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Hospitals' Strategic Behaviours and Patient Mobility: Evidence from Italy

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Abstract
The aim of this study is to explore hospitals' behaviours in attracting extra-regional patients and to investigate the effects of these behaviours on the quality of care to resident patients in a context where choices by regional patients are constrained by a budget cap and extra-regional patients are unconstrained source of revenue. Empirical results suggest that, controlling for hospital fixed effects, patients' demographic and health characteristics, hospitals use waiting times and length of stay to attract exra-regional patients. Regional patients admitted in both private and public hospitals with higher proportions of extra-regional patients show lower mortality rates and reimbursement costs. These results suggest that competition increases the quality of care and reduces costs through spillover effects produced by the market for extra-regional patients. Finally, the pattern of reimbursement asked for extra-regional care generates a financial flow in favour of richer regions, exacerbating the north-south gradient in the Italian NHS.

Keywords: Hospital competition, patient mobility, mixed market, quality of care

JEL Classification: H51, H77, D6, C70

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1 Introduction

In the quest to improve quality and reduce costs, competition in the market for hospital care has been introduced (Oliver and Mossialos, 2005; Gaynor and Town, 2011; Gravelle et al., 2014), but its effect is not clear (Gaynor et al., 2015; Berta et al., 2016) because this sector is highly regulated. Most systems in fact foresee budget caps to the level of hospital activity that reduces competition intensity and may produce undesired effects.

In Italy budget caps limit the number of local residents that can be treated in each Region, while the number of extra-regional patients treated is discretionary. For the same reason, extra-regional mobility in Italy is a frequent phenomenon: about 1 million patients (8.8% of total hospital admissions) seek care outside their region of residence and these flows have not exhibited any tendency to decrease (GIMBE, 2018). Compared to other European countries, patients travel long distances to receive better care (Adolph et al., 2012; Cantarero, 2006). While for the hospitals, extra-regional mobility represents an extra-budget source of revenue, at national level, reimbursements for extra-regional hospital admissions generates additional amounts of financial flows in favour of richer central–northern regions that are net exporters of hospital treatments[1].

The objective of the paper is to investigate hospital strategic behaviors in a mixed market for hospital care with extra-regional mobility. In particular, the study answers the following unexplored research questions:

- What are the strategies used to attract extra-regional patients? Are they hospital specific?
- What are the consequences for regional patients: do they benefit from extra-regional flows or are they somehow discriminated?

We use a unique, population-based, dataset consisting of longitudinal data on 4,902,225 hospital discharges for the period between 2010-2014 at public, private for profit, and private not-for-profit hospitals in Lombardy (Italy), the Italian region with the highest presence of private hospitals, and the only Region to use a true Prospective Payment System (PPS). Our results suggest that two types of extra-regional inflows exist: a) patients from the south, attracted by

[1] See for example the article recently published in the Italian newspaper *L'Espresso*: http://espresso.repubblica.it/attualita/2018/01/18/news/paradosso-sanita-il-sud-paga-piu-tasse-perche-le-persone-devono-andare-al-nord-per-curarsi-1.317263

the quality gap existing between the healthcare services provided in their region, and the same services provided in Lombardy; b) patients from border regions travelling to jump the queue in their region of origin. In line with the predictions of the theoretical model, when discrimination is possible quality indicators are patient-specific. Compared to residents, waiting time is shorter for extra-regional patients while the length of stay is shorter for border patients and longer for residents of southern regions. Our results also suggest that competition for extra regional admissions improves the quality of care for residents: quality of care (measured as mortality and readmissions) is in fact higher for hospitals attracting a higher proportion of non-resident patients. Consistently with our theoretical model, this suggests that competition is driven by the market for extra-regional patients rather than by residents' choices. Finally, we show that price discrimination exists: in spite of PPS scheme, the reimbursement asked for extra-regional admissions is higher than for residents causing a redistribution of resources from poor to rich regions. These results are extremely timely for Italy which may experience an even further decentralization of health care services (Torbica and Fattore, 2005).

2 Related Literature

In spite of the growing literature on quality competition, hospital strategies to attract patients across borders have been neglected. Bisceglia et al. (2018) study the problem from a regulatory point of view and show that prices should be strictly correlated to efficiency. The strategic game that regions can play using patients mobility has been analysed by Levaggi and Menoncin (2013). The authors suggest that in the Italian context, due to a regulatory failure, there is a strong incentive for efficient and less efficient regions to play strategically. Efficient regions want to control expenditure, but have excess capacity. Less efficient regions strategically reduce quality, induce patients to move to more efficient regions to be treated in exchange for a soft budget[2]. Brekke et al. (2014) show that if regions simply differ in their skills, patients moving across borders may be beneficial for high and low skill regions because it provides a strong incentive to stimulate quality improvements and in the long run cross border mobility should disappear (Brekke et al., 2012). However, when regions differ in income and financing abilities, patients mobility

[2]The introduction of hard budget constraints with the so-called "Piani di rientro" has sensibly reduced this incentive.

may have countervailing effects on welfare (Brekke et al., 2016); a result in line with (Levaggi and Zanola, 2004). From an empirical point of view, several contributions explain patients flow and most focused on patient choices (Balia et al., 2017; Fabbri and Robone, 2010; Brenna and Spandonaro, 2015), though strategic behaviours of hospitals have almost been neglected. For aortic valve replacement (Fattore et al., 2014) show that private hospitals attract more patients than other types of organisations. Since no differences in quality were found between private and public providers, this finding suggests that the presence of strategic incentives from the supply side may influence patient choices (Berta et al., 2016).

2.1 The Italian Health Care System

The World Health Organization rated the Italian Health Care system as one of the best in the world. Italy's life expectancy is the fourth highest among OECD countries with a per capita health care spending well below average (OECD, 2017). Despite this success, there are significant regional differences in the quality of care and health of Italian citizens. The average number of acute hospital beds ranges from 2.6 per 1000 inhabitants in Calabria (South) to 3.8 in Friuli Venezia Giulia (North). A similar pattern is observed for waiting times (Osservasalute, 2016). Waiting times for cardiological visits range from 51 days in the North-East to 68 days in the South of Italy (Cittadinanzattiva, 2017). Per capita health care expenditure is higher in the north compared to southern regions even if the gap decreases once adjusted for patient mobility and age differentials (Francese and Romanelli, 2014)

Lombardy is one of the largest regions both in population (10 millions) and gross domestic product per capita (38200 euro in 2017) (ISTAT, 2018). The region has approximately 150 hospitals which treat about 1.7 million patients per year, and a health expenditure of 18 billion Euro, which amounts to 75% of total regional public spending. Lombardy is a major exporter of health care services to extra-regional patients. In 2016 only, the region attracted 115.000 patients (10.6% of the overall number of extra-regional patients), 6.000 more than the previous years. In 1997 Lombardy has adopted a quasi-market model for hospital care, which is a unique example in the Italian experience: providers compete on quality under a prospective payment system based on Diagnosis Related Groups (DRGs). Although in principle the Lombardy case is a quasi-market model in practice competition between public and private providers is highly regulated (Berta et al., 2016). The Region may supply with ex-post funding only to public hospitals that override their budget; private hospitals face instead a hard budget constraint and must comply with a tariff cap. This system creates distortions in the free competition between providers and produces incentives to extra-regional mobility. Extra-regional patients are paid extra budget (outside the tariff caps) using a national tariff (Fabbri and Robone, 2010) at the end of the year. This financing system provides a strong incentive especially for private providers looking to gain additional source of revenues (Brenna, 2011; Levaggi and Menoncin, 2013; Neri, 2015).

3 The model

In line with the literature, and according to the aims of the paper described above, we study the strategies of hospitals to attract patients using a model of spatial competition where providers with asymmetric objectives compete on two different markets: the internal market for resident patients and the market for extra-regional patients. Potential providers are profit-maximizing hospitals (P) and public providers (A) (Brekke et al., 2011; Levaggi and Levaggi, 2017; Galizzi et al., 2015). Public providers have altruistic preferences and cannot retain any surplus. Although they face a binding budget constraint, the regulator may allow for some slack due to their status (Brekke et al., 2015). Private hospitals are surplus maximisers, have a fixed capacity and face a budget constraint on the number of services they can offer to residents. The latter is assumed to be lower than their capacity, i.e. they have an excess of hospital beds that have to be filled with patients from other regions. They are assumed to compete for patients on two levels: on the market for treating resident patients (D) and on the national market to attract patients from other regions (E). In this respect our model is similar to Bisceglia et al. (2018), but with some interesting differences since we assume asymmetry in the competition setting as in Levaggi and Levaggi (2017). The analytical description of the model and the derivation of the quality levels for both hospitals are presented in Appendix A; in what follows we highlight the essential features of the model and the hypotheses that we test.

Public providers do not discriminate among patients and do not actively try to attract extra-regional output. Their optimal level of quality depends on their level of intrinsic motivation and for them it is optimal to set the same level of quality in both market, i.e.

$$q_D^A = q_E^A = \frac{\phi}{2\theta} \tag{1}$$

In the empirical estimation they will be used as a benchmark on which to evaluate how private hospitals respond to competition.

On the contrary, for private hospitals it would be optimal to supply a different level of quality in the two markets (see Appendix A):

$$\begin{aligned} q_E &= \bar{q_E} + m_E \frac{2(\underline{F} - D) - \sigma}{2\sigma\varphi_E} \\ q_D &= \bar{q_D} + m_D \frac{2D - \delta}{2\delta\varphi_D} \end{aligned} \tag{2}$$

where δ and σ are two parameters that relate to the intensity of competition (locally and externally respectively), φ_D and φ_E to patients evaluation of quality; m_D and m_E are cost parameters related to the distance (physical or in terms of preferences) patients experience in choosing their preferred providers. The quality for extra-regional patients depends on the level of quality in the other region. The second element $2(\underline{F} - D)$ shows a positive correlation between quality and the number of extra-regional cases: the higher the need for the hospital to attract patients, the higher the quality. For resident patients, it is interesting to note that $2D - \delta$ is a measure of matching between the regional budget and local demand and for this reason it may even be negative.

