strategic interaction is highly dependent on the cost and reimbursement structure of a hospital market. Also, theoretical considerations on the relationship between competition and quality suggest that the relationship is influenced by the specific organization of the hospital market with regard to e.g., ownership structure. For the German hospital market, the evidence on the topic is scarce.

German hospitals are financed by sickness funds and the state government. While sickness funds (and private health insurers) cover operating costs, the federal state governments are supposed to finance investment needs of hospitals. Out-of-payment-fees for patients are very limited<sup>5</sup>. German hospitals can be public, owned by municipalities, counties, or the state. Alternatively, there are private not-for-profit, owned by e.g., religious institutions, or private for-profit hospitals. While private for-profit hospitals intend to realize a profit, public and not-for-profit hospitals are not allowed to distribute surplus to shareholders. With a market share of 38 percent, private for-profit hospitals have become the dominant ownership structure in the German hospital market in 2019. Private not-for-profit hospitals account for 34 percent, and public hospitals for 28 percent of the market (Statistisches Bundesamt 2021).

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<sup>4</sup> The optimal reaction slope and sign is depends on the marginal cost of the respective treatment.

<sup>5</sup> Patients must pay a fixed fee of €10 per night of their hospital stay, and there are additional charges for services such as a single room or treatment by the chief of medicine.

Reimbursement for treatment takes place based on a G-DRG-system and does not vary between hospitals with different ownership structure. Patients are free in their choice of hospital, and due to the fixed price system, hospitals are encouraged to compete on quality.

In this paper, I apply an empirical framework that integrates two different aspects of hospital competition and relates them to indicators of patient experience in Germany. To examine different aspects of hospital quality, I use a principal factor analysis to extract underlying quality dimensions. I then look at structural competition by constructing a hospital centered Herfindahl-Index that is weighted by hospital size and the share of overlapping departments. My results suggest a non-linear relationship between structural competition and care quality, but no evidence for a relationship with either medical or organizational quality as well as general patient satisfaction. To deal with the remaining unexplained spatial correlation in the model, I apply spatial lag models. I incorporate spatial dependence as a spatial lag that indicates strategic interaction between hospitals. These spatial lags are significant and robust to different specifications. Several robustness checks suggest that the magnitude of impact might vary, but the general result is robust to adjustments.

The structure of the paper is as follows. Section 2 describes the data sources that are used for the analysis, and Section 3 outlines the empirical approach. Section 4 presents the results on competition and quality. Section 5 concludes.

## 2. Data

The main quality data is based on The Patient Experience Questions (PEQ), a patient satisfaction survey offered by the project "Weisse Liste" in cooperation with several large statutory health insurers (Weisse Liste/AOK/BARMER 2016, 2017, 2018). The survey started in 2011 and addresses patients between 18 and 80 years who have recently experienced an inpatient hospital stay (Weisse Liste 2018)<sup>6</sup>. The survey is sent out in five waves per year to patients between 2 and 8 weeks after their stay and asks them to evaluate their experiences concerning the particular stay. The questionnaires contain questions to retrospectively assess different aspects of the patient's hospital stay (see Appendix – A 1. Patient Experience

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<sup>6</sup> Patients with certain characteristics were excluded from the sample: e.g., specific discharge reasons, patients that died after the hospital stay, readmissions within a year, etc.

Questionnaires). The patient experience questionnaire is supposed to identify four quality dimensions: satisfaction with medical provision, satisfaction with care provision, satisfaction with organization and service and likelihood of recommendation. Patients are supposed to rate their experience on a scale of school grades ranging from 1 (very good) to 6 (very bad). The results are aggregated by hospital, including only hospitals for which at least 75 surveys were received<sup>7</sup>. For 2018, the survey comprises 408,364 questionnaires for 1,495 hospitals with 273 questionnaires per hospital on average<sup>8</sup>.

The data that I use to construct the competition measure, as well as information on hospital characteristics, is obtained from the database of structured quality reports (2016, 2017, Qualitätsberichte 2018). Those reports contain address, number of departments, number of beds, number of cases, ownership status, and teaching status.

To construct a measure for structural competition respectively market structure, I calculate an adapted version of the Hirschman-Herfindahl-Index (HHI). Following Propper et al. (2004) and Bloom et al. (2015), I calculate the HHI based on catchment areas instead of administrative units (e.g. counties). Those catchment areas are based on a fixed radius around the location of the hospital. This approach is used to capture demand patterns of patients since patients are highly sensitive to travel time (shown e.g. by Gowrisankaran et al. (2015)). This size of the radius is clearly an arbitrary choice. To make results as comparable as possible to Longo et al. (2017), I use a radius of 30 km in the basis specification and test later if the results are sensitive to using differently sized catchment areas. I further adapt the Herfindahl Index by a double weighting. Within the catchment area, each potential competitor is weighted by the number of overlapping<sup>9</sup> departments and by the number of beds<sup>10</sup>. The HHI is then calculated as the sum of squares of the weighted market shares and can range from close to zero to one. A hospital with a HHI of 1 would be a monopolist within a radius of 30 km, while a hospital with a HHI close to 0 acts in a highly competitive market. For a more intuitive interpretation of the

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<sup>7</sup> Alternatively, hospitals are also included if at least 50 surveys for a specific department were received.

<sup>8</sup> For 2017, 483,707 surveys cover 1,514 hospitals, and for 2016 there are 501,469 surveys for 1,528 hospitals.

<sup>9</sup> The more common departments two potential competitor hospitals have, the more overlap exists between their treatment profile and the more patients they are competing for.

<sup>10</sup> The number of beds approximates the treatment volume and accounts for the potential market share of competing hospitals.

results, I use the inverse HHI as a structural competition measure. Thus, a higher measure is related to a higher level of competition.

I add further regional information to control for regional variation at county level (INKAR 2020). Using hospital and regional control variables, I try to control for demand as well as supply shifters. As demand shifters, I add population density, the share of elderly as well as the share of a working population, the median household income, and residents per practitioner. As potential supply shifters, I include cases per doctor and per nurse as well as the share of employed in the service and social service industry and the share of open jobs for skilled and unskilled workers<sup>11</sup>. Since hospital planning and financing of the hospital investments are within the federal state powers, I add federal state fixed effects to account for differences in those areas.

Table 2.1 shows the number of hospitals that are included in the analysis. In the basis specification, I only evaluate the year 2018. Despite losing a big number of data points, there is a strong advantage of a cross-sectional analysis in this case. To use a distance matrix, which is required for the Spatial lag estimations in panel data estimation, a constant number of hospitals is required for all years. Hence, the number of hospitals that can be included in the analysis would be reduced. In this case, a missing hospital is not just a missing observation but also a missing potential competitor. Therefore, the estimation of strategic interaction would be doubly impacted. I therefore chose to estimate a cross-section estimation for the year 2018 but repeat the analysis for the years 2017 and 2016 as well as a panel estimation as a robustness check.

**Table 2.1: Hospitals in the Sample**

	2016	2017	2018
Total number of hospitals <sup>1</sup>	2,264	2,281	2,291
Specialty or day clinics	1,012	1,046	1,048
Hospitals with Missing values <sup>2</sup>	109	61	34
Hospitals in the Sample	1,143	1,174	1,209

Notes: <sup>1</sup> According the structured quality reports <sup>2</sup>Missing values in any variable included in the analysis.

<sup>11</sup> In absence of a measure of shortage of specialists in the medical sector, I use those indicators to proxy for the number of missing doctors and nurse in the region.

Using this strategy enables me to work with only a few missing observations (between 3,2 and 10,8 percent depending on the year). I do not include specialty<sup>12</sup> and day clinics since they do not compete with other clinics in a straightforward sense. Although they might also be subjected to competition, defining who can be considered a competitor is complex. I, therefore, exclude those hospitals for the analysis.

### 3. Methodology

I investigate the impact of structural competition (market structure) and strategic competition (interaction) on quality and do so by first estimating the effect of structural competition and then include estimates for strategic interaction.

