Hospital mergers:
just what the doctor ordered?

An analysis of hospital mergers in Portugal

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I dedicate this work to my wonderful grandma Manuela, who raised me with all the love in the world, and to my beautiful nephew, Salvador, may you grow up to be as happy and strong as I dream you will.

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Abstract

Facing a fragile financial situation, the Portuguese governments have been implementing reforms to offset the increasing healthcare costs. Attempting to cut expenses, a number of mergers between public hospitals were employed.

Using a fixed effects model and a differences-in-differences estimator, this thesis analyses the effects of twelve mergers on the hospitals' financial performance and efficiency. The data set includes the years between 2004 and 2011.

The results suggest that, while these mergers caused the efficiency of the hospitals to decrease, they are yet to produce effects on the institutions' financial performance.

JEL classification: I11, I18, L32.

Keywords: Portuguese hospitals, hospital mergers, health, expenditure, efficiency.

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Nomenclature

ALOS	Average Length Of Stay
DiD	Difference-in-Differences
DS	Day Surgeries
EM	Emergencies
IE	Inpatient Episodes
LTC	Log of Total Costs
OS	Outpatient services
OV	Outpatient visits

Description of the variables

Total cost — TC: Total expenditure of a hospital institution, as declared in the respective financial report.

Average length of stay — ALOS: Total days of hospital stay divided by the number of inpatient episodes.

Case-mix index — CMI: Value that indicates the complexity of the hospital's inpatient episodes. The higher the index, the greater the complexity.

Day surgeries — DS: Surgical episodes with hospitalization inferior to 24 hours.

Emergencies — EM: Acute health problems that require immediate medical attention.

Inpatient episodes — IE: A patient stay in a hospital superior to 24 hours.

Outpatient services — OS: Medical procedures or tests, with an hospital stay under 24 hours.

Outpatient visits — OV: Patient visits to a hospital for treatment or diagnosis, with a stay inferior to 24 hours.

Treat — Variable considering the hospitals that merge.

After — Variable that represents the years after the merger.

Aftertreat — Variable corresponding to the merged hospitals, in the years after the merger .

EPE — Variable that controls for the implementation of the enterprise management model in hospitals.

Variables used in the statistical analysis

after	Variable *after*
aftertreat	Variable *aftertreat*
epe	Variable *epe*
cmi	Case-mix index
cmi2	Squared case-mix index
lds	Log of day surgeries
lds2	Squared log of day surgeries
lem	Log of emergencies
lem_os	Product of log of emergencies and log of outpatient services
lem2	Squared log of emergencies
lie	Log of inpatient episodes
lie_cmi	Product of log of inpatient episodes and case-mix index
lie_em	Product of log of inpatient episodes and log of emergencies
lie_ov	Product of log of inpatient episodes and log of outpatient visits
lie_os	Product of log of inpatient episodes and log of outpatient services
lie2	Squared log of inpatient episodes
lov	Log of outpatient visits
lov_ds	Product of log of outpatient visits and log of day surgeries
lov_os	Product of log of outpatient visits and log of outpatient services
lov2	Squared log of outpatient visits
los	Log of outpatient services
los2	Squared log of outpatient services
treat	Variable *treat*

1. Introduction

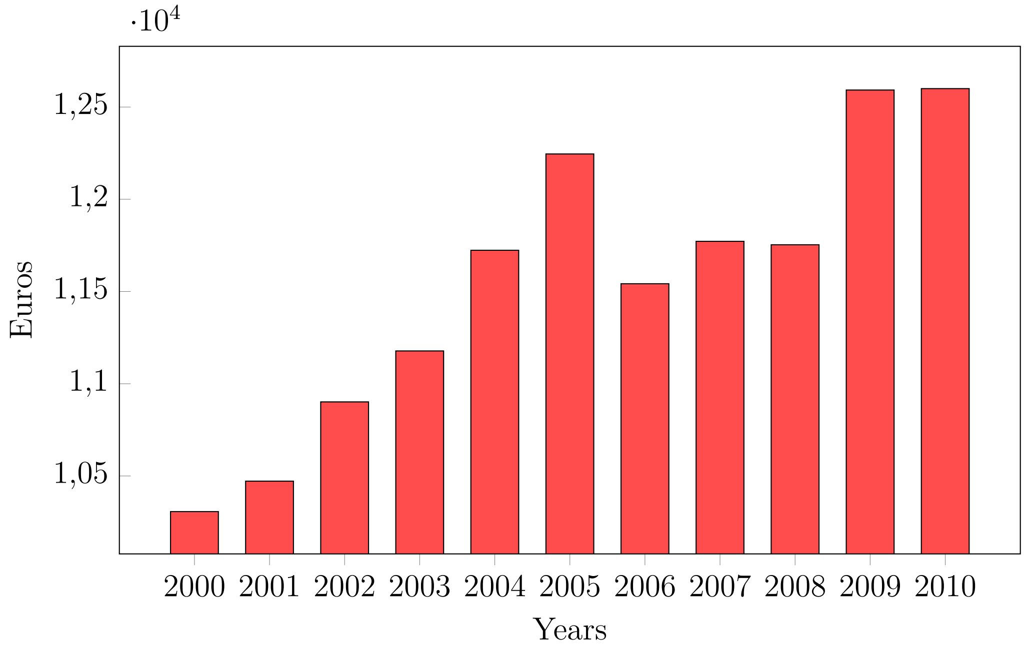
1.1. Motivation

The XXI century brought several challenges to the Portuguese economy. In the last decade, the government budget deficit beat its records in 2005 and 2009, hitting 6,5% and 10,2% of GDP, respectively. Consequently, the state's debt stock, which entered the year 2000 at 53% of GDP, reached a peak of 88% by the end of the decade, and another one by middle 2013, of nearly 127% of GDP. Unemployment, one of the most affected macroeconomic aggregates, which started the decade at 4,2%, had more than doubled by the end 2010, to an almost 11% mark, reaching 16,4% in January 2013[1].