When discrimination is not possible or advisable, the level is set in order to get extra-regional patients , i.e.

$$q_D = q_E = \bar{q_E} + m_E \frac{2(\underline{F} - D) - \sigma}{2\sigma\varphi_E} \tag{3}$$

In other words, quality is driven by the competition in the market for extra-regional patients.

By comparing Eq. 1 with Eq. 3, we can note that private hospitals are making a bigger effort to attract extra-regional patients, which implies that it is more likely that a non-resident is admitted to a private hospital. Since the market for extra-regional patients is more competitive, we should observe a positive relationship between quality and the attraction index of each hospital (see Eq. 3).

4 Empirical strategy

4.1 Data Source

We use longitudinal data on hospital discharges (SDO) over the period 2010-2014 in private (for profit), public and non-profit hospitals in Lombardy (data from 150 hospitals for 5 years). Control variables include patients age and gender, Diagnostic Related Group (DRG) weight, co-existing co-morbidities included in the Elixhauser index (e.g. coagulopathy, obesity, weight loss etc.) (Elixhauser et al., 1998) and the transit in Intensive Care Unit (ICU). Dummy variables are also used to identify the month the patient was hospitalized (to capture seasonal effects), whereas to control for type of admission major disease categories (MDCs) fixed effects are included. Information on ownership status of the hospital (public, private for-profit, private not-for-profit) are linked with patient-level administrative data to control for different behaviour across hospital ownerships.

4.2 Methods

Our analysis starts with the description of the dataset to analyze differences between regional and extraregional patient characteristics. Seasonality in extra regional admission is accounted for using the estimations from a logistic regression model adjusted for patient characteristics, hospital, year and month of admission fixed effects . The dependent variable is a binary indicator whose value is 1 if the patient is extraregional and 0 otherwise.

To test the predictions of the theoretical model (quality indicators may be set according to the region of the residences of patients, see equation 2) we investigate the differences in terms of quality between resident and extra-regional patients through a Coarsened Exact Matching

(CEM) to reduce the selection bias. CEM is a non-parametric method highly effective in removing imbalance between treatment and control groups in non-experimental frameworks. Furthermore, CEM avoids the need to control for observables covariates, and it allows to estimate the effects of interest using a test of the mean differences between the compared groups (Iacus et al., 2011, 2012; Berta et al., 2017). Patients living in Lombardy are exactly matched with patients living in another region which have the same characteristics selected for the comparison. In our approach we use the hospital of admission, the year and month of hospitalization, the MDC code assigned to the discharge, gender, age, DRG weight and co-morbidities and if two patients are admitted for a surgical or medical hospitalization.

As quality measures, we propose to use waiting times (W), patient length of stay (LOS), and reimbursement. Waiting times for elective surgery (measured as the number of days elapsing between the time the patient was added to the waiting list and the day of the hospital admission), are a major political issue in many OECD countries. In the absence of price rationing, waiting times may have a countervailing effect: they may constitute a way of rationing health care services, but they may also increase the supply of care if workers are intrinsically motivated (Riganti et al., 2017). This variable will be considered only for surgical DRG, the target that may inform patients choices. LOS is a typical indicator of efficiency (shorter stays are associated with higher hospital efficiency), but it is also an indicator of the intensity of treatment (Balia et al., 2017). The third outcome measure is reimbursement which allows to identify whether the extra-regional patients are concentrated in DRGs where the reimbursement is higher compared to patients living in Lombardy. In order to identify for possible strategies to attract patients with different motivations to travel to Lombardy, we will split the sample of incoming patients into the subgroups presented in Figure 1.

[Figure 1 about here]

"Border" comprises patients coming from regions sharing a border with Lombardy (top-right map in 1). These patients may move to avoid waiting for treatment because of activity thresholds in their region of residence, in spite of a marginal difference in the quality of care. In general we expect these patients to be healthier than residents. "South" comprises patients coming from the South of Italy (bottom-left map in 1).; these patients are more likely to move to receive a better service than in their resident region, given the north/south divide as concerns quality shown in section 2.1. "Non border non south" is the residual category which comprises a heterogeneous group of regions with different levels of quality (as well as income).

We expect patients coming from a different region to have a longer LOS (to avoid an early discharge) and to wait less (a strategy to attract patients given the difference in the budget cap).

The differences do not imply that resident patients are discriminated. Waiting times depend on the presence of the budget cap for regional patients, while differences in LOS may be determined by travelling distance to the hospital. For this reason, we estimate a set of regression models to study the quality determinants for resident patients using Eq. 4:

$$\begin{aligned} log(y_{iht}) = \quad & \alpha \quad +\lambda Extra_{ht} + \beta Age_{iht} + \gamma Sex_{iht} + \sum_{c=1}^{30} \delta_c Comorb_{ihtc} + \\ + \quad & \sum_{m=1}^{25} \vartheta_m MDC + \sum_{s=1}^{12} \omega_s Month + \sum_{t=1}^{5} \tau_t Year + \boldsymbol{\theta} Own_h \\ + \quad & \boldsymbol{\delta} Extra_{ht} * Own_h + \varepsilon_{iht} \end{aligned} \tag{4}$$

using the subset of Lombardy patients. The dependent variables are waiting times, length of stay, readmission and two additional quality indicators: 30 days-mortality and hospital re-admissions, which are more objective measures of quality and do not depend on external constraints.

The models include an interaction between the percentage of extra-regional patients admitted to hospital h at time t and the hospital ownership (Private for Profit, Private Not-for-Profit and Public hospitals). In addition to the covariates for the hospital ownership and the percentage of extra-regional patients, each model includes patients covariate controlling for age (Age_{iht})and sex (Sex_{iht}). As in Berta et al. (2018), we also include a dummy for each of the 30 co-morbidities ($Comorb_{ihtc}$) in order to adjust for each co-morbidity affecting patients severity. Furthermore, we include several fixed effects (MDC, Year, Month). The marginal effect of interaction between the percentage of extra-regional patients admitted to hospital h at time t and the hospital ownership is of interest and shows the average trend of the dependent variables for increasing values of extra-regional patients by hospital ownership.

5 Results

Descriptive statistics show that, on average, 10% of the patients admitted to Lombardy hospitals come from other regions and is almost equally distributed between "Border" and "South" patients. This proportion changes significantly between private (18% of patients admitted are extra-regional) vs. public hospitals (6% of extra-regional admissions) and non-profit hospitals (6% of extra-regional admissions). Non border non south mobility represents about 1.2% of total admissions and these patients seem to prefer to be admitted to non-profit hospitals. The most important differences between extra-regional and resident patients are presented in Table 1.

[Table 1 about here]

Compared to residents, extra-regional patients are more likely to be younger, with a small gender bias. Patients severity, measured using co-morbidities, is lower for border patients and higher for those coming from the south; per the distribution across hospitals, private providers usually admit less severe patients.

The DRG weight is higher for private hospitals, probably because of the prevalence of surgical admissions; age and gender are not significantly different across hospitals. In general residents wait longer than extra-regional patients with significant difference across hospital ownership; the same pattern exists for mortality and readmission, although the difference is not as wide as for waiting times. Finally the reimbursement is consistently higher for extra-regional patients; this result does not simply depend on the difference in DRG weight[3]. Extra-regional admissions are not constant across months as shown in Figure 2 which analyses hospitals strategies for attracting extra-regional patients with respect to the month of admission.

[Figure 2 about here]

In general, the probability of an extra-regional hospitalization decreases in August and increases in the last months of the year, especially for private and not-for-profit hospital. This result is in line with what expected: due to the cap on their activity level, hospitals are more likely to fill their beds with extra-regional patients towards the end of the year, when they are more likely to be close to their threshold as concerns admission of resident patients.

[3]The reimbursement per unit DRG is higher for patients coming from the south.

CEM method introduced to analyse the differences between patients living in Lombardy and patients living in different regions, provides the results presented in tables 2 − 3 −4.

[Table 2-3-4 about here]

The results consistently suggest that patients from the south wait less compared to regional ones, stay longer in hospital and a higher reimbursement is asked to their region of origin. The first two indicators suggest that hospitals, in their quest to attract patients, try to offer to extra-regional patients a more attractive service. The third result is in line with Fattore et al. (2014) where the authors found that, for aortic valve replacement, extra-regional patients were more likely to be assigned to a DRG with a higher reimbursement. The strategy is quite consistent across hospitals, with private and not for profit hospitals showing a more striking difference in the treatment. This result is in line with Balia et al. (2017). Border patients follow a rather different pattern: they experience the shortest length of stay, wait less, but their reimbursement is also lower than for resident patients. This confirms the hypothesis that these patients, healthier and less complicated than average, travel to be treated more quickly. In line with the predictions of the theoretical model, the difference is significant only for non profit and private hospitals; public hospitals do not appear to treat border patients differently from local residents. This seems to suggest that the first two quality indicators are set according to equation 2.However, as shown above, this does not mean that resident patients are discriminated. To investigate this problem, we estimate equation (4) using waiting times, length of stay, readmission 30 days-mortality and hospital re-admissions as dependent variables. The results are presented in Table 6 in Appendix B. In Figure 3 we present the graphical representation.