#### 3.1 Estimation

In a first step, I test whether a hospital reacts to the structural competition (market structure) that it is embedded in, using the following model:

$$(1) \quad y_i = f(hhi_i, X_i, \epsilon_i)$$

where  $y_i$  is a quality indicator of hospital  $i = 1, \dots, I$ ;  $hhi_i$  indicates the market structure of hospital  $i$  according to an adaption of the Herfindahl-Index which is based on beds rather than hospitals;  $X_i$  is a vector of covariates that controls for the hospital characteristics (ownership type, size, teaching hospital) and regional characteristics of the county where the hospitals' county is located (population density, labor market situation, age structure);  $\epsilon_i$  is the error term. From (1), I specify a cross-sectional OLS model:

$$(2) \quad y_i = \beta_0 + \beta_1 hhi_i + \beta_2 X_i + \epsilon_i$$

Following (Propper et al. 2004), I include the indicator for market structure in its first and second order polynomial in order to allow for a non-linear relationship.

In a second step, I test whether the hospital responds to the quality of its competitors (strategic competition) using the function:

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<sup>12</sup> This included hospitals that offer only psychiatric and psychological treatment.

$$(3) \quad y_i = f(y_j, X_i, \epsilon_i)$$

which translates into the cross-sectional spatial lag model:

$$(4) \quad y_i = \beta_0 + \beta_2 X_i + \sum_{j=1}^J \rho w_{ij} y_j + \epsilon_i$$

where  $y_j$  is the quality of hospital  $j$ 's competitor  $j = 1, \dots, N$ ;  $w_{ij}$  is a weight that is assigned based on the spatial relationship between hospital  $i$  and  $j$ , and  $X_i$  includes the same covariates as in equation 2.

In a third step, (1) and (3) are combined into:

$$(5) \quad y_i = f(y_j, hhi_i, X_i, \epsilon_i)$$

which is specified as the following model:

$$(6) \quad y_i = \beta_0 + \beta_1 hhi_i + \beta_2 X_i + \sum_{j=1}^J \rho w_{ij} y_j + \epsilon_i$$

In the basis specification, I follow Bloom et al. (2015) and Longo et al. (2017) with regard to the assumption that competition between hospitals takes place in a 30 km radius around the hospital. Hence, I calculate the market structure indicator within 30 km around a hospital  $i$  according to the following formula:

$$(7) \quad hhi_i = Beds / \sum_{j=1}^n dep_{ij} * size_{ij} * dist_{ij} * Beds_j^2$$

with  $dep_{ij}$  being a share of departments that are common between the target and rival hospital and ranging from 0 to 1. In case of  $dep_{ij} = 1$ , all departments of the target hospital  $i$  are also existent in a competing hospital  $j$  - hence hospital  $j$  is seen as a full competitor. If  $dep_{ij} = 0$ , the competing hospital has none of the departments of the target hospital  $i$  and therefore is not regarded as competition at all. The indicator  $size_{ij}$  relates the size of hospital  $i$  to its competitor  $j$ . The indicator takes the value 1 if the competitor has more or an equal number of beds as hospital  $i$ . If it has fewer beds, the indicator takes the value  $size_{ij} = Beds_j / Beds_i$ . The intuition behind this adjustment is that a competition hospital with fewer beds could be seen as only a partial competitor since it does not have the capacity to treat all potential patients coming from hospital  $i$ . Indicator  $dist_{ij}$  can take the values 0 and 1, depending on the distance between target and competitor hospital. If the distance between both hospitals is

equal or less than 30 km,  $dist_{ij}$  takes the value 1 and is a potential competitor. For a distance greater than 30 km,  $dist_{ij}$  is 0.

The spatial weight is not based on a distance matrix<sup>13</sup> as used by Longo et al. (2017). I rather use a k-nearest-neighbor-distance matrix (KNN-Matrix) that assigns spatial weights greater 0 to the k hospitals that are closest to the index hospital  $i$ :

$$(8) \quad w_{ij}(k) = \begin{cases} 0 & \text{if } i = j, \forall k \\ d_{ij}^{-1} & \text{if } d_{ij} \leq d_i(k) \text{ and } w_{ij}(k) = \frac{w_{ij}}{\sum_j w_{ij}(k)} \\ 0 & \text{if } d_{ij} > d_i(k) \end{cases}$$

where  $d_{ij}$  is the travel distance between hospital  $i$  and  $j$ , and the pairs are sorted by distance. The matrix takes the value 0 in its axis, where hospital  $i =$  hospital  $j$ . The  $k$  closest hospitals are identified and weighted with its inverse distance  $1/d_{ij}$ . The matrix takes the value 0 if the distance exceeds  $d_{ij}(k)$ . Finally, the matrix  $W$  is row standardized - all elements of one row add up to one ( $\sum_k w_{ij}(k) = 1$ ).

In the basic specification, I set  $k = 8$ . Hence, only the eight closest hospitals are considered competitors by the spatial weights. This again is an arbitrary decision. I choose  $k = 8$ , since as Table 4.2 shows that hospital faces, on average, eight competitors within a 30 km radius. Longo et al. (2017) choose a 30 km-distance-matrix and I use a 30 km-radius catchment area to construct the indicator for structural competition. Hence, an eight-nearest-neighbor-matrix covers a similar area on average. There are two distinct advantages of choosing a KNN-Matrix over a fixed radius distance matrix. The first argument is flexibility with regard to the competitive environment. If hospital  $i$  has no competition within 30 km, it might still be impacted by its closest competitor that happens to be located further away. In contrast, a hospital that faces a large number of competing hospitals within 30 km might only react to the closest subset of hospitals. As a second argument, there is a technical aspect that favors a KNN-Matrix over a Fixed Distance-Matrix. To construct a Fixed Distance-Matrix, all observations must have at least one competitor within the given radius. This is not the case for a 30 km radius, for which there are monopolists. Those would have to be excluded from

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<sup>13</sup> In a distance matrix for a given radius, all hospitals within the given radius obtain a spatial weight greater 0. Longo et al. (2017) use this kind of spatial weights with a 30 km radius.



the analysis. A KNN-Matrix does not require to drop any observations and is therefore favorable to a fixed distance matrix.

The estimated coefficient  $\rho$  approximates the reaction of target hospital  $i$  to an increase in quality of its competitor's hospital  $j$ . This spatial correlation approximates strategic interaction between hospitals. However, if unobserved characteristics impact both hospitals, this apparent spatial correlation could be spurious. Therefore, I also include a number of regional indicators to control for the environment of hospitals, captured in the vector  $X_i$ . I estimate spatial cross-sectional models by Maximum Likelihood.

### 3.2 Dependent Variables

The indicators for hospital quality are based on the 15 questions of the Patient Experience Questionnaire. To construct indicators that capture the underlying dimensions of hospital quality, I apply a principal-factor analysis (PFA). The principal-factor is a multivariate method to reduce the number of variables in a data set into a number of smaller dimensions that are supposed to represent underlying factors. In this application, I assume that hospital quality is determined by different factors, which I try to extract with the aforementioned method. Based on the number of eigenvalues above 1<sup>14</sup>, I extract three principal factors and their predicted values as dependent variables, following the equation:

$$(9) \quad \sum_{n=1}^{15} F_k = L_{kn} X_{kn}$$

where  $F_k$  are the extracted factors. Those factors  $F_k$  are linear combinations of the input variables  $X_{kn}$ , weighted by the Loadings  $L_{kn}$ . I estimate the principal factors using Maximum Likelihood and use them as dependent variables during further analysis. In addition, I construct an indicator by calculating the mean of the ratings for all 15 questions:

$$(10) \quad \text{Mean quality}_i = \frac{\sum_{n=1}^{15} X_{ni}}{15}$$

This indicator is supposed to capture mean hospital quality without the differentiation between the dimensions.

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<sup>14</sup> A common criterion for determining the number of principal factors is to use only a factor with an eigenvalue above 1.