The graphs that follow show the evolution of the government's health final consumption expenditure, respectively, per capita and in percentage of GDP. There is a consistent cost growth tendency during the first decade of the XXI century, expressing the increase of the state's health burden, as figure 1.1 shows. Since 2000, the state's per capita health expenses, without considering investment, have increased in about 22%. Figure 1.2 draws an equally troubling picture, with health costs in relation to GDP increasing by fairly 15% during the decade. The growth in health costs was not followed by significant changes in the performance of the Portuguese economy, creating a critical situation for the state's finances. Accordingly, merging public hospitals was chosen as a way to reform the health sector.

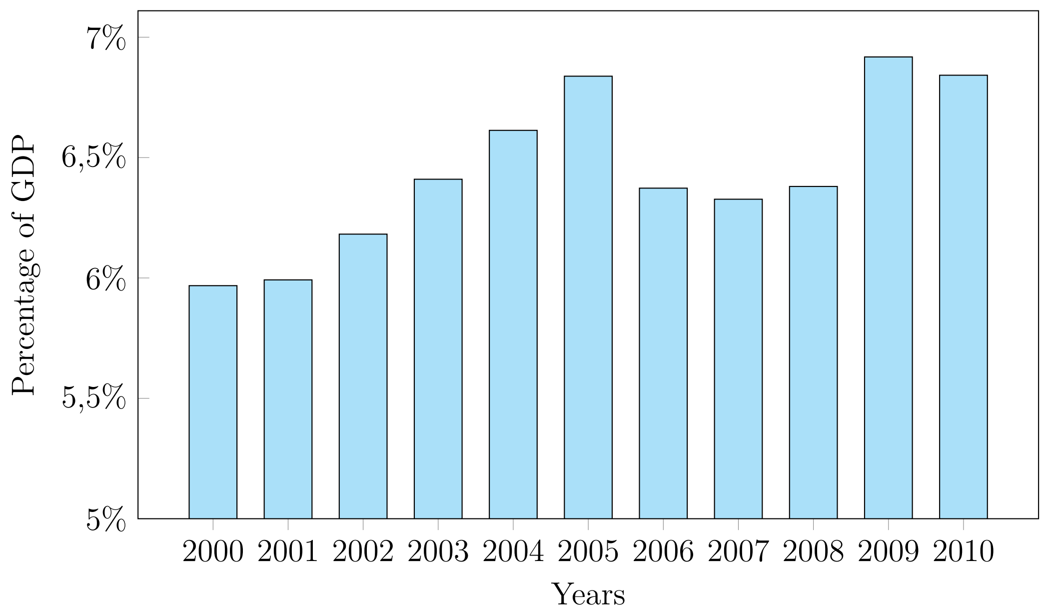
[1] Sources: Banco de Portugal: dívida directa do estado em percentagem do PIB; Banco de Portugal: taxa de desemprego em Portugal; Pordata: administrações públicas, défice público em percentagem do PIB.

Figure 1.1.: Government health final consumption expenditure, per capita, in euros



Notes: Constant Prices, base year 2012.
Sources: INE (2014) (Variable: *Despesa corrente pública em saúde*). INE, Consumer Price Index (*Índice de Preços no consumidor, base 2012.*

Figure 1.2.: Government health final consumption expenditure, as percentage of GDP



Source: INE (2014) (Variable: *Despesa corrente pública em saúde*)

The first hospital merger laws appeared in Portugal in 1946 (Diário do Governo, 1968), with a small number of mergers happening until the end of the 90s. The new century brought new economic challenges and with it, the changes in NHS' organization, including a merger wave in the hospital sector. According to the legislation, the objective of the mergers is, through the common management, to share resources in a way that answers to the existing lacks of means, and to cut costs. The common administration is also expected to create savings and economies of scale, to bring a better and more homogeneous decision-making process and to allow for better management of human resources . (Diário da República, 2004)

1.2. Context and structure of the work

In the framework of the Portuguese National Health Service, this thesis uses a sample containing data from thirty hospitals, for the eight years between 2004 and 2011. While the data set includes observational data, the conditions of a natural experiment can be replicated, as two groups of hospitals can be identified and compared, a treatment group—twelve hospitals that merged during the eight years observed in the data set—and a control group—composed of eighteen hospitals that did not merge during the considered timeline. The treatment group registers the changes the mergers caused in the hospitals. Still, this does not reveal what would have happened if the mergers had not taken place. That is the role of the control group, to simulate what would have happened in the absence of the mergers. In other words, comparing both groups it is possible to simulate an experiment where can be observed what happened due to the mergers, which would not have happened otherwise.

It would be ideal to study a random sample of hospitals. It is here assumed that the choice of the treated hospitals was random, as the government chose the hospitals that would merge. Nonetheless, we know this was not so, as the dimension, location, among other features influenced the choice of the hospitals that merged, representing a handicap of this study.

Improving the hospitals' financial performance was a central objective of these mergers. The expectation, thus, is that the mergers bring down the expenditure of the institutions. Still, joining separately managed hospitals into a single management may still cause the opposite effect as, for instance, increasing the institutions' size may diminish the financial control. It is also possible that the mergers have no influence on the financial performance of the involved hospitals. Therefore, the first objective of this thesis is to find what happened to the hospital's financial performance, measured by the hospitals' total costs.

Additional, it makes sense to analyse if the efficiency of the hospitals changed, as a result from the mergers. Did the common management brought efficiency gains? Or, on the other hand, the bigger scale caused an efficiency decrease, or even no effect at all? In accordance, the second objective of this research is to identify whether the mergers caused any changes to the hospitals' efficiency, measured by the average length of stay, a classic physical efficiency measure. To sum up, this study's research question is: "Did the merged hospitals observe changes in the financial performance or efficiency?".