[Figure 3 about here]

The difference in mortality rates follows an interesting pattern: it is consistently higher for hospitals admitting mostly residents patients with private hospitals performing slightly better than the public and no profit ones. As the fraction of extra-regional patients increases, mortality for regional patients decreases which is consistent with equation 3. This result is more relevant for public hospitals since there is a significant difference in residents mortality between public hospitals attracting extra-regional patients vs. public hospitals with a low volume of export. As expected, readmissions are consistently lower for private hospitals but, as the number of extra-regional patients increases, readmissions increase for public hospitals and decrease for no profit and private ones. LOS of residents follows a pattern that is similar to mortality as it decreases as the number of extra-regional patients increases.

For low volumes of extra-regional patients, waiting times for resident patients are similar across hospital ownerships. However, they are longer in public hospitals when the volume of extra-regional patients increases while they decrease for private and non profit hospital. For public hospitals the increase in waiting time for resident patients may be directly linked to the improvement in the other quality measures: residents may observe the quality difference and may ask to be admitted in these hospitals; however, due to the budget cap, the increase in demand may increase waiting time. For private hospitals, the same effect is not observed: this may depend on a different management strategy of waiting lists. These results are robust to different specifications of Eq. (4) as shown in Appendix C.1. Overall, Figure 3 suggests that to attract patients from beyond the borders, hospitals have to improve their quality indicators.

6 Conclusions and Policy Implications

The paper explores hospital strategic behaviours in attracting extra-regional patients and its effects on the quality of care provided to resident patients. Given the heterogeneity of health care quality across regions, Italian citizens travel for different reasons: patients from the south seek better care while patients from border regions may simply want to jump the queue in their region of residence. Our model shows that hospital seeking to increase their activity level above their regional budget cap are well aware of this and strategically use waiting time and length of stay to attract extra regional patients. Independently of patient characteristics and hospital ownership, extra-regional patients wait less time, a main pull factor for patients mobility AAVV, 2014. Hospitals are also able to offer different LOS to their patients: a shorter stay for border patients and a longer one for those travelling long distance. However, this fast lane treatment does not come without costs for less efficient/southern regions: compared to regional patients, non border extra-regional ones are assigned to a higher DRG cost.

The analysis of the consequences of hospital choices on the quality of care provided to regional patients shed further interesting results. Consistently with previous findings (Berta et al., 2016), our results suggest that private hospitals admitting a high proportion of extra-regional patients decrease their incentive to opportunistic behaviours towards resident patients that are, all being equal, less costly for the region. Our results show that medical quality measures such as mortality and readmission are comparatively higher for hospitals that admit more extra-regional patients. These two complementary findings provide evidence on an unexplored topic: quality improvements for regional patients are driven by the competition to attract extraregional patients rather than by patients' choice at local level. This result casts some doubts on the effectiveness of patients' choices in a traditional definition of spatial/local competition to improve quality.

From a policy perspective, our results have three implications: the first is that in a context, such as the Italian one, where hospital quality indicators are not available (as in other countries), patients expectations are fulfilled: the most popular destinations among extra-regional patients are the best hospitals in terms of standard quality indices. Secondly, because of financial incentives, hospitals wanting to attract extra-regional patients improve their quality by reducing mortality and readmissions even for regional patients, but regional ones may not be able to fully exploit this improvement due to budget caps that increase waiting time.

Thirdly, the effect of having a higher proportion of extra-regional patients is relevant on the reimbursement outcome. The results of this study suggest that a high proportion of extra-regional patients decrease the reimbursement cost for regional ones for all types of hospitals. This result, when combined with the conclusion that the price for extra-regional patients is higher, conflicts with standard economic theory of price discrimination. Contrary to what is observed in the US where price discrimination allows for a cost-shifting from the poor to the rich (from Medicaid to private insurance) (Clemens and Gottlieb, 2017; Dobson et al., 2006), the financial consequences of the Italian fiscal federalism is the redistribution of costs from richer to poorer regions.

Disclosure of interest

No potential conflict of interest was reported by the authors

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Lombardy resident

	Overall		Not for Profit		Private for Profit		Public	
	mean	sd	mean	sd	mean	sd	mean	sd
Age	60,2092	19,7362	60,9819	18,9067	61,8156	18,0866	59,6344	20,2720
Female	0,5365	0,4987	0,5272	0,4993	0,4963	0,5000	0,5496	0,4975
Sum of Comorbidities	0,6424	0,9400	0,5607	0,8685	0,5759	0,8903	0,6728	0,9615
DRG Weight	1,1826	0,8746	1,1904	0,9025	1,3219	0,9619	1,1407	0,8389
LoS	6,9163	7,9375	5,8150	6,7006	5,2009	6,1552	7,5672	8,4467
Waiting Times	54,5113	74,2517	49,2725	73,5989	46,1399	59,0661	60,6847	81,6095
Reimbursement	3546,5570	3507,9530	3366,9250	3537,3660	3683,4310	3803,0450	3530,4100	3410,9670

Border Patients

	Overall		Not for Profit		Private for Profit		Public	
	mean	sd	mean	sd	mean	sd	mean	sd
Age	55,9097	17,5024	57,6650	16,5439	56,9643	16,4700	54,2343	18,6668
Female	0,5481	0,4977	0,4912	0,4999	0,5552	0,4969	0,5598	0,4964
Sum of Comorbidities	0,5581	0,8430	0,5497	0,7763	0,4882	0,7889	0,6329	0,9096
DRG Weight	1,4000	1,0846	1,4180	1,3226	1,5258	1,0639	1,2644	0,9977
LoS	5,2579	6,4244	5,1755	6,0854	4,0991	4,8234	6,4802	7,6406
Waiting Times	45,9862	64,7407	36,5756	62,7983	43,1540	57,2889	56,7366	77,4626
Reimbursement	4062,9860	4267,7480	3833,9790	4758,9610	4373,8060	4311,1110	3819,3080	4020,9520

No Border No South

	Overall		Not for Profit		Private for Profit		Public	
	mean	sd	mean	sd	mean	sd	mean	sd
Age	54,7096	16,9563	57,7917	15,7236	55,5840	16,2661	52,5306	17,8443
Female	0,5032	0,5000	0,3953	0,4889	0,5424	0,4982	0,5074	0,5000
Sum of Comorbidities	0,6641	0,8310	0,5777	0,6819	0,6855	0,8464	0,6779	0,8680
DRG Weight	1,5046	1,1974	1,6045	1,5968	1,5966	1,1481	1,3683	1,0294
LoS	5,7471	6,8472	6,1166	6,6532	4,4324	5,5020	6,9512	7,8632
Waiting Times	41,5383	67,1589	35,8833	69,4380	35,7381	57,6001	55,9983	79,2358
Reimbursement	4346,1880	4665,9620	4502,8810	5605,3020	4459,6970	4628,5440	4164,1140	4252,0230

South

	Overall		Not for Profit		Private for Profit		Public	
	mean	sd	mean	sd	mean	sd	mean	sd
Age	55,1689	16,9667	57,6926	15,8038	54,9412	16,2714	54,4382	17,9146
Female	0,4925	0,4999	0,3952	0,4889	0,5314	0,4990	0,4923	0,4999
Sum of Comorbidities	0,6742	0,8620	0,6243	0,7311	0,6340	0,8564	0,7307	0,9080
DRG Weight	1,5199	1,2237	1,6712	1,6359	1,6273	1,2264	1,3622	1,0027
LoS	6,4776	7,8849	6,6318	7,2107	4,9979	5,8901	7,8128	9,3807
Waiting Times	44,3010	69,4454	37,1235	73,8957	38,3687	58,2696	58,2358	81,1441
Reimbursement	4683,4730	4821,1730	5163,3940	5882,2470	4921,4040	4710,7620	4279,7990	4436,2170

Table 1: Descriptive statistics

Ownership	Comparison	Estimate	Std.Err	p-value	Signif.
Overall	Extraregion Yes vs No	0.0502	0.0023	0.0000	***
Public	Extraregion Yes vs No	0.0395	0.0032	0.0000	***
Private for Profit	Extraregion Yes vs No	0.0379	0.0035	0.0000	***
Private Not for Profit	Extraregion Yes vs No	0.0986	0.0057	0.0000	***
Overall	Border vs Lombard	-0.0041	0.0030	0.1716	
Public	Border vs Lombard	0.0011	0.0043	0.8054	
Private for Profit	Border vs Lombard	-0.0227	0.0044	0.0000	***
Private Not for Profit	Border vs Lombard	0.0449	0.0083	0.0000	***
Overall	South vs Lombard	0.1132	0.0037	0.0000	***
Public	South vs Lombard	0.0929	0.0052	0.0000	***
Private for Profit	South vs Lombard	0.1111	0.0056	0.0000	***
Private Not for Profit	South vs Lombard	0.1539	0.0085	0.0000	***
Overall	Lombard vs No Border No South	0.0673	0.0058	0.0000	***
Public	Lombard vs No Border No South	0.0266	0.0088	0.0025	***
Private for Profit	Lombard vs No Border No South	0.0770	0.0084	0.0000	***
Private Not for Profit	Lombard vs No Border No South	0.0863	0.0141	0.0000	***