## 4. Results

### 4.1 Principal factor analysis

Table 4.1 shows the results of the principal factor analysis. The table shows the factor loadings  $L_{kn}$  that are assigned to each variable in order to calculate the factor  $F_k$ . Generally, a variable with a positive factor score is associated with a higher level of the respective quality dimension, and conversely, a variable with a negative factor score is associated with lower quality. As an advantage of a principal factor analysis, the assignment of a variable to a dimension is data-driven and not exclusive. A variable can contribute to several factors with varying intensity. The contribution intensity is expressed by the factor score. However, many variables can be linked to one main factor. In the third and fourth columns of the table, communality and uniqueness of the variables are measured. The communality shows the proportion of the variance contributed by the common factors, whereas the uniqueness is the proportion of variance unexplained by the common factors. High communality shows that the variable in question is very well explained by the underlying dimensions.

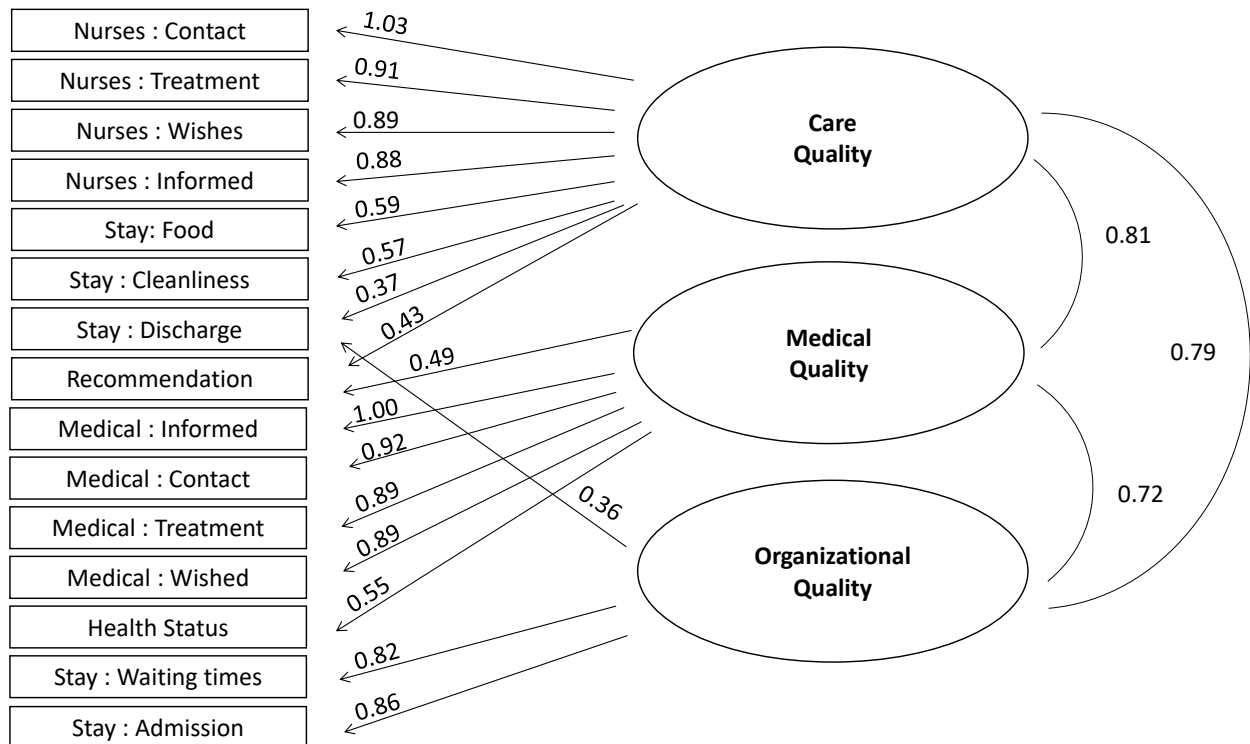
**Table 4.1: Principal Factor analysis**

Variable	Care Quality	Medical Quality	Organizational Quality	Communality	Uniqueness
Medical: Wishes	0.03	<b>0.89*</b>	0.07	0.93	0.07
Medical: Contact	-0.06	<b>0.92*</b>	0.13	0.93	0.07
Medical: Informed	-0.07	<b>1.00*</b>	0.04	0.94	0.06
Medical: Treatment	0.19	<b>0.89*</b>	-0.14	0.90	0.10
Nurses: Wishes	<b>0.89*</b>	0.11	0.00	0.95	0.05
Nurses: Contact	<b>1.03*</b>	-0.08	0.00	0.94	0.06
Nurses: Informed	<b>0.88*</b>	0.05	0.06	0.95	0.05
Nurses: Treatment	<b>0.91*</b>	0.09	0.00	0.96	0.04
Stay: Waiting times	0.10	0.07	<b>0.82*</b>	0.92	0.08
Stay: Admission	0.03	0.05	<b>0.86*</b>	0.84	0.16
Stay: Cleanliness	<b>0.57*</b>	0.04	0.27	0.71	0.29
Stay: Food	<b>0.59*</b>	-0.07	0.28	0.60	0.40
Stay: Discharge	<b>0.37*</b>	0.22	<b>0.36*</b>	0.78	0.22
Recommendation	<b>0.43*</b>	<b>0.49*</b>	0.08	0.89	0.11
Health Status	0.15	<b>0.55*</b>	0.06	0.53	0.47
SS loadings	5.49	4.78	2.5		
Care Quality	1.00	0.82	0.81		
Medical Quality	0.82	1.00	0.74		
Organiz. Quality	0.81	0.74	1.00		

\*Can be interpreted as mainly attributed to the respective factor.

I derive 3 PFA-based factors that summarize different aspects of the patient's subjective evaluation of their hospital stay. The assignment is additionally displayed graphically in Figure 4.1.

**Figure 4.1: Assignment of Factor Loading to Factors**



Notes: The main contributing variables are depicted as well as the correlations of the factors with each other.

The first factor captures mainly care aspects of the stay, such as treatment by the nurses and the comfort of the general stay and could be summarized as care quality. The second factor captures various aspects that depict the medical quality of the treatment, and the third factor captures the efficiency and organizational quality of the hospital treatment. Most variables show high level of communality, suggesting that they are well explained by the underlying quality dimensions. An exception is health status and some aspects of the stay, such as food and cleanliness. It is reasonable to assume the health status is strongly impacted by factors beyond the hospital quality that cannot be captured in the model. For some other aspects as contentment with food and cleanliness preferences between patients might differ considerably that can also not be captured by the model.

## 4.2 Descriptive Results

Table 4.2 shows descriptive statistics of the hospitals that are included in the analysis as well as an overview of the outcome quality indicators and the competition variables as the main explanatory indicators. Due to the construction of the quality indicators by principal factor analysis, they are all centered around a mean of zero with a standard deviation of 1. To alleviate interpretation of the indicators, I also re-centered the indicator for mean quality to a mean of 0. However, the standard deviation differs from the other indicators of quality. Positive values are associated with better quality, while negative values correspond with worse quality. The competition indicators show that a hospital faces, on average, 18 other hospitals within a 30 km radius. However, not all these hospitals can be considered competing hospitals, as they e.g. have different departments.