This research contributes to the current literature in several ways. Firstly, it provides a different geographic standpoint, given that the majority of the research on hospital mergers reflects the United States' case, which is usually focused on prices—as American hospitals are mostly supported by private health insurances. The present analysis explores the Portuguese case, where, unlike the Unites States, there is a greater prevalence of public hospitals and public health insurance (see section 1.3.2). Secondly, it attempts to provide some evidence on the effects of the Portuguese public hospital merger policy, and get answers as to if this strategy is returning the expected results.

The study is organized in seven chapters. The second chapter defines the experiment, followed by third chapter, which describes the construction of the sample and shows descriptive statistics. The fourth chapter describes the methodology used in the analysis of the data, while the results are presented in the fifth chapter. Chapter six develops a robustness analysis of the results and chapter seven presents the conclusions of the research.

1.3. Literature review

1.3.1. Reasons for merging

The main motivations behind hospital mergers are economic. For starters, these motives are the cost savings originated by the cut of duplicated services and the improvements in management and production processes. Additionally, merged hospitals benefit from better access to capital, as well as quality improvements from higher volumes of specialized procedures. These mergers are also believed to promote better allocation of resources and personnel, generating better geographic coverage and better use of human resources, reducing idle staff, for instance. (Connor et al., 1997)[2]

Menke (1997) proposes that merged hospitals may face lower costs, since they can jointly acquire and share inputs, in addition to having an higher likelihood of accessing lower interest rates of capital. On the other hand, Garside (1999) suggests that hospital mergers induce cost efficiency at the production level through economies of scale and scope, and represent a way of dealing with excess capacity.

Luft et al. (1987) suggests that for hospitals, being part of a bigger group that attracts more patients, will help create doctors with better skills. Finally, merging creates a bigger market power for the involved institutions, allowing them a bigger bargaining power whenever negotiating with private insurers. In return, due to the added negotiating capacity, higher prices will probably be charged, according to Tenn (2011)[3].

1.3.2. Evidence on mergers in the hospital industry

In the literature concerning hospital mergers, the most commonly studied indicators are prices and costs, and some authors analyse them together. The interest in analysing prices or costs depends on the hospital's financing scheme. In the United States it is more interesting to study prices because the system mostly functions on a

[2] Although this paper names these reasons for merging, the causal effect could go in the opposite direction. In other words, hospitals that have these characteristics can represent better candidates to mergers.

[3] This is a motive to merge that does not apply to the Portuguese case. Prices and the negotiation with private insurers correspond, for instance, to the United States' case, as it is explained in section 1.3.2.

price basis[4], due to an enormous prevalence of private health insurances. In contrast, in Portugal it makes sense to analyse costs, since the Portuguese NHS' hospitals are state financed, through a contract program. The Ministry of Health pays for major production categories, such as inpatient episodes, using a Diagnostic Related Groups measure to adjust prices—the government determines prices unilaterally. (Valente, 2010)

Controlling and reducing costs was a central objective of the Portuguese public hospitals mergers. In accordance, relevant studies on the impact of mergers on hospital costs are now presented[5]. Coyne (1982) investigated the effects of hospital mergers on costs and productivity and observed an increase in both indicators. The study registered, however, an exception for county hospitals, which showed a decrease in costs and no relevant productivity changes. Sinay (1998), another study focusing on costs, found evidence of a fall in expenditure. The author states that there appeared to be gains due to economies of scale and scope and adds that the observed merged hospitals suffered from diseconomies of scale prior to the merger. Dranove and Lindrooth (2003) executed a similar analysis. This study sustains that mergers do not generate savings on a consistent basis. Additionally, the authors affirm that significant savings existed after three or four years only for the case where there was closure or transformation of one of the facilities. Spang et al. (2001), studying the merger impact on hospital costs and prices, concluded that the effects vary with markets and hospital conditions.

Under circumstances closer to this thesis', Gaynor et al. (2012) studied a wave of hospital mergers in the English NHS between 1997 and 2006. These mergers implied hospital closure, leading to the disappearance of one quarter of the NHS' hospitals. Using a matching technique to compare the performance of the merged hospitals with those which did not merge, the study analysed the changes in two sets of outcome variables. The first set corresponds to activity, including indicators such as financial performance, staffing and labour productivity. The second indicator set, considers variables such as waiting times and a set of clinical outcomes that measure the performance of English hospitals. This analysis found little gains in merging, as it discovered a decrease in activity, through the reduction of admissions and staff, poorer financial performance and unchanged labour productivity. While

[4] In the United States, insurance companies pay hospitals on a per-diem or fee-for-service schemes. Insurance companies and hospitals negotiate the fees annually and the bargaining power of each part is decisive.

[5] The mentioned articles analyse large samples of hospitals.

most quality measures showed no change, waiting times rose.

The literature that analyses the effects of hospital mergers on costs did not offer consistent conclusions. Although the results it presents are rather ambiguous, the different studies seem to offer more evidence against merging, than in favour of it. Some authors[6] suggest these divergences may happen due to the different conditions proportioned by the geographical location, the market in which these institutions operated and the specific conditions that the hospitals were subject to.

[6] See Dranove and Lindrooth (2003) and Spang et al. (2001).