Table 2: Comparison of Lenght of stay across patients and by ownership

Ownership	Comparison	Estimate	Std.Err	p-value	Signif.
Overall	Extraregion Yes vs No	-0.0790	0.0052	0.0000	***
Public	Extraregion Yes vs No	-0.0911	0.0101	0.0000	***
Private for Profit	Extraregion Yes vs No	-0.1130	0.0059	0.0000	***
Private Not for Profit	Extraregion Yes vs No	-0.0114	0.0145	0.4291	
Overall	Border vs Lombard	-0.0643	0.0070	0.0000	***
Public	Border vs Lombard	-0.0487	0.0154	0.0016	***
Private for Profit	Border vs Lombard	-0.0708	0.0073	0.0000	***
Private Not for Profit	Border vs Lombard	-0.1206	0.0204	0.0000	***
Overall	South vs Lombard	-0.0736	0.0082	0.0000	***
Public	South vs Lombard	-0.1175	0.0155	0.0000	***
Private for Profit	South vs Lombard	-0.1311	0.0090	0.0000	***
Private Not for Profit	South vs Lombard	0.1266	0.0217	0.0000	***
Overall	Lombard vs No Border No South	-0.1610	0.0148	0.0000	***
Public	Lombard vs No Border No South	-0.1632	0.0320	0.0000	***
Private for Profit	Lombard vs No Border No South	-0.2058	0.0152	0.0000	***
Private Not for Profit	Lombard vs No Border No South	-0.0874	0.0363	0.0160	**

Table 3: Comparison of waiting time across patients and by ownership

Ownership	Comparison	Estimate	Std.Err	p-value	Signif.
Overall	Extraregion Yes vs No	0.0490	0.0058	0.0000	***
Public	Extraregion Yes vs No	-0.0055	0.0054	0.3082	
Private for Profit	Extraregion Yes vs No	0.1184	0.0099	0.0000	***
Private Not for Profit	Extraregion Yes vs No	0.0228	0.0190	0.2295	
Overall	Border vs Lombard	-0.0589	0.0076	0.0000	***
Public	Border vs Lombard	-0.0494	0.0070	0.0000	***
Private for Profit	Border vs Lombard	-0.0270	0.0123	0.0283	**
Private Not for Profit	Border vs Lombard	-0.2171	0.0279	0.0000	***
Overall	South vs Lombard	0.2582	0.0090	0.0000	***
Public	South vs Lombard	0.0696	0.0087	0.0000	***
Private for Profit	South vs Lombard	0.3833	0.0150	0.0000	***
Private Not for Profit	South vs Lombard	0.3866	0.0270	0.0000	***
Overall	Lombard vs No Border No South	-0.1753	0.0173	0.0000	***
Public	Lombard vs No Border No South	-0.0642	0.0174	0.0002	***
Private for Profit	Lombard vs No Border No South	-0.1882	0.0286	0.0000	***
Private Not for Profit	Lombard vs No Border No South	-0.3804	0.0508	0.0000	***