**Table 4.2: Summary Statistics**

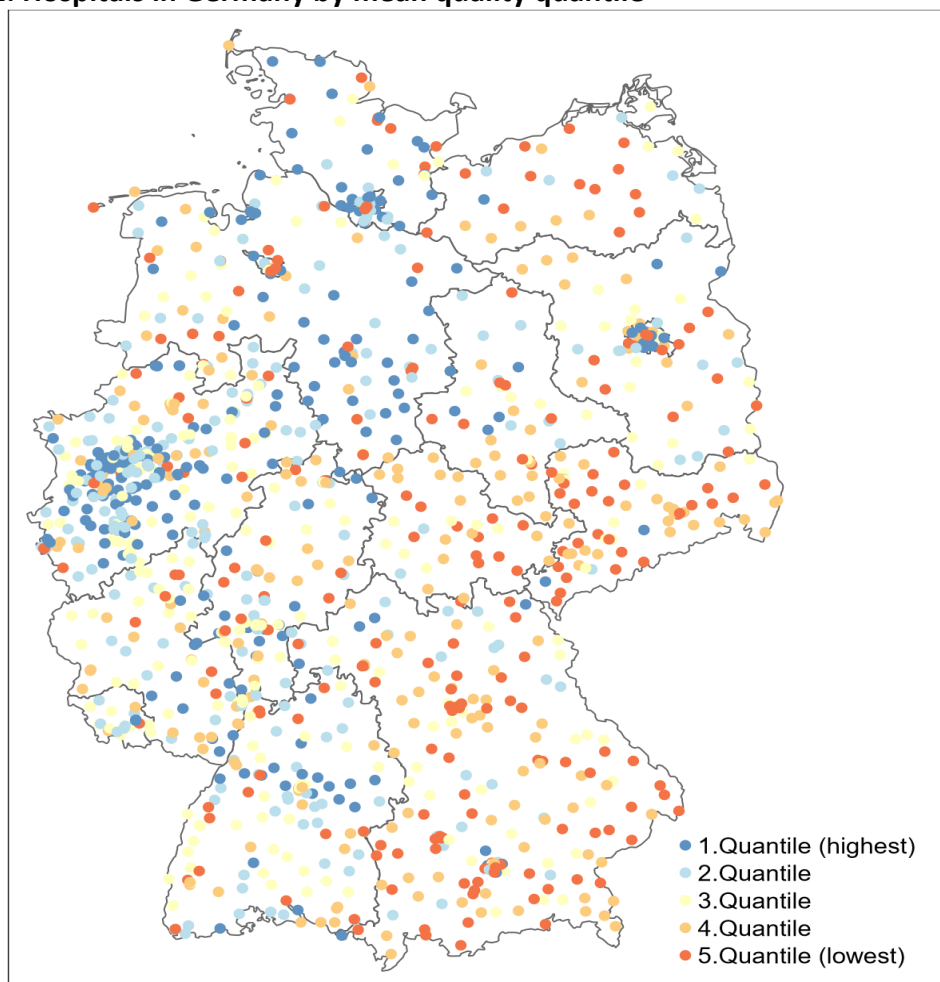
Variable	Mean	St. Deviation	Minimum	Maximum
<b>Quality Indicators</b>				
Mean Quality	0	0.21	-0.78	0.75
Care quality	0	0.99	-3.82	3.77
Medical Quality	0	0.99	-4.76	4.24
Organizational Quality	0	0.97	-3.81	3.17
<b>Hospital Characteristics</b>				
Share: Public	36%			
Share: NFP	46%			
Share: FP	18%			
Share: Basic provider	15%			
Share: Teaching hospital	2%			
No. of departments	9.5	6.2	1.0	47.0
In-patient cases	1,4569.0	12,376.4	0.0	145,543.0
Day cases	381.5	1,235.5	0.0	15,794.0
Outpatient cases	3,4264.6	80,928.6	0.0	1,568,896.0
Cases per doctor	95.8	31.8	0.0	597.9
Cases per nurse	51.4	17.4	0.0	229.3
<b>Regional Characteristics</b>				
Population density	794.65	1,101.25	36	4601
Share: Population 65+	21.72	2.8	15.62	30.76
Share: Population with degree	14.23	7.26	5.34	42.93
Share: Working population	82.45	3.66	61.19	92.73
Median Household inc.	3,076.07	463.31	2103	4596
Share: Work soc. serv. industry	23.98	4.32	10.2	43.3
Share: Work in Service industry	39.54	14.91	15.4	96.6
Residents per practitioner	741	157.68	328.1	1363.9
Unemployed per open jobs	32.01	17.26	7.8	126.9
Share: open jobs - skilled	65.81	4.12	37.3	78.8
Share: open jobs - unskilled	18.2	4.66	8.1	53.6
<b>Competition indicators</b>				
No. competitors within 10 km	3.37	5.17	0	24
No. competitors within 20 km	9.77	11.77	0	54
No. competitors within 30 km	18.37	19.64	0	95
No. competitors within 40 km	28.35	27.7	0	126
No. competitors within 50 km	39.55	35.49	1	157
No. competitors within 10 km (adj.)	1.35	2.34	0	18
No. competitors within 20 km (adj.)	4.13	5.4	0	35.1
No. competitors within 30 km (adj.)	8.02	9.19	0	64.79
No. competitors within 40 km (adj.)	12.61	13.11	0	94.74
No. competitors within 50 km (adj.)	17.82	17.14	0.33	114.39

Notes:  $N_{\text{Total}} = 3,526$ ;  $N_{2016} = 1143$ ,  $N_{2017} = 1,174$ ,  $N_{2018} = 1,209$ .

Once I account for the size of the hospitals as well as for the share of common departments, a hospital faces, on average, eight competing hospitals. However, there is great variation, ranging from monopolists within the 30 km radius to hospitals under highly competitive pressure facing 65 competitors. In addition, the distribution is highly right skewed with a big discrepancy between mean and median. While an average hospital faces, on average, eight competing hospitals, 50% of the hospitals face 4.5 or less real competitors.

Figure 4.2 shows the geographic distribution of the sample hospitals by mean patient experience grouped into quantiles.

**Figure 4.2: Hospitals in Germany by mean quality quantile**



Note: The indicator "Mean Quality" was used to group all hospitals in the sample into quantiles for the year 2018.

The figure shows a clustering of hospitals regarding quality. Hospitals of similar quality quantiles are often located in geographical proximity. There appear to be clusters of good quality as well as clusters of inferior quality. There could be a number of alternative

explanations for this finding. The quality clusters of hospitals could also be caused by regional characteristics. For example, the level of investment subsidies for hospitals varies greatly between the states (AOLG 2019). Also, different demographic parameters and different supply of health care provision can impact the perceived quality of hospitals. This underlines the need to control for additional regional characteristics.