2. Design of the experiment

In order to estimate the effect of the mergers, it is not enough to observe what happened to the treated hospitals before and after the introduction of the treatment. Imagining an experiment with mice, in which these animals are being treated against a particular disease, just observing the reaction of the mice to the medicine—comparing their health before and after the treatment—does not control for over time changes not related with the treatment. For instance, it does not control for the fact that these mice could have simply healed on their own, nor does it consider the chance of an environmental factor helping the mice heal, or even that the sample includes the most healthy and disease-resistant mice, instead of being randomly chosen. The solution is to include a counterfactual group in the analysis, which is not exposed to the treatment. Nonetheless, it is not sufficient to study one time period. Using the example, just comparing the treated with the untreated mice, in the period after the introduction of the medicine still does not take into account unmeasured differences between the two groups of animals, which might influence the results. However, comparing both groups in the periods before and after the treatment, allows the observation of the disease response of mice that undergone treatment and compare it to that of the animals that did not take the medicine. In other words, the control group allows the observation of what would have happened to the treated mice, if they had not been treated. The situation of the present study is the same, there is a treatment group consisting of hospitals that merged, and a control group composed by hospitals that did not merge.

2.1. Data set restrictions

Only NHS' hospitals with publicly available data are considered. Unless they are involved in a merger, specialized institutions such as maternities, medical centres, or psychiatric, oncology, orthopaedic or children's hospitals are not considered, given that these institutions have different cost functions. Hospitals under Public Private Partnership schemes generally do not make their data public, and therefore are not included in the sample.

Local Health Units—*Unidades Locais de Saúde*, in other words, a merger between hospitals and clinics—typically do not discriminate between hospital and clinic financial information, nor do non-merged clinics publish this information. Thus, a before-after comparison cannot be done, because it is not possible to add up the clinics' data to the hospitals' in the before period, nor is it possible to remove this data from the merged institutions, in the after period. For these reasons, Local Health Units are not considered, nor do the hospitals that integrate one.

2.2. Identification

This study compares a treatment group with a control group, during two stages, the period before and the period after the merger. All the hospitals considered in both groups were selected for they meet the criteria presented in the previous section. The variables that compose the experiment are presented as follows.

2.2.1. Treatment group

The treatment group includes the hospitals that are involved in a merger, in other words, hospitals that are subject to the treatment. The mergers happen in different years and the treated hospitals are always considered in the treatment group. The challenge was that, before the merger, merged hospitals exist as two, or more, separated institutions, producing separated data. Therefore, the data of independent hospitals that eventually merge was consolidated[7] into a single entity during the period before the merger, appearing as one single hospital throughout the data set's timeline.

This group is composed by twelve hospitals that merge between 2005 and 2010, assuring that, for all treated hospitals, there is in the sample at least one year

[7] The indicators were added up, for instance, for *Centro Hospitalar Lisboa Norte*. For this hospital, before 2008, the total costs of *Hospital Santa Maria* and *Hospital Pulido Valente* were summed up annually. For the indicators that assume the form of an average or index, such as the average length of stay, for each given year, a mean of the hospitals for was computed.

before and one year after the merger[8]. Although no such restriction was made, all the treated hospitals only merge once in the data set.

2.2.2. Control group

The control group is formed by 18 hospitals that did not merge during the years considered in the data set. Control group hospitals are considered in this group during all the years observed in the sample.

2.2.3. Before and after periods

For each treat and control group hospital, there is a period before the merger—or the treatment—moment, and a period after the treatment happens. In the treatment group these periods are defined according to the hospitals' merger date. A treated hospital is in the before period until the year the merger happens (exclusive). From that year on, the treated hospital is considered to be in the after period (inclusive). Years in the after period are identified by the *after* variable.

This study considers a merger to take place in the year the law approved it, if it happened in the first three months of the year. If otherwise, the approval took place in the last three months, the merger is considered to have happened in the following year. None of the analysed mergers was approved outside of the first or last three months of the year.

For the control group, the before and after periods do not exist because these hospitals do not merge. In order to create a before and after period for these hospitals, the following method was applied. For each of the thirty hospitals, data about the number of available beds was collected—the number of beds is indicator of hospital dimension. Then the number of beds in the control group's hospitals was compared to that of the treatment group's hospitals. Finally, the control group hospitals were given the same *after* variable as the treatment group hospital with the most similar

[8] This study requires the data set to have information, for every treated hospital, of at least one year before merging and one year after merging, in order to be able to assess the effects of the treatment. Therefore, mergers that happened in the first or last year of the sample's timeline—2004 or 2011—are not taken into account. There is one hospital that merges in 2004, *Centro Hospitalar do Barlavento Algarvio*, and several that merge in 2011, such as *Centro Hospitalar de São João*. All these hospitals were considered in the control group.

number of beds—these control group hospitals behave the same way regarding the before and after periods as its pair in the treatment group.

Table 2.1.: Treatment group

Treat
CH Alto Ave
CH Barreiro-Montijo
CH Entre Douro e Vouga
CH Gaia-Espinho
CH Lisboa Norte
CH Lisboa Central
CH Lisboa Ocidental
CH Médio Ave
CH Porto
CH Setúbal
CH Tâmega-Sousa
CH Trás-Os-Montes/Alto Douro

Notes: This table shows the hospitals that merged considered in the sample. H refers to hospital, and CH refers to hospital center (*centro hospitalar*).

Table 2.2.: Control group

Control
CH Barlavento
CH Coimbra
CH Cova da Beira
CH Médio Tejo
CH Póvoa Varzim-Vila do Conde
H Curry Cabral
H Espirito Santo
H Faro
H Figueira Foz
H Garcia de Orta
H Infante D. Pedro
H Litoral Alentejano
H Santa Maria Maior
H Santarém
H Santo André
H São João
H São Teotónio
H Universidade de Coimbra

Notes: This table shows the sample's hospitals that did not merge.
H refers to hospital, and CH refers to hospital center (*centro hospitalar*).