Table 4: Comparison of reimbursement across patients and by ownership

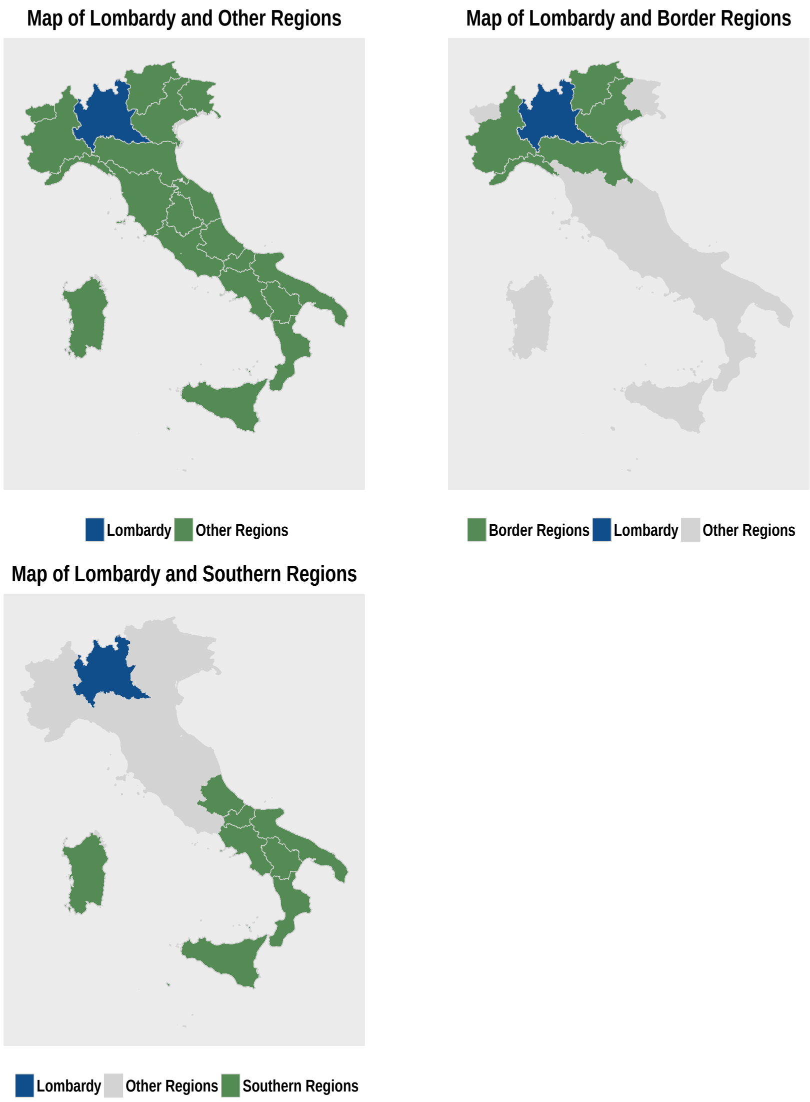

Figure 1: Definition of export areas

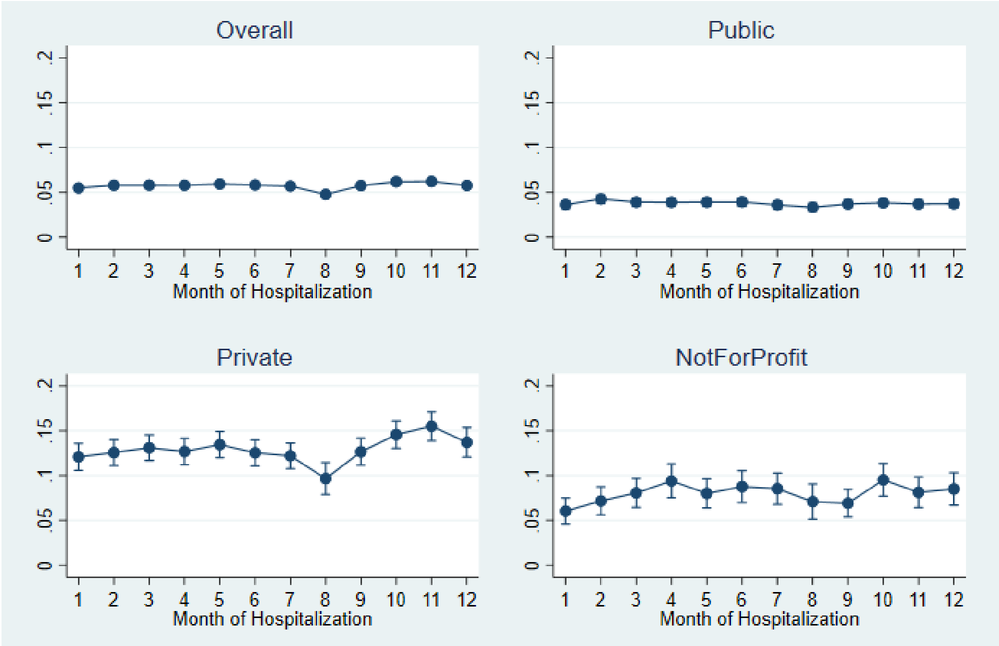

Figure 2: Probability of an extra-regional hospitalization by month of admission

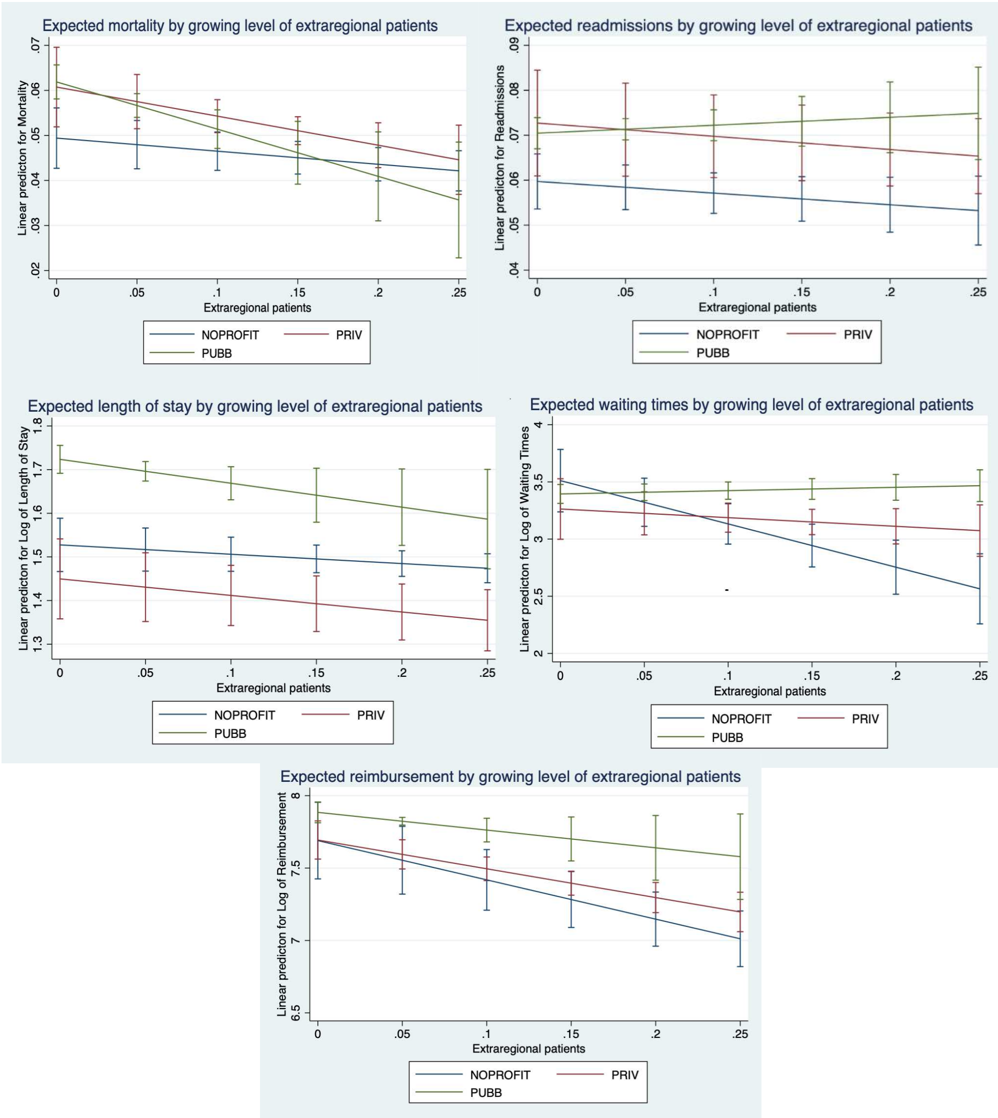

Figure 3: Quality in Lombardy as function of extra-regional patients by hospital ownership

Appendix

A The theoretical model

Let us consider two communities both consisting of a unit mass of patients needing hospital care. Health care is supplied for free, but users incur linear distance costs to acquire it. Individuals are allowed to choose the preferred provider and in doing so they evaluate hospital quality and travel costs. The unit cost to produce care with a minimum verifiable level of quality ($q = 0$) is equal to k. Quality can be enhanced, but its cost is hospital-specific. As in Levaggi and Levaggi (2017) the staff of public hospitals is intrinsically motivated to supply the quality of care because they derive utility from its enhancement. For them, the cost to produce quality is non monetary and simply depends on the difference between the utility derived from quality enhancement and the disutility of such effort. Workers in private hospitals lose their intrinsic motivation and to increase quality the management has to pay higher salaries, which we measure through a linear cost in quality k. We also assume the presence of a fixed cost F which depends on the bed capacity of the hospital itself. With these assumptions, the cost function for a generic hospital can be written as:

$$C = \beta + (1-\rho)kq_,D + \rho\frac{\theta}{2}q^2 + F \tag{5}$$

where D is the hospital demand. For $\rho = 0$ the hospital is a private organisation while $\rho = 1$ represents a public provider.

Private hospitals are surplus maximisers and are entitled to retain the full difference between revenue and costs; public hospitals have a more complex function that depends on their surplus (of which they can retain only a fraction $1-\rho$) and quality. For each patient treated the provider in each Region foresees a reimbursement T_i. Let us define $S_i = T_i - \beta$; the objective function of the providers can be written as:

$$\begin{aligned} V &= (1-\rho)\Pi + \rho q \\ &= (1-\rho)(TD - kqD) + \rho\phi q - \rho\frac{\theta}{2}q^2 - F \end{aligned} \tag{6}$$

where Π is the surplus, and $0 \leq \rho \leq 1$ measure the degree to which the hospital is profit-constrained.

The demand D is derived from the choices of patients that choose the provider that maximise their net utility. In what follows we assume that the demand may derive from two different sources: patients resident in the Region where the hospitals are located, D_D, and patients coming from other Region, D_E. In choosing their quality level, hospital can discriminate over patients according to their geographical location by offering a different level of quality. We denote q_D the quality offered to residents and q_E the level for non resident. The resident demand for each hospital is derived from a spatial model with oligopolistic competition which can be considered a modified (to a line city) version of the oligopolistic model presented in Levaggi and Levaggi (2017) where hospital care is provided by a public hospital at located in 0 and a private hospital located in 1[4]. The location of the indifferent consumer (x_D) determines the demand for each hospital:

$$x_D = \frac{\varphi\left(q_R - \bar{q_R}\right)}{m_D} + \frac{1}{2} \tag{7}$$

where q_D is the quality of the hospital and $\bar{q_D}$ is the quality of the other competitors.

In this setting we can introduce more private hospitals by considering that the demand for private and public hospital is split equally among private hospitals from one side and public providers from the other side, so that the demand can be written as

$$D_D \quad = \quad \delta\left(\frac{1}{2} + \frac{\varphi_D\left(q_D - \bar{q}_D\right)}{m_D}\right)$$

For the external demand demand, we can imagine a similar process, but in this case the hospital located outside the regional boundaries provides a service that corresponds to the quality of the average hospital in the other region, in this case the indifferent consumer is located at

$$x_E = \left(\frac{\varphi\left(q_E - \bar{q_E}\right)}{m_E} + \frac{1}{2}\right) b \tag{8}$$

[4]See also Levaggi and Levaggi (2018)

and the demand for treatment for patients can be written as:

$$D_E \quad = \quad \sigma\left(\frac{1}{2}+\frac{\varphi_E(q_D-\bar{q}_E)}{m_E}\right)$$

where δ are two parameters that relates to the intensity of competition (locally and externally respectively), φ_D and φ_E to patients evaluation of quality; m_D and m_E are cost parameters related to the distance (physical or in terms of preferences) patients experience in choosing either of the types of providers.

A.1 Public hospitals

Public hospitals do not set quality in order to attract patients: in a spatial competition model, quality is in fact used as an instrument to increase surplus. However, the hospital staff is intrinsically motivated because it derives utility from quality enhancement through the parameter ϕ which reflects the altruistic aspect of intrinsic motivation, i.e. the common concern that the staff and patients have for quality. In other words, also public hospital care for quality, but in a different way from private hospitals. Their objective function can be written as:

$$V^A = \phi\left(q_D^A + q_E^A\right) - \frac{\theta}{2}\left(q_D^A + q_E^A\right)^2 - \bar{H}$$

The F.O.C. for the problem can be written as:

$$\frac{\partial V^A}{\partial q_D^A} = \frac{\partial V^A}{\partial q_E^A} = \phi - \theta\left(q_D^A + q_E^A\right)$$

Several solutions are compatible with this condition; the more likely case is that the patients receive the same level of care, i.e. $q_D^A = q_E^A = \frac{\phi}{2\theta}$ which becomes the benchmark for the private hospital, i.e. $q_R^A = \bar{q_D} = \frac{\phi}{2\theta}$.

A.2 Private hospitals

Private hospitals maximise the surplus that they can fully retain. Let us consider the strategy of an hospital that want to maximise its profit by taking into account the demand of resident and non resident patients. They face a fixed cost F and a bed capacity that can be translated into a maximum number $\overline{F}$ of patients that can be admitted. The Regional Health care system set the maximum number of resident patients that the hospital will be reimbursed, D, hence the hospital management also estimates that a minimum number of non-resident patients $\underline{F} - D$ has to be admitted in order to break even.

A.2.1 Quality discrimination is possible

Let us first assume that hospitals can provide a different level of quality to domestic and non domestic patients. The problem they face can be written as:

$$\max_{q_L, q_E} \mathit{\Pi} = (S_D - kq_D)\delta\left(\frac{\varphi_D\,(q_D - \bar{q_D})}{m_D} + \frac{1}{2}\right) + (S_E - kq_E)\sigma\left(\frac{\varphi_E(q_E - \bar{q_E})}{m_E} + \frac{1}{2}\right)$$

$$s.t.$$

$$\delta\left(\frac{\varphi_D\,(q_D - \bar{q_D})}{m_D} + \frac{1}{2}\right) \leq D$$

$$\underline{F} \leq \delta\left(\frac{\varphi_D\,(q_D - \bar{q_D})}{m_D} + \frac{1}{2}\right) + \sigma\left(\frac{\varphi_E(q_E - \bar{q_E})}{m_E} + \frac{1}{2}\right) - H \leq \overline{F}$$

Let us observe the second constraint. The two constraints are clearly antagonist, i.e. if the first is binding the second is non binding and vice versa. We can have three different cases

a) internal solution i.e. both constraints are not binding

b) $D + \delta\left(\frac{\varphi(q_D - \bar{q_D})}{m_D} + \frac{1}{2}\right) \geq \underline{F}$ binding as an equality

c)$D + \delta\left(\frac{\varphi(q_D - \bar{q_D})}{m_D} + \frac{1}{2}\right) \leq \underline{F}$ binding as an equality

From a mathematical point of view, case b) and c) are solved in the same way, the conditions on the parameters determine which conditions is binding. In what follows we will then write the solution for a generic constraint $D + \delta\left(\frac{\varphi(q_D - \bar{q_D})}{m_D} + \frac{1}{2}\right) = F$ The Lagrangian for the problem can be written as:

$$\begin{aligned}\mathcal{L} = \quad & (S_D - kq_D)\delta\left(\tfrac{\varphi_D(q_D - \bar{q_D})}{m_D} + \tfrac{1}{2}\right) + (S_E - kq_E)\sigma\left(\tfrac{\varphi_E(q_E - \bar{q_E})}{m_E} + \tfrac{1}{2}\right) \\ & -\lambda_1\left(\delta\left(\tfrac{\varphi_D(q_D - \bar{q_D})}{m_D} + \tfrac{1}{2}\right) - D\right) - \lambda_2\left(\delta\left(\tfrac{\varphi_D(q_D - \bar{q_D})}{m_D} + \tfrac{1}{2}\right) + \sigma\left(\tfrac{\varphi_E(q_E - \bar{q_E})}{m_E} + \tfrac{1}{2}\right) - F\right)\end{aligned}$$