### 4.3 Regression Results

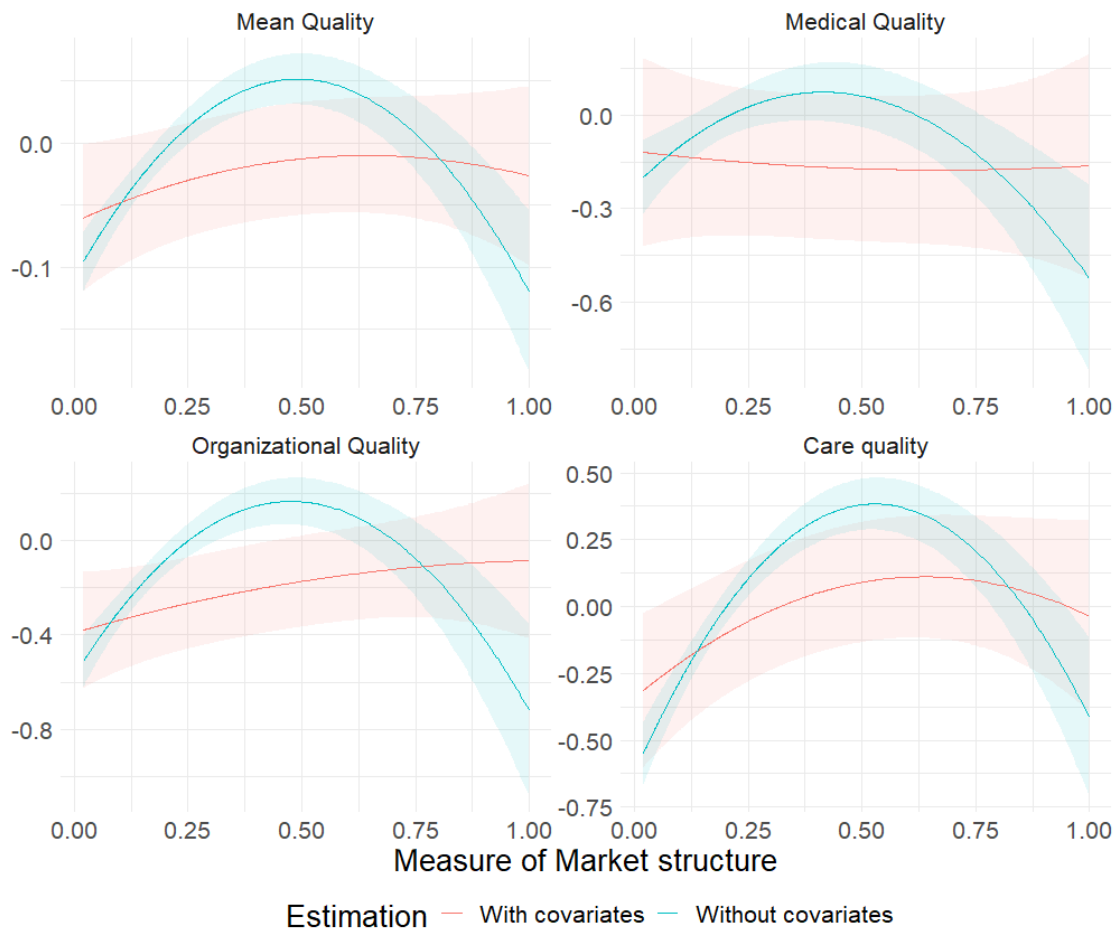
Figure 4.2 shows a strong regional variation of hospital quality. Using the estimation strategy as described in section 3.1, I attempt to analyze if parts of this variation can be explained by market structure (structural competition) or strategic interaction (strategic competition). In a first step, I test the hypothesis that hospital quality is impacted by its surrounding market structure after controlling for hospital and regional characteristics. Table 4.3 shows the regression results, and Figure 4.3 shows the marginal effect of competitive intensity.

**Table 4.3: Linear regressions for Structural competition with and without control variables**

	Mean Quality		Care Quality		Medical Quality		Organizational Quality	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Market structure	0.65*** (0.08)	0.17* (0.10)	3.80*** (0.40)	1.42*** (0.48)	1.45*** (0.41)	-0.18 (0.50)	3.09*** (0.41)	0.56 (0.42)
Market structure <sup>2</sup>	-0.66*** (0.10)	-0.13 (0.10)	-3.60*** (0.45)	-1.12** (0.48)	-1.75*** (0.46)	0.13 (0.49)	-3.23*** (0.49)	-0.26 (0.44)
Controls	No	Yes	No	Yes	No	Yes	No	Yes
R <sup>2</sup>	0.05	0.34	0.08	0.32	0.01	0.27	0.05	0.47
Adj. R <sup>2</sup>	0.05	0.32	0.07	0.29	0.01	0.24	0.05	0.45
Num. obs.	1209	1209	1209	1209	1209	1209	1209	1209
N Clusters	1209	1209	1209	1209	1209	1209	1209	1209

Notes: \*\*\*p < 0.01; \*\*p < 0.05; \*p < 0.1. Robust SE in brackets.

Year 2018; Control variables include : Ownership, number of departments, basic provider, inpatient cases, day cases, outpatient cases, teaching hospital, cases per doctor, cases per nurse, population density, share of population 65+, share of population with a degree, share of working population, median household income, share of people employed in the social service industry, share if people employed in the service industry, residents per practitioner, unemployed per open jobs, share of skilled open jobs, share of unskilled open jobs, state fixed effects.

**Figure 4.3: Marginal effects of Market structure on Quality Outcomes**

Notes: The Marginal effects are calculated based on the OLS estimations (Table 4.3)

The first column of each indicator shows the regression results without including further controls. The second column includes control variables for hospital and regional characteristics as well as state fixed effects. If quality is regressed on competition, without the inclusion of further control variables, all quality measures exert a strong non-linear relationship with market structure. However, a share of the association can be explained by regional and hospital characteristics. Once I control for those characteristics, I only find evidence for a relationship between market structure and care quality. For this indicator, the relationship has a non-linear form that resembles a reversed u-shape with a maximum in a moderately competitive environment. With all other aspects held stable, hospitals in such a moderately competitive environment appear to offer higher quality than hospitals in highly competitive regions. For mean quality, I find a linear relationship suggesting that increasing structural competition corresponds to higher average quality. However, the result is only significant at the 10% -level. For organizational and medical quality, there is no evidence for a

significant relationship once control variables are included. It appears that structural competition might impact hospital quality, but mainly via the channel of care quality.

In a second step, I test if spatial correlation is present in the residuals of regressions estimated above as well as in the indicator itself. Table 4.4 shows the results of a spatial dependence test for both cases. A positive test statistic for the Global Moran test indicates positive spatial interaction, a negative test statistic would imply negative spatial dependence. Spatial correlation is significant for all quality indicators and moderate in magnitude. The magnitude of the spatial correlation is within the range of spatial correlation found by Gravelle et al. (2014) and Longo et al. (2017). They are comparable to the magnitude of the indicator considered for patient experience in Gravelle et al. (2014) but considerably higher than the spatial autocorrelation for patient experience indicators found by Longo et al. (2017). Significant spatial dependence is also present in the residuals, indicating that there is remaining spatial correlation that cannot be fully explained by regional characteristics and hence should be accounted for within the model.

**Table 4.4: Spatial Tests**

	Mean Quality	Care Quality	Medical Quality	Organizational Quality
<b>Spatial Dependence in the indicator</b>				
Global Moran I	0.256 (0.000)	0.278 (0.000)	0.236 (0.000)	0.236 (0.000)
<b>Spatial Dependence in the residuals</b>				
Global Moran I	0.069 (0.000)	0.077 (0.000)	0.063 (0.000)	0.066 (0.000)

Notes: p-values in bracket; A positive test statistic corresponds to a positive spatial interaction dependence effect. Year 2018

I therefore estimate a Spatial lag model that incorporates spatial autocorrelation as lag. Table 4.5 summarizes the results. The first column for each indicator reports the results of the linear regression showing the indicator for market structure. In the second column (SLM 1), I estimate the spatial lag model without including the indicator for market structure, thereby only controlling for strategic competition. This was the approach chosen by (Longo et al. 2017).



Table 4.5: Spatial Regression

	Mean Quality			Care Quality			Medical Quality			Organizational Quality		
	OLS	SLM 1	SLM 2	OLS	SLM 1	SLM 2	OLS	SLM 1	SLM 2	OLS	SLM 1	SLM 2
Market Structure	0.17*	0.13	1.42***	-0.18	1.12**	-0.19	0.56	-0.19	0.4	0.56	0.4	0.4
Market Structure <sup>2</sup>	-0.1	-0.1	-0.48	-0.5	-0.49	-0.33	-0.42	-0.33	-0.32	-0.42	-0.32	-0.32
Strategic Interaction	-0.13	-0.10	-1.12**	0.13	-0.92*	0.13	-0.26	0.13	-0.15	-0.26	-0.15	-0.15
	-0.1	-0.1	-0.48	-0.49	-0.47	-0.33	-0.44	-0.33	-0.31	-0.44	-0.31	-0.31
	0.16***	0.16***	0.21***	0.19***	0.19***	0.14***	0.13***	0.14***	0.12***	0.13***	0.12***	0.12***
	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04	-0.04
Controls	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Num. obs.	1,209	1,209	1,209	1,209	1,209	1,209	1,209	1,209	1,209	1,209	1,209	1,209
AIC (Linear)	-699.98	-700.89	3,152.10	3,215.53	3,152.10	3,215.53	2,787.48	3,211.68	2,788.15	2,787.48	2,788.15	2,787.48
AIC (Spatial)	-713.31	-711.05	3,134.78	3,133.31	3,133.31	3,207.03	2,779.41	3,203.23	2,779.41	2,779.41	2,780.60	2,780.60
Parameters	42	44	42	42	44	44	42	42	44	42	42	44
Log Likelihood	398.66	399.53	-1,525.39	-1,522.66	-1,522.66	-1,559.51	-1,347.70	-1,559.61	-1,346.30	-1,559.51	-1,347.70	-1,346.30
LR: statistic	14.42	13.08	24.48	20.78	20.78	10.50	10.74	10.45	10.74	10.74	10.74	8.88
LR: p-value	0	0	0	0	0	0	0	0	0	0	0	0

Notes: \*\*\*p < 0.01; \*\*p < 0.05; \*p < 0.1. SE in brackets.