Table 2.3.: Non-selected hospitals

Other hospitals
H Arcebispo João Crisóstomo
H Cândido de Figueiredo
H Distrital de Águeda
H Distrital de Pombal
H Dr. Francisco Zagalo
H Joaquim Urbano
H José Luciano de Castro
H Nossa Senhora da Conceição
H Professor Doutor Fernando Fonseca
CH do Oeste Norte
CH de Torres Vedras
H Visconde de Salreu

Notes: This table includes the hospitals that met the criteria explained in section 2.1, but were not included in the sample due to lack of public data.
H refers to hospital, and CH refers to hospital center (*centro hospitalar*).

3. Data

The sample was built using the information available in the financial reports of each of the analysed institutions, and in the cases in which the report was not available the NHS' financial reports[9] were used. The data set is an unbalanced panel, as occasionally there were hospitals that did not publish some data. It contains observations for the following indicators: total costs[10] (in constant prices of 2012, in thousands of euros), average length of stay (in days), and number of inpatient episodes, outpatient visits, outpatient services, emergencies and day surgeries, as well as a case-mix index[11]. The data set includes observations within the eight-year period of 2004 to 2011[12]. The variables *treat*, *after* and *aftertreat* were added, as explained in chapter 2. It was also added the variable enterprise management model, which controls for the organizational change in Portuguese hospitals, which happened to all the institutions in the data set.

The variables total costs, inpatient episodes, outpatient episodes, outpatient visits, outpatient services, emergencies and day surgeries were transformed into logarithms[13]. The average length of stay and the case-mix index were not transformed, for a more interesting interpretation of results. Lastly, interaction effects and non-linear effects were added. These effects were attained by multiplying all production variables against all production variables.

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[9] The NHS' financial reports include financial information for some of the NHS' hospitals. The used data set uses some information from the reports published between 2004 and 2008.

[10] Total costs are presented in constant prices, base year 2012, computed using the INE Consumer Price Index.

[11] Some institutions did not divulge their case-mix index for some years. This happen in two forms: either they only publish it after a given year or, contrariwise, they stop publishing it after a given year. For the first case, the case-mix index in the previous years was assumed to be constant and equal to the first value available. For the second case, the index for the following years was assumed to remain constant and equal to the last value available.

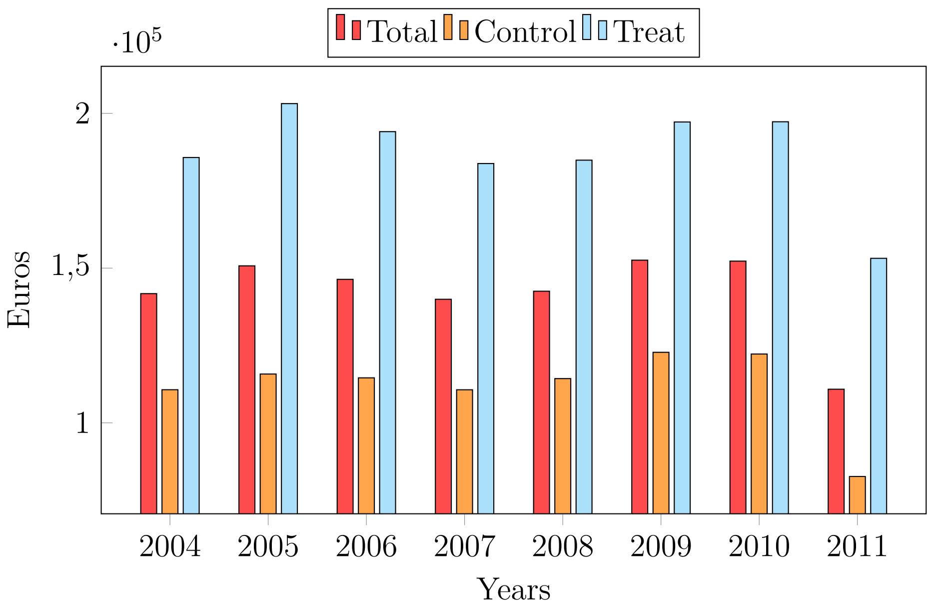
[12] The time range was chosen to cover as many mergers possible, given the limited data availability.

[13] Given that there are zero and blank observations, the transformations into logarithms followed the formula log(x+1), in which x is the transformed variable

3.1. Descriptive statistics[14]

3.1.1. Total cost

Figure 3.1.: Mean of total costs



Notes: Constant prices, base 2012. Computed using INE Consumer Price Index.
Values in hundreds of millions of euros.
For instance, 1,2 means 120.000.000€.

Total cost is the study's main indicator, as the hospital mergers are expected to reduce health costs. The data tells us that, through a generally constant upward trend, the cost of the examined hospitals increased 7,4% between 2004 and 2010, around 1,2% per year, on average. The mean of total costs for the sample is around 147 million euros.

The treatment group showed a cost growth pattern very similar to the average of all hospitals, with the biggest difference being a more pronounced expenditure fall

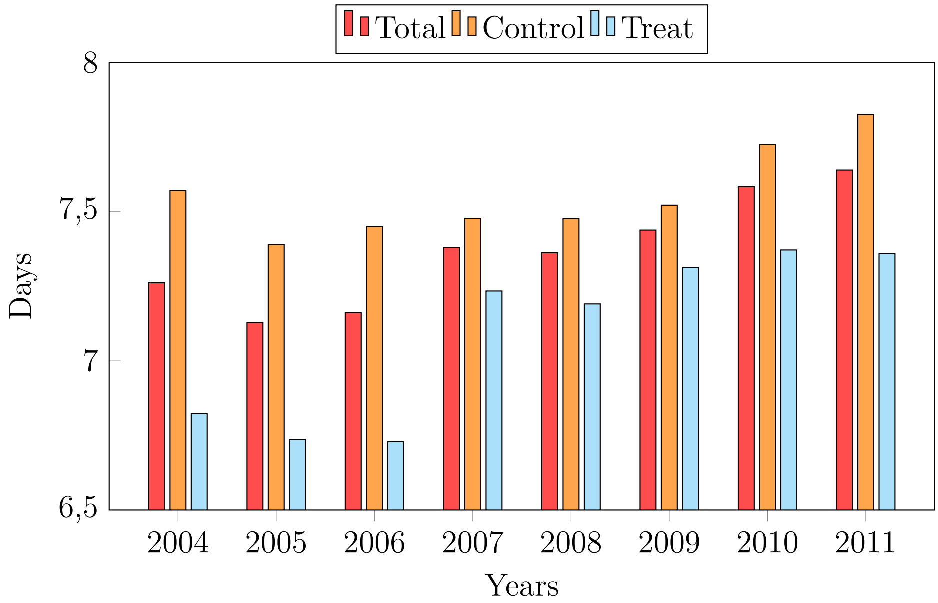
[14] The graphs often show a disparity between 2011 and the other years. This happens given that, for 2011, there is only data available for 20 hospitals (instead of 30), which may influence the means. For this reason, the change rates and averages discussed in the text correspond only to the 2004-2010 period. This issue is discussed with further detail in chapter 6.