The F.O.C. can be written as:

$\frac{\partial L}{\partial q_D} : \frac{1}{2}\delta \frac{-4k\varphi_D q_D + 2k\varphi_D a_D - km_D + 2\varphi_D S_D - 2\lambda_1 \varphi_D - 2\lambda_2 \varphi_D}{m_D} = 0$

$\frac{\partial}{\partial q_E} : \frac{1}{2}\sigma \frac{-4k\varphi_E q_E + 2k\varphi_E a_E - km_E + 2\varphi_E S_E - 2\lambda_2 \varphi_E}{m_E} = 0$

$\frac{\partial L}{\partial \lambda_1} : \delta \left(\frac{\varphi_D (q_D - \bar{q_D})}{m_D} + \frac{1}{2} \right) - D = 0$

$\frac{\partial L}{\partial \lambda_2} : \delta \left(\frac{\varphi_D (q_D - \bar{q_D})}{m_D} + \frac{1}{2} \right) + \sigma \left(\frac{\varphi_E (q_E - \bar{q_E})}{m_E} + \frac{1}{2} \right) - F = 0$

and the solution can be written as:

$$q_D = \bar{q_D} + m_D \frac{2D - \delta}{2\delta\varphi_D}$$
$$q_E = a_E + m_E \frac{2(F-D) - \sigma}{2\sigma\varphi_E}$$

If the second constraint is not binding, it is sufficient to solve the problem using the first three FOC's. The optimal quality will be equal to:

$$q_D = a_D + m_D \frac{2D - \delta}{2\delta\varphi}$$
$$q_E = \frac{1}{4} \frac{2k\bar{q_E} - km_E + 2\varphi_E S_E}{k\varphi_E}$$

The problem admits an internal solution if $\underline{F} < D_E < \overline{F}$. Let us then define the demand for the internal solution. The indifferent patient will be located at

$$x_E^* = \left(\frac{\varphi \left(\frac{1}{4} \frac{2k\varphi_E \bar{q_E} - km_E + 2\varphi_E S_E}{k\varphi_E} - \bar{q_E} \right)}{m_E} + \frac{1}{2} \right) \tag{9}$$

Since $D_E = x_E^* \sigma$, the unconstrained demand from non-resident patients is equal to

$$D_E = \sigma \left(\frac{1}{4} + \frac{1}{2} \frac{w (S_E - k\bar{q_E})}{km_E} \right)$$

The solution is compatible with the constraints if $F \leq D_E \leq \overline{F}$ otherwise one of the other two constraints is binding. The complete solution for the problem can be written as:

$$
\begin{array}{lll}
if & \sigma\left(\frac{1}{4}+\frac{1}{2}\frac{\varphi_E(S_E-k\bar{q_E})}{km_E}\right)<\underline{F}-D & q_E=\bar{q_E}+m_E\dfrac{2(\underline{F}-D)-\sigma}{2\sigma\varphi_E} \\
if & \sigma\left(\frac{1}{4}+\frac{1}{2}\frac{\varphi_E(S_E-k\bar{q_E})}{km_E}\right)>\overline{F}-D & q_E=\bar{q_E}+m_E\dfrac{2(\overline{F}-D)-\sigma}{2\sigma\varphi_E} \\
if & \underline{F}-D\leq\sigma\left(\frac{1}{4}+\frac{1}{2}\frac{\varphi_E(S_E-k\bar{q_E})}{km_E}\right)\leq\overline{F}-D & q_E=\dfrac{\bar{q_E}}{2}+\dfrac{S_E}{2k}-\dfrac{m_E}{4\varphi_E} \\
 & & q_D=\bar{q_D}+m_D\dfrac{2D-\delta a}{2\delta\varphi_D}
\end{array}
$$

A.2.2 Quality discrimination is not possible

In this case we assume that the quality of hospital care for domestic patients should be the same from that offered to non resident. The problem can be written as:

$$
\max_{q_D,q,E} \mathit{\Pi}=(S_D-kq_D)\delta\left(\frac{\varphi_D\,(q_D-\bar{q_D})}{m_D}+\frac{1}{2}\right)+(S_E-kq_E)\sigma\left(\frac{\varphi_E(q_E-\bar{q_E})}{m_E}+\frac{1}{2}\right)
$$

$$
s.t.
$$

$$
\delta\left(\frac{\varphi_D\,(q_D-\bar{q_D})}{m_D}+\frac{1}{2}\right)\leq D
$$

$$
q_D=q_E
$$

$$
\underline{F}\leq\delta\left(\frac{\varphi\,(q_D-\bar{q_D})}{m}+\frac{1}{2}\right)+\sigma\left(\frac{\varphi(q_E-\bar{q_D})}{t}+\frac{1}{2}\right)-H\leq\overline{F}
$$

As before all these constraints cannot be binding. In our model, given the nature of the constraint on the internal demand, we assume that the competitive market on which the demand is set is the non domestic one, i.e. we assume that the quality is set on the market for non resident. We also assume that since quality is higher than what would allow to get D patients, the hospital always If this is the case, the first constraint is not binding in quality setting while the second one can be substituted back into the objective function. The problem can be written as:

$$\max_{q_E} \Pi = (S_D - kq_E)\delta \left(\frac{\varphi_D \left(q_E - \bar{q_D}\right)}{m_D} + \frac{1}{2} \right) + (S_E - kq_E)\sigma \left(\frac{\varphi_E (q_E - \bar{q_E})}{m_E} + \frac{1}{2} \right)$$

$$s.t.$$

$$\underline{F} \leq D + \sigma \left(\frac{\varphi (q_E - \bar{q_D})}{m_E} + \frac{1}{2} \right) - H \leq \overline{F}$$

Let us observe the constraint. The two constraints are clearly antagonist, i.e. if the first is binding the second is non binding and vice versa, we have three different cases

a) internal solution i.e. both constraints are not binding

b) $D + \sigma \left(\frac{\varphi_E (q_E - \bar{q_E})}{m_E} + \frac{1}{2} \right) \geq \underline{F}$ binding as an equality

c)$D + \sigma \left(\frac{\varphi_E (q_E - \bar{q_E})}{m_E} + \frac{1}{2} \right) \leq \underline{F}$ binding as an equality

From a mathematical point of view, case b) and c) are solved in the same way, and the conditions on the parameters determine which conditions is binding. In what follows we will write the solution for a generic constraint $D + \delta \left(\frac{\varphi_E (q_E - \bar{q_E})}{m_E} + \frac{1}{2} \right) = F$. The Lagrangian for the problem can be written as:

$$\begin{aligned} \mathcal{L} =& (S_D - kq_E)\delta \left(\frac{\varphi_D (q_E - \bar{q}_D)}{m_D} + \frac{1}{2} \right) + (S_E - kq_E)\sigma \left(\frac{\varphi_E (q_E - \bar{q_E})}{m_E} + \frac{1}{2} \right) \\ & - \lambda \left(D + \sigma \left(\frac{\varphi_D (q_E - \bar{q_E})}{m_E} + \frac{1}{2} \right) - F \right) \end{aligned}$$

The F.O.C. can be written as:

$\frac{\partial}{\partial q_E} : -\frac{1}{2} \frac{4k\delta\varphi_D q_E - 2k\varphi_D \bar{q_D}\delta + km_D\delta - 2\varphi S_D\delta + k\sigma m_D}{m_D} - \sigma w \frac{2kq_E - k\bar{q_E} - S_E + \lambda}{m_E} = 0$

$\frac{\partial L}{\partial \lambda} : D + \sigma \left(\frac{\varphi_D (q_E - \bar{q_E})}{m_E} + \frac{1}{2} \right) - F = 0$

and the solution can be written as:

$$q_D = \bar{q}_E + m_E \frac{2(F-D)-\sigma}{2\sigma\varphi_E}$$

$$q_E = \bar{q}_E + m_E \frac{2(F-D)-\sigma}{2\sigma\varphi_E}$$

If the constraint is not binding, it is sufficient to solve the problem using the first FOC's. The optimal quality will be equal to:

$$
\begin{aligned}
q_E &= \frac{\bar{q}_E}{2}\frac{\sigma m_D \varphi_E}{\delta m_E \varphi_D + \sigma m_D \varphi_E} + \frac{\bar{q}_D}{2}\frac{\delta m_E \varphi_D}{\delta m_E \varphi_D + \sigma m_D \varphi_E} \\
&+ +\frac{1}{4}\frac{2\left(\sigma m_D w S_E + \delta m_E \varphi_D S_D\right) - k m_D m_E \left(\sigma + \delta\right)}{k\left(\delta m_E \varphi_D + \sigma m_D \varphi_E\right)}
\end{aligned}
$$