Year 2018; Control variables include: Ownership, number of departments, basic provider, inpatient cases, day cases, outpatient cases, teaching hospital, cases per doctor, cases per nurse, population density, share of population 65+, share of population with a degree, share of working population, median household income, share of people employed in the social service industry, share if people employed in the service

therefore compare the results with the results obtained by Longo et al. (2017). In a third estimation (shown as SLM 2), market structure is included to combine both approaches. For all indicators, there is a positive and statistically significant spatial lag. 10 % higher quality in rival hospitals increases own quality between 1,2% and 2,1% depending on the quality indicator and model specification. Those effects are higher than the results reported by Longo et al. (2017) but similar to the results that Gravelle et al. (2014) found for patient satisfaction. All spatial lags are significant. The comparison of both spatial model specifications suggests that both the indicator for structural competition and the indicator for strategic competition measure different concepts that are at most partially related. The inclusion of structural competition reduces the spatial effect coefficient only marginally. The structural competition indicator also appears to be robust to the inclusion of spatial dependence. Its magnitude is slightly lower in the spatial models compared to the linear estimation, but it remains statistically significant and stable in its functional form of the relationship. The LR tests suggest for all indicators that the models sufficiently deal with spatial correlation as no remaining spatial correlation can be detected in the residuals.

#### **4.4 Robustness Checks and Sensitivity Analysis**

Since my analysis is based on several assumptions concerning the specification of the catchment area and the definition of the distance matrix, I carry out several sensitivity analyses to test whether the results change if different assumptions are applied. All tables concerning robustness checks can be found in the appendix.

I first vary the radius that identifies the catchment area on which the market structure indicator is built upon and repeat the linear estimations of Table 2.1. The results are shown in Table A 0.1. In the main specification, I construct a catchment area for a hospital with a 30 km radius around the hospital. Now, I also estimate the model using a 10, 20, 40 and 50 km-radius. The results are robust for care quality concerning magnitude and functional form. For medical and organizational quality, there is no consistent pattern. Mean quality as combination of the different quality aspects is robust to different radii regarding the functional form and magnitude.

In a further robustness check, I also vary the distance matrix  $WY$ . The results in Table A 0.2 suggest that the results are not sensitive to the inclusion of different numbers of neighbors into the K-nearest-neighbor matrix.

Next, I repeat the OLS estimations for the years 2016 and 2017. I additionally apply a pooled cross section for all years. The results are depicted in Table A 0.3. The main results are stable over the years. The samples of 2016 and 2017 show a strong impact of structural competition on care quality that is even slightly higher in magnitude than in the year 2018. In line with the results for the individual years, the results for the pooled cross sections show effects similar in magnitude and significance. Furthermore, there is limited evidence for an impact of structural competition on organizational and mean quality. As for medical quality, there appears to be no evidence for a relationship between structural competition and quality. Those results also hold once spatial dependence is accounted for by Spatial lag estimations (Table A 0.4). Current methods in spatial econometrics require a balanced panel for spatial panel estimation. Beyond a loss of observations, that also means that potential competitors cannot be taken into account, which leads to a potential negative bias of the estimation for spatial dependence. In line with that consideration, the estimates for spatial dependence in the panel estimation are considerably lower. Still, they remain significant.

In the last robustness check, I add further weights to the distance matrix. So far, competitors are weighted by their distance to the hospital and then row standardized. Analog to weighting competitor hospitals by size and overlapping departments to construct the market structure indicator, I also add competitions weights to the distance matrix. Each competitor hospital obtains a competition weight that is calculated from the share of overlapping departments and the bed size. This adjustment considers that the closest hospital  $j$  might be closest in distance to hospital  $i$  but does not necessarily constitute the greatest competitive pressure, since it could be either very small or offer very different kinds of treatment (represented by different departments). To correct for those possibilities, I re-estimate the base results with the adjusted distance matrix. As the results in Table A 0.5 show, the strategical interaction effect becomes considerably stronger for all quality measures. While the base impact ranges from 1,2% to 2,1% for a 10% higher quality in rival hospitals, the results of the weighted regression suggest that 10% higher quality in rival hospitals corresponds to an increase between 2,4% and 2,8%.

## 5. Discussion and policy implications

In this paper, I investigated whether a hospital reacts to structural and strategic competition by adjusting its quality. For policy makers, the question about the relationship between competition and hospital quality is a crucial issue. Several competition enhancing reforms had been introduced during the last decades without clear evidence on how hospital quality would be impacted. Theoretical models cannot offer clear-cut predictions about the impact of competition on quality (e.g. Brekke et al. 2011). In fact, several models suggest that the nature of the relationship depends on the particular organization of the hospital market, e.g., with regard to ownership or cost structure of the market (e.g. Herr 2009, Sanjo 2009, Brekke et al. 2014). Empirically, the findings of Duggan (2002) in the light of the theoretical considerations add to the notion that the specific design of the market matters.

Hence, to shed light on this relationship, I examine how competition impacts subjective hospital quality. I focus on the German hospital market that is characterized by a fixed pricing, a diverse ownership structure and a very dense hospital market. Compared to the US and to the UK, for which most empirical studies on the topic were conducted, Germany has a high number of beds per 1,000 people<sup>15</sup> and a great amount of local dispersion of hospital beds<sup>16</sup>. Analyzing Germany can therefore shed light on the relationship between competition and hospital quality for countries that have a large number of hospitals in total but also have a high amount of regional variation in hospital density.

I examine competition by differentiating between structural competition, measured as market structure, and strategic competition, measured as spatial interaction effects. My findings show a non-linear relationship between structural competition and care quality, but neither evidence for a relationship with medical or organizational quality nor with general patient satisfaction. To address spatial correlation in the model that is not explained by regional and hospital characteristics, I apply spatial lag models that incorporate spatial dependence indicating strategic interaction between hospitals exists. I find that 10% higher quality in rival

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<sup>15</sup> For Germany, the number of hospital beds per 1 000 people from 10,4 in 1990 to 8,0 in 2017 but is still well above the numbers for the UK (2,5 in 2017) and the US (2,9 in 2017) (World Health Organization 2022).

<sup>16</sup> The number of hospital beds per 1 000 people per county in 2016 ranges from 0.2 to 29.6 (INKAR 2020).

hospitals increases the quality between 1,2% and 2,1%. The results suggest that indicators for structural and strategic competition are largely independent of each other. Including the indicator for strategic interaction does not change the estimates for structural competition in a major way and vice versa. Hence, a model that only includes structural or strategic competition does not capture all aspects of competition. I document that structural competition is only correlated with care aspects of hospital quality, while evidence for strategic competition can be found in care, medical and organizational quality, as well as general patient satisfaction. The relationship between competition and care quality appears to be of a non-linear nature. A non-linear relationship has also been found by Kessler and McClellan (2000), who find that the beneficial impacts of competitiveness are greater for areas in the most respectively least competitive quartiles in the US. For example, Propper et al. (2004) also allow for a non-linear functional form with regard to competition but find no evidence on such form for the UK. However, as mentioned before, the UK and the US have a considerably lower hospital density and a potentially narrower range of market structure variation. In other words, non-linear effects might not be observed since even the most competitive areas in the UK or US might have a lower amount of competition than the most competitive areas in Germany. This would imply that the relationship between competition and hospital quality could be a positive one in less dense hospital markets, as found in several studies.