between 2005 and 2008. Moreover, on average, this group appeared to be quite more costly than the control group. For instance, whereas in no year the treatment group registered an average total cost under one 180 million euros, this value was never reached neither by the control group, nor by the whole sample.

Finally, as expected, the control group presented a more solid cost increase tendency along the years, and it showed no more than a shy expenditure decrease in 2007. The group assumed a global rate of change of 10% between 2004 and 2010, a superior figure than the treatment group's 6% (approximately).

3.1.2. Average length of stay

Figure 3.2.: Mean of the average length of stay



Note: Values in days.

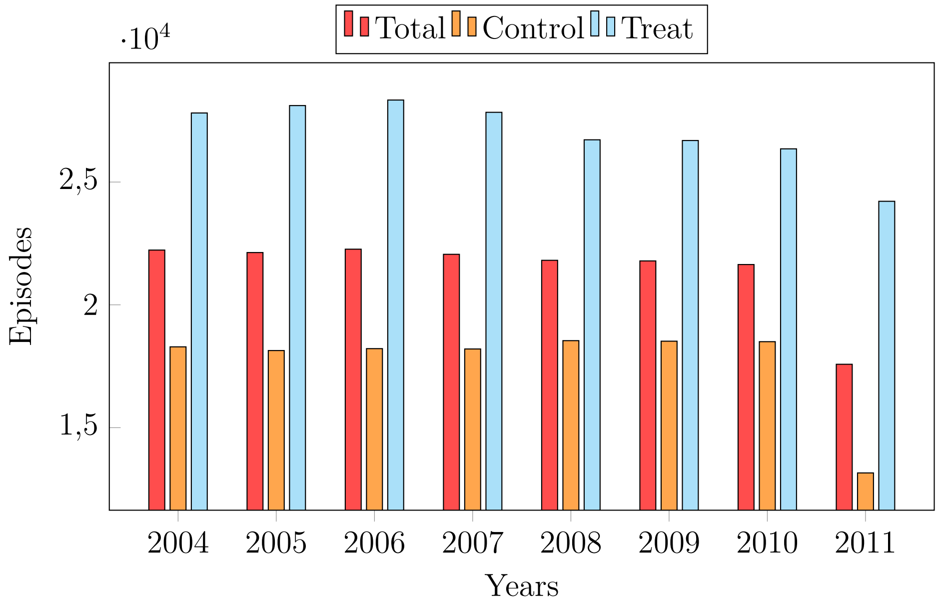
The data shows that, although the average length of stay did not suffer great changes along time, the sample observed a rising trend along time, translating into an efficiency downward trend. For the used sample, the average number of hospitalization days was about 7,36 days.

The treatment group is more efficient than the sample's average, for all years. There seems to be a structure break in 2007, when this group's average length of stay suffered a spike. This will not be a problem in the analysis, as the time variables will control for this effect. Generally, during the rest of the period, there was a rise in the average number of stay days.

Contrariwise, the control group assumed a steadier tendency along the years. Its change rate between 2004 and 2010 was a shy 2%, compared with the 8% of the treatment group.

3.1.3. Inpatient episodes

Figure 3.3.: Mean of inpatient episodes



Notes: Values in tens of thousands of episodes.
For instance, 1,5 means 15.000 episodes.

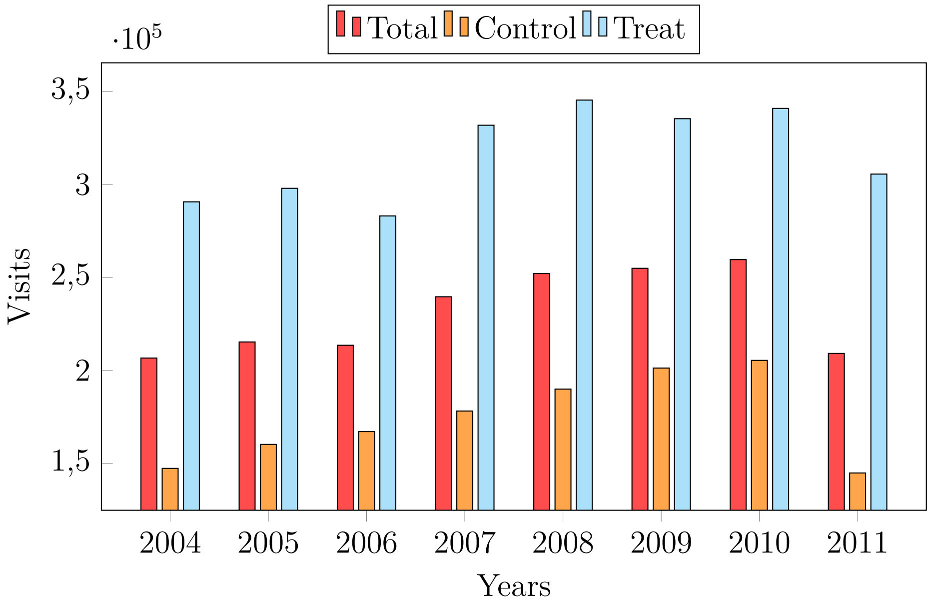
Observing the whole hospital sample, the mean of inpatient episodes demonstrated a very sticky behaviour, averaging 21.603 episodes. Nonetheless, since 2004, the number of episodes fell in about 2,65% until 2010, around 4% per year.