B Tables for additional results

	Lenght of Stay				Waiting Times				Reimbursement			
VARIABLES	Overall	No Profit	Profit	Public	Overall	No Profit	Profit	Public	Overall	No Profit	Profit	Public
Gender F=1	0.061***	0.069***	0.050***	0.062***	0.044***	0.054***	0.060***	0.027***	0.076***	0.135***	0.106***	0.056***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.007)	(0.003)	(0.003)	(0.001)	(0.006)	(0.004)	(0.001)
Age	0.008***	0.007***	0.010***	0.008***	0.001***	0.002***	0.001***	0.001***	0.005***	0.001***	0.008***	0.005***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Border	-0.049***	-0.008*	-0.054***	-0.022***	-0.080***	-0.056***	-0.115***	-0.023***	-0.058***	-0.263***	-0.032***	-0.011***
	(0.002)	(0.004)	(0.002)	(0.003)	(0.004)	(0.011)	(0.005)	(0.007)	(0.003)	(0.012)	(0.007)	(0.003)
No Border No South	0.028***	0.093***	0.043***	0.016***	-0.117***	-0.040**	-0.157***	-0.101***	-0.137***	-0.270***	-0.175***	-0.022***
	(0.003)	(0.007)	(0.004)	(0.005)	(0.007)	(0.018)	(0.008)	(0.012)	(0.005)	(0.020)	(0.012)	(0.005)
South	0.090***	0.151***	0.089***	0.099***	-0.077***	0.133***	-0.124***	-0.095***	0.266***	0.405***	0.355***	0.128***
	(0.002)	(0.004)	(0.003)	(0.003)	(0.004)	(0.011)	(0.005)	(0.007)	(0.003)	(0.012)	(0.007)	(0.003)
Febr vs. Jan	-0.009***	-0.014***	-0.004	-0.009***	-0.087***	-0.058***	-0.122***	-0.066***	-0.004	-0.026*	-0.007	0.000
	(0.002)	(0.005)	(0.003)	(0.002)	(0.004)	(0.014)	(0.007)	(0.006)	(0.003)	(0.014)	(0.009)	(0.002)
March vs. Jan	-0.007***	-0.012**	-0.002	-0.007***	-0.112***	-0.064***	-0.172***	-0.079***	-0.008***	-0.047***	-0.017**	0.001
	(0.002)	(0.005)	(0.003)	(0.002)	(0.004)	(0.014)	(0.007)	(0.006)	(0.003)	(0.014)	(0.009)	(0.002)
April vs. Jan	-0.007***	-0.008*	-0.003	-0.008***	-0.105***	-0.056***	-0.148***	-0.085***	-0.005	-0.032**	-0.008	-0.001
	(0.002)	(0.005)	(0.003)	(0.002)	(0.005)	(0.014)	(0.007)	(0.006)	(0.003)	(0.014)	(0.009)	(0.002)
May vs. Jan	-0.008***	-0.015***	-0.009***	-0.006***	-0.101***	-0.054***	-0.156***	-0.071***	0.001	-0.035**	0.008	0.003
	(0.002)	(0.005)	(0.003)	(0.002)	(0.004)	(0.014)	(0.007)	(0.006)	(0.003)	(0.014)	(0.009)	(0.002)
June vs. Jan	-0.008***	-0.011**	-0.011***	-0.006***	-0.150***	-0.097***	-0.210***	-0.118***	0.010***	-0.001	0.029***	0.004
	(0.002)	(0.005)	(0.003)	(0.002)	(0.004)	(0.014)	(0.007)	(0.006)	(0.003)	(0.014)	(0.009)	(0.002)
July vs. Jan	-0.005***	-0.000	0.005	-0.009***	-0.222***	-0.159***	-0.291***	-0.185***	0.026***	0.033**	0.069***	0.010***
	(0.002)	(0.005)	(0.003)	(0.002)	(0.005)	(0.014)	(0.007)	(0.006)	(0.003)	(0.014)	(0.009)	(0.002)
Agust vs. Jan	0.027***	0.045***	0.066***	0.012***	-0.214***	-0.090***	-0.274***	-0.202***	0.060***	0.121***	0.168***	0.026***
	(0.002)	(0.006)	(0.004)	(0.002)	(0.006)	(0.018)	(0.009)	(0.007)	(0.003)	(0.016)	(0.010)	(0.002)
Sept. vs. Jan	-0.016***	-0.015***	-0.007**	-0.018***	0.044***	0.088***	0.050***	0.025***	0.021***	0.012	0.060***	0.008***
	(0.002)	(0.005)	(0.003)	(0.002)	(0.005)	(0.014)	(0.007)	(0.007)	(0.003)	(0.014)	(0.009)	(0.002)
Oct. vs. Jan	-0.009***	-0.023***	0.008**	-0.014***	-0.065***	-0.047***	-0.124***	-0.026***	0.004	-0.037***	0.020**	0.003
	(0.002)	(0.005	(0.003)	(0.002)	(0.004)	(0.014)	(0.007)	(0.006)	(0.003)	(0.014)	(0.009)	(0.002)
Nov. vs. Jan	-0.000	-0.016***	0.006*	-0.000	-0.085***	-0.052***	-0.132***	-0.059***	0.006**	-0.036***	0.017*	0.007***
	(0.002)	(0.005)	(0.003)	(0.002)	(0.004)	(0.014)	(0.007)	(0.006)	(0.003)	(0.014)	(0.009)	(0.002)
Dic. Vs. Jan	0.012***	0.001	0.032***	0.006***	-0.158***	-0.119***	-0.211***	-0.131***	0.009***	0.007	0.009	0.008***
	(0.002)	(0.005)	(0.003)	(0.002)	(0.005)	(0.015)	(0.007)	(0.007)	(0.003)	(0.014)	(0.009)	(0.002)
TIPCM = 2, M	0.281***	0.221***	0.347***	0.270***					-0.516***	-0.655***	-0.698***	-0.448***
	(0.001)	(0.003)	(0.002)	(0.001)					(0.002)	(0.008)	(0.005)	(0.001)
DRG Weight	0.312***	0.289***	0.327***	0.311***	-0.020***	0.023***	-0.028***	-0.019***	0.540***	0.537***	0.541***	0.531***
	(0.000)	(0.001)	(0.001)	(0.001)	(0.001)	(0.004)	(0.002)	(0.002)	(0.001)	(0.004)	(0.002)	(0.001)
Constant	0.358***	0.512***	-0.562***	0.484***	3.171***	2.468***	3.467***	3.153***	6.000***	5.738***	5.487***	6.229***
	(0.024)	(0.051)	(0.052)	(0.032)	(0.057)	(0.115)	(0.099)	(0.083)	(0.043)	(0.140)	(0.139)	(0.036)
MDC FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
30 Comorbidity FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Hosp. FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Observations	4,902,225	487,898	1,111,198	3,303,129	1,750,920	224,186	634,607	892,127	4,902,225	487,898	1,111,198	3,303,129
R^2	0.329	0.338	0.398	0.280	0.209	0.259	0.229	0.186	0.267	0.225	0.211	0.370
Adjusted R^2	0.329	0.338	0.398	0.280	0.208	0.258	0.229	0.186	0.267	0.225	0.211	0.370

Notes: The coefficients and standard errors (in brackets) are reported.
*** represents significance at the 1% level, ** represents significance at the 5% level and *represents significance at the 10% level.

Table 5: Quality measures for hospital care: Lombardy residents vs other Regions

VARIABLES	(1) LOS	(2) WT	(3) Reimb	(4) Mortality2	(5) Readmission2
Constant	0.300***	3.198***	5.983***	-0.095***	0.014**
	(0.075)	(0.186)	(0.186)	(0.013)	(0.007)
Gender F=1	0.059***	0.034***	0.067***	-0.003***	-0.010***
	(0.004)	(0.009)	(0.008)	(0.000)	(0.001)
Age	0.009***	0.001***	0.006***	0.002***	-0.000***
	(0.000)	(0.001)	(0.000)	(0.000)	(0.000)
DRG_weight	0.325***	-0.019	0.555***	0.020***	0.005***
	(0.008)	(0.023)	(0.015)	(0.001)	(0.001)
Febr vs. Jan	-0.012***	-0.086***	-0.009*	-0.004***	-0.001
	(0.002)	(0.011)	(0.004)	(0.000)	(0.001)
March vs. Jan	-0.010***	-0.110***	-0.009*	-0.007***	-0.001*
	(0.003)	(0.011)	(0.006)	(0.001)	(0.001)
April vs. Jan	-0.009***	-0.111***	-0.004	-0.008***	-0.000
	(0.003)	(0.014)	(0.005)	(0.001)	(0.000)
May vs. Jan	-0.009***	-0.098***	-0.001	-0.009***	-0.001
	(0.003)	(0.012)	(0.005)	(0.001)	(0.001)
June vs. Jan	-0.008***	-0.153***	0.006	-0.010***	-0.001
	(0.003)	(0.015)	(0.005)	(0.001)	(0.001)
July vs. Jan	-0.008**	-0.227***	0.022***	-0.010***	-0.005***
	(0.003)	(0.018)	(0.006)	(0.001)	(0.001)
Agust vs. Jan	0.029***	-0.233***	0.055***	-0.005***	0.001
	(0.007)	(0.029)	(0.010)	(0.001)	(0.001)
Sept. vs. Jan	-0.015***	0.036***	0.017***	-0.007***	-0.003***
	(0.003)	(0.013)	(0.005)	(0.001)	(0.001)
Oct. vs. Jan	-0.012***	-0.066***	-0.000	-0.008***	-0.003***
	(0.003)	(0.011)	(0.006)	(0.001)	(0.001)
Nov. vs. Jan	-0.001	-0.086***	0.005	-0.008***	-0.012***
	(0.003)	(0.010)	(0.005)	(0.001)	(0.001)
Dic. Vs. Jan	0.013***	-0.163***	0.006	-0.004***	-0.054***
	(0.004)	(0.013)	(0.005)	(0.001)	(0.002)
(mean) extrareg	-0.214	-3.785***	-2.713***	-0.029*	-0.026
	(0.140)	(0.933)	(0.468)	(0.017)	(0.021)
OWN = 2, PRIV	-0.078	-0.248	0.004	0.011**	0.013*
	(0.055)	(0.192)	(0.149)	(0.006)	(0.007)
OWN = 3, PUBB	0.196***	-0.116	0.195	0.012***	0.011***
	(0.035)	(0.146)	(0.139)	(0.004)	(0.003)
1b.own1#co.extra	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2.own1#c.extra	-0.165	3.029**	0.725	-0.036	-0.003
	(0.236)	(1.297)	(0.644)	(0.036)	(0.030)
3.own1#c.extra	-0.334	4.073***	1.488*	-0.076**	0.044
	(0.301)	(1.026)	(0.875)	(0.035)	(0.033)
MDC FE	✓	✓	✓	✓	✓
30 Comorbidity based on Elixhauser	✓	✓	✓	✓	✓
Hosp. FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Observations	4,425,803	1,479,955	4,425,803	4,425,803	4,425,803
Adjusted R-squared	0.311	0.155	0.256	0.160	0.0574

Notes: The coefficients and standard errors (in brackets) are reported.
***: significance at the 1% level, **:significance at the 5% level;* significance at the 10% level.