A reason that this relationship is only observed in care quality could be its cost structure. It is possible that there is a concave cost structure inherent to care quality. Demand for medical staff might be higher in areas with many hospitals than in other places, which makes it more difficult and potentially costly to find nurses. If the difficulty to find medical staff increases in a non-linear way, the marginal cost of care might outweigh the marginal benefit at some point of the curve. In such a case, hospitals might have the incentive to cream-skim (Brekke et al. 2014) and provide different levels of quality based on the profitability of patients. The net effect on quality would then depend on the particular composition of profitable and not-profitable patients. Offering systematically different levels of quality to patients is in turn subject to the level of asymmetric information. While asymmetric information is a general problem of hospital treatments, care quality is especially affected. Evaluation of nursing care is far less measurable by objective standards and protocols than are medical treatments for which there are protocols and guidelines. Hence, quality of care might be an area prone to

differentiating on quality since compromising on the quality of medical treatment could generate great additional cost via e.g. lawsuits over medical malpractice.

If quality of care is more prone to such rationales, the inconclusive empirical findings could be in part explained. Results then depend strongly on the quality indicator and which aspect of hospital quality it represents. For outcomes representing more quality of medical treatment, a less pronounced relationship would be expected than for outcomes representing more aspects of care quality.

I also examine potential strategic competition and find a strong and consistent presence of strategical interaction effects. This is in line with the results of Gravelle et al. (2014) for patient experience, while Longo et al. (2017) do not find evidence for strategic interaction in aspects of patient experience. The model by Gravelle et al. (2014) implies that the presence of strategical interactions is a result of the underlying cost structure, and more specifically the marginal cost of providing quality. This marginal cost is likely to differ not just between hospital markets (due to cost structure elements) but also within a hospital between treatments. Looking at patient experience aggregated on a hospital level, the effect is a net effect. Again, depending on the patient and treatment composition, the net effect can differ.

The consequences of my results for hospital planning are twofold. On the one hand, they suggest that an overly competitive environment is not beneficial for hospital quality, at least concerning care quality. On the other hand, reducing competition by mergers and hospital closures must take place in consideration of the existing competitive environment. If the hospital to merge or close is not selected based on quality aspects, there could be adverse effects due to strategic interaction. In turn, initiatives to increase quality might have multiplying effects on the surrounding hospitals and are not limited to the hospitals they were aimed at. That makes a strong case to not rely only on consolidation of the hospital market by insolvencies but to rather aim for a structured readjustment that focuses on quality standards.

As a limitation of my study, there is always the risk of omitted variable bias. If I am not able to account for some unobserved regional characteristics that influence quality and vary in similar manners to competition, this would bias my results upwards. For example, if patients in different regions would systematically evaluate hospitals differently, that would bias my results in overstating the effect for spatial dependence. Also, I cannot control for varying

severity of cases. However, I reduce the potential bias by including a wide range of regional and hospital characteristics as well as state fixed effects. Hence, some obvious influences like general satisfaction with the hospital system of the state or regional differences in mentality are accounted for on the state level. However, it is still possible that the found spatial dependence reflects not only strategical competition but also other regional aspects that are not accounted for, which would overstate the amount of strategical competition. It also remains a limitation to the study that I evaluate subjective perceptions of hospital quality.

Even with this caveats, I can add further insights to the linkage between competition and quality by providing some support for the hypothesis that competition influences hospital quality in a complex but significant manner. In contrast to previous studies, I model competition as structural competition and strategic interaction and show that both concepts capture distinct aspects of competition. Moreover, I focus on aspects of hospital quality, such as care quality that are typically not measured by standardized hospital indicators and rarely analyzed in the existing literature.

A topic for future research is to see if those patterns can also be found in indicators of objective hospital quality, such as mortality rates or complications. However, there are only few indicators that are suitable to analyze care aspects in hospital quality for reasons discussed above. Also, an analysis of different treatments could shed light on potential patterns of strategical interactions.

In sum, I add to the literature by finding evidence that structural and strategic competition are both interlinked with hospital quality but in rather separate and independent ways. Controlling for only one of both aspects might not be sufficient to capture the impact of competition sufficiently and comprehensively.

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## Appendix Chapter 4

### A 1. Patient Experience Questionnaires

1. Wurden Ihre Wünsche und Bedenken in der ärztlichen Behandlung berücksichtigt?
2. Wie beurteilen Sie den Umgang der Ärztinnen und Ärzte im Krankenhaus mit Ihnen?
3. Wurden Sie von den Ärztinnen und Ärzten im Krankenhaus insgesamt angemessen informiert?
4. Wie schätzen Sie die Qualität der medizinischen Versorgung in Ihrem Krankenhaus ein?
5. Wurden Ihre Wünsche und Bedenken in der Betreuung durch die Pflegekräfte berücksichtigt?
6. Wie beurteilen Sie den Umgang der Pflegekräfte mit Ihnen?
7. Wurden Sie von den Pflegekräften insgesamt angemessen informiert?
8. Wie schätzen Sie die Qualität der pflegerischen Betreuung in Ihrem Krankenhaus ein?
9. Mussten Sie während Ihres Krankenhausaufenthaltes häufig warten?
10. Verließ die Aufnahme ins Krankenhaus zügig und reibungslos?
11. Wie beurteilen Sie die Sauberkeit in Ihrem Krankenhaus?
12. Entsprach die Essensversorgung im Krankenhaus Ihren Bedürfnissen?
13. Wie gut war Ihre Entlassung durch das Krankenhaus organisiert?
14. Würden Sie dieses Krankenhaus Ihrem besten Freund/Ihrer besten Freundin weiterempfehlen?
15. Hat sich Ihr Gesundheitszustand durch den Krankenhausaufenthalt verbessert?

## A 2. Additional Regressions

**Table A 0.1: OLS Estimations with market structure indicator based on different radii**

Market structure based on ...	Mean Quality	Care Quality	Medical Quality	Organizational Quality
<b>10 km</b>	0.196 (0.133)	1.190* (0.673)	0.760 (0.648)	0.316 (0.568)
<b>10 km<sup>2</sup></b>	-0.213** (0.101)	-1.013** (0.508)	-1.163** (0.491)	-0.453 (0.430)
<b>20 km</b>	0.179* (0.098)	1.513*** (0.480)	0.146 (0.499)	0.378 (0.403)
<b>20 km<sup>2</sup></b>	-0.173** (0.079)	-1.228*** (0.382)	-0.416 (0.400)	-0.371 (0.327)
<b>30 km</b>	<b>0.166*</b> <b>(0.098)</b>	<b>1.423***</b> <b>(0.479)</b>	<b>-0.178</b> <b>(0.497)</b>	<b>0.564</b> <b>(0.419)</b>
<b>30 km<sup>2</sup></b>	<b>-0.129</b> <b>(0.098)</b>	<b>-1.118**</b> <b>(0.482)</b>	<b>0.131</b> <b>(0.485)</b>	<b>-0.259</b> <b>(0.437)</b>
<b>40 km</b>	0.182 (0.122)	1.315** (0.595)	0.149 (0.611)	0.774 (0.506)
<b>40 km<sup>2</sup></b>	-0.159 (0.138)	-1.236* (0.681)	-0.241 (0.674)	-0.417 (0.579)
<b>50 km</b>	0.278* (0.152)	2.066*** (0.751)	0.221 (0.753)	1.101* (0.645)
<b>50 km<sup>2</sup></b>	-0.234 (0.200)	-2.219** (-1.013)	0.082 (0.930)	-0.473 (0.864)

Notes: \*\*\*  $p < 0$ ; \*\*  $p < 0$ ; \*  $p < 0$ . Robust SE in brackets.

The basis specification in marked bold. Estimation specification corresponds to the estimation specification used in Table 4.3 (including control variables).