The treatment group assumed a bolder evolution compared with the other group. It registers an increase in the number of episodes until the year 2006, when the trend is inverted and a persistent fall in this indicator began, translating into a decrease of about 5% from 2004 to 2010. Furthermore, the treatment group's production is reasonably higher than in the comparison group, by twenty thousand episodes, on average.

The control group observed a rather shy and highly irregular evolution of inpatient episodes, with a global change rate of about 1%.

3.1.4. Outpatient visits

Figure 3.4.: Mean of outpatient visits



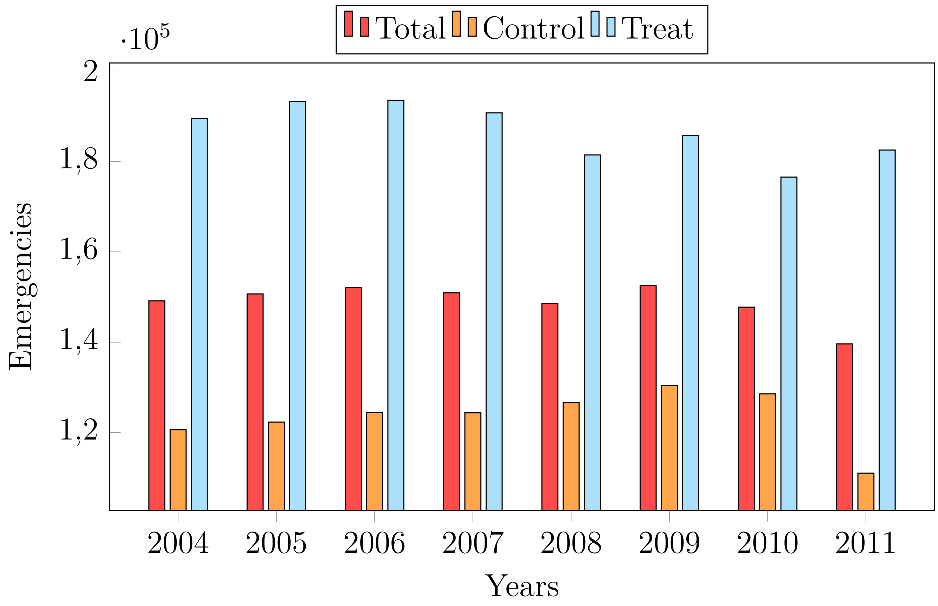
Notes: Values in hundreds of thousands of visits.
For example, 1,5 means 150.000 visits.

Outpatient visits is the biggest output of the analysed hospitals and grew consistently between 2004 and 2010. It rose, on average, in more than fifty thousand visits, for a global change rate of approximately 25%, with an average of 232.555 visits.

The treatment group is the biggest producer of this service, observing a more erratic growth than the other group. Only in 2006 and 2009 there were observed reductions in this production line, which contributed to the great increases in outpatient visits these hospitals achieved, for a global rate of change around 17%. On the other hand, the control group had a very steady increase pattern and the highest global growth rate, averaging 39%.

3.1.5. Emergencies

Figure 3.5.: Mean of emergencies



Notes: Values in hundreds of thousands of emergencies.
As an example, 1,2 means 120.000 emergencies.

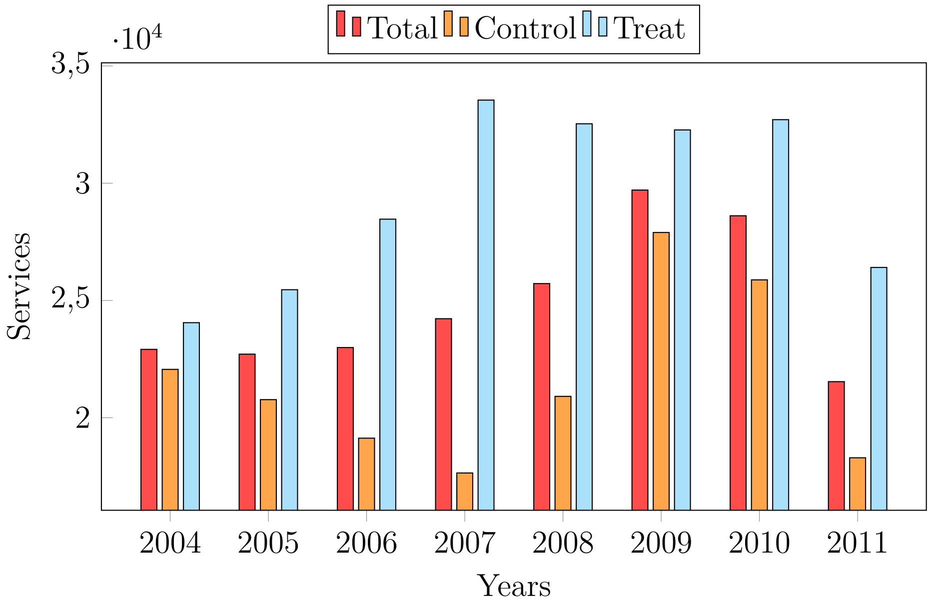
Emergencies are associated with sudden non-specific health problems that require immediate attention. For that reason, it is without surprise that this indicator remained quite constant along the years, with an average of 149.317 emergency episodes. In fact, between 2004 and 2010 there was a slight decrease in the number of episodes, which is less than 1%.