Table 6: Change in quality due to extra-regional patients by ownership

C Robustness checks

C.1 Change in quality for residents with DRG mix as control variable

In order to check that the results in Figure 3 do not depend on a change in the DRG mix, we have re-run Eq. 4 using DRG instead of MDC as a control variable as shown in the following equation:

$$\begin{aligned} log(y_{iht}) = \quad & \alpha \quad + \lambda Extra_{ht} + \boldsymbol{X}_{iht} + \sum_{d=1}^{D} \gamma_m DRG + \sum_{c=1}^{30} \delta_c Comorb. \\ + \quad & \sum_{s=1}^{12} \omega_s Month + \sum_{t=1}^{T} \tau_t Year + + \boldsymbol{\theta} Own_h + \boldsymbol{\delta} Extra_{iht} * Own_h + \varepsilon_{iht} \end{aligned}$$

The results are presented in Table 7 and the marginal effects in Figure 4

VARIABLES	(1) LOS	(2) WT	(3) Reimb	(4) Mortality	(5) Readmission
Constant	2.203***	2.998***	9.343***	0.083***	0.118***
	(0.069)	(0.169)	(0.121)	(0.019)	(0.009)
Gender F=1	0.022***	0.005	0.031***	-0.003***	-0.010***
	(0.003)	(0.006)	(0.007)	(0.000)	(0.001)
Age	0.005***	-0.000	0.001***	0.002***	-0.000***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Febr vs. Jan	-0.009***	-0.089***	-0.009**	-0.003***	-0.001
	(0.002)	(0.010)	(0.004)	(0.000)	(0.001)
March vs. Jan	-0.005**	-0.115***	-0.009*	-0.006***	-0.001**
	(0.003)	(0.011)	(0.005)	(0.001)	(0.001)
April vs. Jan	-0.009***	-0.109***	-0.006	-0.007***	-0.001
	(0.002)	(0.013)	(0.004)	(0.001)	(0.000)
May vs. Jan	-0.006**	-0.098***	-0.004	-0.008***	-0.000
	(0.003)	(0.012)	(0.004)	(0.001)	(0.001)
June vs. Jan	-0.008***	-0.148***	0.001	-0.008***	-0.001*
	(0.003)	(0.014)	(0.005)	(0.001)	(0.001)
July vs. Jan	-0.013***	-0.212***	0.010**	-0.008***	-0.004***
	(0.003)	(0.017)	(0.005)	(0.001)	(0.001)
Agust vs. Jan	0.008	-0.192***	0.036***	-0.004***	0.001
	(0.005)	(0.027)	(0.008)	(0.001)	(0.001)
Sept. vs. Jan	-0.016***	0.031**	0.011***	-0.006***	-0.002***
	(0.003)	(0.012)	(0.004)	(0.001)	(0.001)
Oct. vs. Jan	-0.013***	-0.076***	-0.007	-0.007***	-0.002***
	(0.003)	(0.011)	(0.005)	(0.000)	(0.001)
Nov. vs. Jan	-0.003	-0.092***	-0.002	-0.006***	-0.012***
	(0.002)	(0.010)	(0.005)	(0.001)	(0.001)
Dic. Vs. Jan	-0.000	-0.157***	-0.006	-0.003***	-0.054***
	(0.003)	(0.012)	(0.004)	(0.001)	(0.002)
(mean) extrare	-0.134	-3.662***	-2.549***	-0.011	-0.043***
	(0.136)	(0.884)	(0.412)	(0.015)	(0.015)
OWN = 2, PRIV	-0.019	-0.220	0.077	0.009**	0.012**
	(0.047)	(0.188)	(0.132)	(0.004)	(0.006)
OWN = 3, PUBB	0.172***	-0.076	0.191	0.010***	0.008***
	(0.035)	(0.146)	(0.122)	(0.003)	(0.002)
1b.own1#co.extra	0.000	0.000	0.000	0.000	0.000
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
2.own1#c.extra	-0.370*	2.928**	0.429	-0.014	0.000
	(0.200)	(1.239)	(0.616)	(0.024)	(0.020)
3.own1#c.extra	-0.456	4.200***	1.243	-0.056**	0.029
	(0.277)	(0.964)	(0.853)	(0.027)	(0.023)
DRG FE	✓	✓	✓	✓	✓
30 Comorbidity based on Elixhauser	✓	✓	✓	✓	✓
Hosp. FE	✓	✓	✓	✓	✓
Year FE	✓	✓	✓	✓	✓
Observations	4,425,803	1,479,955	4,425,803	4,425,803	4,425,803
Adjusted R^2	0.454	0.229	0.387	0.223	0.130

Notes: The coefficients and standard errors (in brackets) are reported.
***: significance at the 1% level, **:significance at the 5% level;* significance at the 10% level.

Table 7: Quality measures for residents. Adjusted by DRG

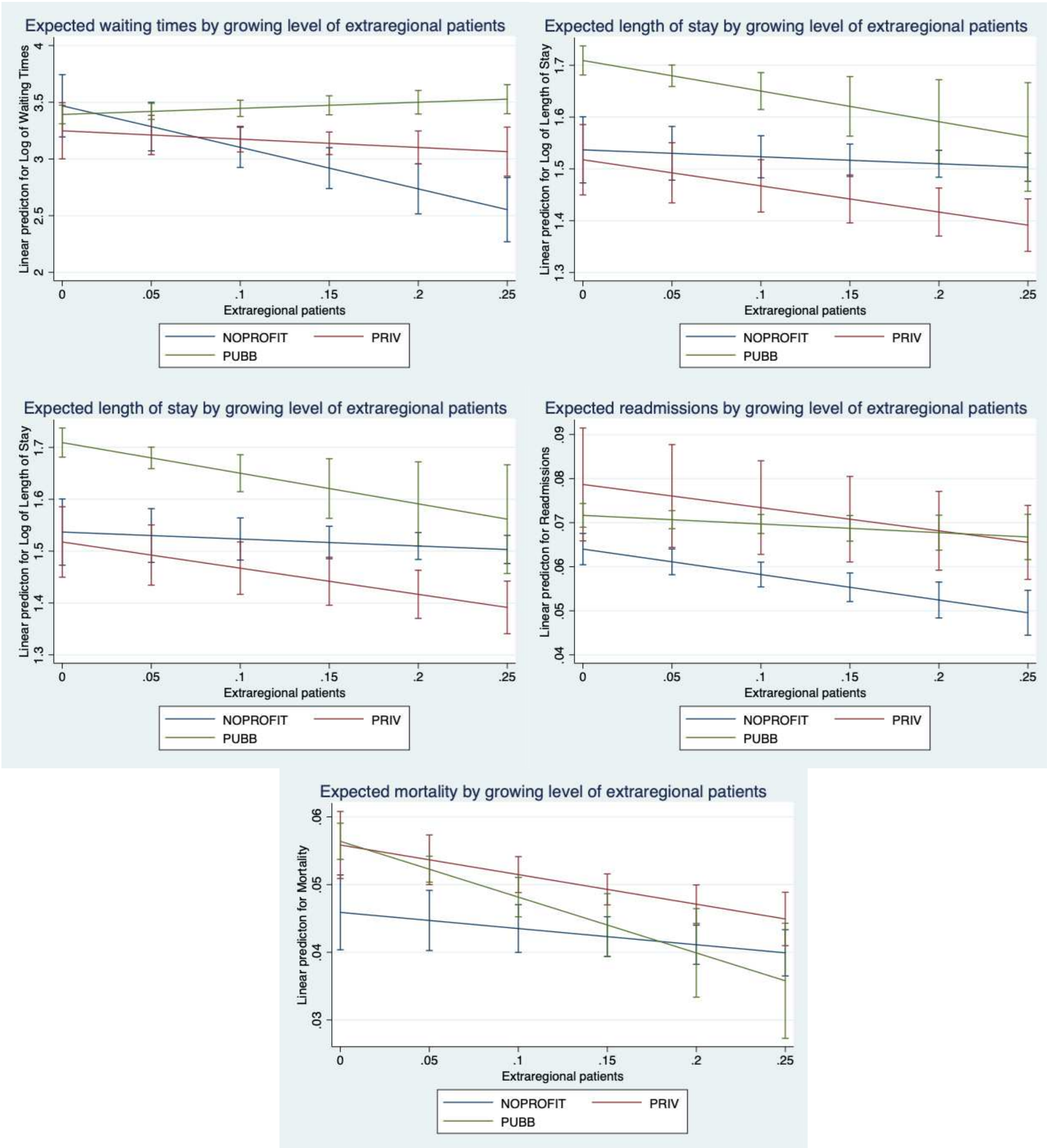

Figure 4: Marginal effects on quality indicators. Adjusted for DRG