**Table A 0.2: Spatial Lag Model Estimation based on different distance matrices**

Distance matrix based on ...	Mean Quality	Care Quality	Medical Quality	Organizational Quality
<b>1 Neighbor</b>	0.081 *** (0.021)	0.099 *** (0.021)	0.073 *** (0.022)	0.063 *** (0.020)
<b>6 Neighbors</b>	0.136 *** (0.038)	0.175 *** (0.037)	0.130 *** (0.039)	0.102 *** (0.037)
<b>7 Neighbors</b>	0.150 *** (0.039)	0.184 *** (0.039)	0.139 *** (0.040)	0.116 *** (0.038)
<b>8 Neighbors</b>	<b>0.156 ***</b> <b>(0.041)</b>	<b>0.193 ***</b> <b>(0.040)</b>	<b>0.143 ***</b> <b>(0.042)</b>	<b>0.122 ***</b> <b>(0.040)</b>
<b>9 Neighbors</b>	0.157 *** (0.042)	0.196 *** (0.042)	0.145 *** (0.043)	0.124 *** (0.041)
<b>10 Neighbors</b>	0.161 *** (0.043)	0.201 *** (0.043)	0.147 *** (0.044)	0.127 *** (0.042)

\*\*\*  $p < 0.01$ ; \*\*  $p < 0.05$ ; \*  $p < 0.1$ . SE in brackets.

The basis specification in marked bold. Estimation specification corresponds to the estimation specification used in Table 4.5 (SLM 2).

**Table A 0.3: OLS Estimations for different years and as pooled cross-section**

Sample		Mean Quality	Care Quality	Medical Quality	Organizational Quality
<b>Year 2016</b>	Market structure	0.270*** (0.094)	1.944*** (0.452)	0.190 (0.494)	1.045*** (0.401)
	Market structure <sup>2</sup>	-0.273*** (0.087)	-1.720*** (0.413)	-0.521 (0.452)	-0.986** (0.383)
<b>Year 2017</b>	Market structure	0.209** (0.100)	1.487*** (0.480)	0.049 (0.504)	0.746* (0.428)
	Market structure <sup>2</sup>	-0.243** (0.097)	-1.568*** (0.455)	-0.454 (0.490)	-0.799* (0.423)
<b>Year 2018</b>	Market structure	<b>0.166*</b> <b>(0.098)</b>	<b>1.423***</b> <b>(0.479)</b>	<b>-0.178</b> <b>(0.497)</b>	<b>0.564</b> <b>(0.419)</b>
	Market structure <sup>2</sup>	<b>-0.129</b> <b>(0.098)</b>	<b>-1.118**</b> <b>(0.482)</b>	<b>0.131</b> <b>(0.485)</b>	<b>-0.259</b> <b>(0.437)</b>
<b>All years</b>	Market structure	0.215** (0.087)	1.648*** (0.413)	0.031 (0.435)	0.768** (0.370)
	Market structure <sup>2</sup>	-0.215** (0.083)	-1.486*** (0.393)	-0.289 (0.411)	-0.667* (0.364)
<b>All years (balanced)</b>	Market structure	0.207** (0.089)	1.640*** (0.422)	-0.004 (0.440)	0.756** (0.376)
	Market structure <sup>2</sup>	-0.215** (0.084)	-1.525*** (0.398)	-0.287 (0.412)	-0.674* (0.367)

Notes: \*\*\*  $p < 0$ ; \*\*  $p < 0$ ; \*  $p < 0$ . Robust SE in brackets.

The basis specification in marked bold. Estimation specification corresponds to the estimation specification used in Table 4.3 (including control variables).

**Table A 0.4: Spatial Lag Model Estimation for different years and as pooled cross section**

Sample		Mean Quality	Care Quality	Medical Quality	Organizational Quality
<b>Model including structural competition indicator (SLM 2)</b>					
2016	Strategic interaction	0.124 *** (0.043)	0.147 *** (0.043)	0.112 ** (0.044)	0.135 *** (0.041)
	Market structure	0.246 *** (0.095)	1.750 *** (0.467)	0.204 (0.488)	0.884 ** (0.402)
	Market structure <sup>2</sup>	-0.258 *** (0.093)	-1.594 *** (0.458)	-0.548 (0.481)	-0.886 ** (0.395)
2017	Strategic interaction	0.134 *** (0.042)	0.156 *** (0.041)	0.147 *** (0.042)	0.119 *** (0.040)
	Market structure	0.170 * (0.098)	1.228 *** (0.474)	-0.001 (0.489)	0.567 (0.414)
	Market structure <sup>2</sup>	-0.212 ** (0.095)	-1.356 *** (0.460)	-0.412 (0.474)	-0.662 * (0.401)
<b>2018</b>	<b>Strategic interaction</b>	<b>0.156 ***</b> <b>(0.041)</b>	<b>0.193 ***</b> <b>(0.040)</b>	<b>0.143 ***</b> <b>(0.042)</b>	<b>0.122 ***</b> <b>(0.040)</b>
	<b>Market structure</b>	<b>0.129</b> <b>(0.101)</b>	<b>1.125 **</b> <b>(0.495)</b>	<b>-0.190</b> <b>(0.509)</b>	<b>0.397</b> <b>(0.429)</b>
	<b>Market structure <sup>2</sup></b>	<b>-0.104</b> <b>(0.098)</b>	<b>-0.918 *</b> <b>(0.482)</b>	<b>0.129</b> <b>(0.497)</b>	<b>-0.152</b> <b>(0.417)</b>
All years (balanced)	Strategic interaction	0.078*** (0.002)	0.130*** (0.000)	0.080*** (0.002)	0.056** (0.022)
	Market structure	0.186*** (0.001)	1.414*** (0.000)	-0.015 (0.959)	0.665*** (0.006)
	Market structure <sup>2</sup>	-0.196*** (0.000)	-1.336*** (0.000)	-0.268 (0.342)	-0.603** (0.011)
<b>Without Structural Competition indicator (SLM 1)</b>					
2016	Strategic interaction	0.130 *** (0.043)	0.167 *** (0.042)	0.108 ** (0.044)	0.144 *** (0.040)
2017	Strategic interaction	0.140 *** (0.042)	0.170 *** (0.041)	0.146 *** (0.042)	0.125 *** (0.040)
2018	Strategic interaction	0.162 *** (0.041)	0.207 *** (0.040)	0.143 *** (0.042)	0.133 *** (0.039)
All years (balanced)	Strategic interaction	0.088*** (0.001)	0.149*** (0.000)	0.082*** (0.002)	0.067*** (0.005)

\*\*\*  $p < 0$ ; \*\*  $p < 0$ ; \*  $p < 0$ . SE in brackets.

The basis specification in marked bold. Estimation specification corresponds to the estimation specification used in Table 4.5 (SLM1, SLM 2).

**Table A 0.5: Spatial Lag Model Estimations with additional weighting**

	Mean Quality	Care Quality	Care Quality	Organizational Quality
<b>Base results</b>				
Strategic interaction	0.156*** (0.041)	0.193*** (0.040)	0.143*** (0.042)	0.122*** (0.040)
Market structure	0.129 (0.101)	1.125** (0.495)	-0.190 (0.509)	0.397 (0.429)
Market structure <sup>2</sup>	-0.104 (0.098)	-0.918* (0.482)	0.129 (0.497)	-0.152 (0.417)
<b>Double weighted estimation</b>				
Strategic interaction	0.272*** (0.050)	0.238*** (0.052)	0.238*** (0.052)	0.276*** (0.048)
Market structure	0.124 (0.100)	1.228** (0.494)	-0.311 (0.507)	0.388 (0.423)
Market structure <sup>2</sup>	-0.100 (0.098)	-0.983** (0.482)	0.214 (0.495)	-0.119 (0.412)

\*\*\*  $p < 0$ ; \*\*  $p < 0$ ; \*  $p < 0$ . SE in brackets.

The basis specification in marked bold. Estimation specification corresponds to the estimation specification used in Table 4.5 (SLM 2).