The group of the treated showed a more erratic behaviour than the sample, but produced a bigger number of emergency episodes. These figures have a downward trend, however, notwithstanding the small growth observed in the first two periods, as well as the one in 2009. The global change rate for this group is approximately -7%.

For the control group, the number of emergency episodes was clearly smaller than the treatment group's figures. Still, this group observed a rise in the number of emergencies throughout the period, corresponding to a global growth of almost 7%, symmetrical to the treatment group's growth rate.

3.1.6. Outpatient services

Figure 3.6.: Mean of outpatient services



Notes: Values in tens of thousands of services.
Exemplifying, 2,5 means 25.000 services.

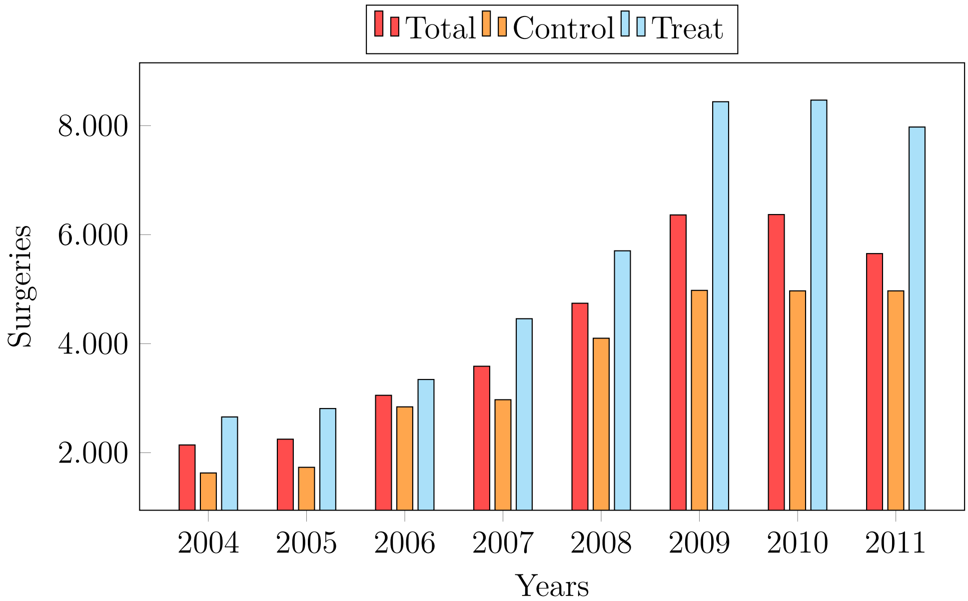
Outpatient services are a new type of production and are greatly linked with cancer treatments. This line of production's growth along time resembles an exponential shape and it increased in approximately 30% globally. On average, the examined hospitals produced 24.960 outpatient services, until 2010.

Curiously, the evolution of this production line for either group is quite different from the sample's. Outpatient services in the treatment group grew exponentially until the year 2007, stabilizing thereafter. This corresponds to a global increase of approximately 36%, turning this group into the heavier producer.

The control group's production of outpatient services falls until 2007. Thereafter, it enters a period of strong growth, only offset in 2010. corresponding to a global growth of about 17%, less than half of the treatment group's.

3.1.7. Day surgeries

Figure 3.7.: Mean of day surgeries



Note: Values in number of surgeries.

Day surgeries was another indicator that exhibited an exponentially shaped growth along the timeline. This growth corresponds to a change rate of approximately 225%, which means that this production line more than doubled during the analysed period, with an average of 4.379, until 2010.

The treatment group's behaviour showed the same trend as the sample, with the difference that it observes greater values. It has a global change rate of approximately 248%, a bigger figure than the sample's.

Likewise, the control group's outpatient episodes evolution also has an exponential shape, a more erratic one, though. For this group there is a change rate of 233% in the period.

4. Method

The method used to estimate the treatment effect is the Differences-in-Differences (DiD) estimator[15]. Chapter 2 showed it was not enough to compare the situation of the treated hospitals before and after the treatment, and that a control group was needed. For a given dependent variable, the DiD estimator separately calculates the differences between the before and after periods for the treat and control groups, computing then the difference of those differences.

The impact of the treatment on the hospitals' total costs is estimated through equation 4.1. The mergers' impact on the average length of stay is measured by equation 4.2. Both equations are based on a translog cost function, equation 4.1 includes the hospitals' outputs[16] as regressors, while equation 4.2 considers the hospital production related to the efficiency—inpatient episodes and the case-mix index. The equations include the interaction effects and non-linear effects (see final paragraph of chapter 3) of the respective regressors. Finally, the equations incorporate the variables *treat*, *after*, *aftertreat* and *epe*[17], in addition to eight time variables—that take into account the effect of the years.

[15] All econometric calculations were made with the software Stata.
[16] Hospitals with higher production levels are also expected to be more costly and less efficient, therefore the institutions' outputs should be taken into account in the estimation.
[17] Which controls for the adoption of the enterprise management model.

$$log\,tc_{it} = \alpha_i + \beta_2 treat_{it} + \beta_2 after_{it} + \beta_3 aftertreat_{it} + \beta_4 epe_{it} + \sum_{j=1}^{n} \alpha_j log\,X_j + 0,5 \sum_{j=1}^{n} \sum_{k=1}^{n} \delta_{ij} log\,X_j log\,X_k + \sum_{t=2005}^{2011} \gamma_t t + \epsilon_{it} \tag{4.1}$$

$$alos_{it} = \alpha_i + \beta_1 treat + \beta_2 after_{it} + \beta_3 aftertreat_{it} + \beta_4 epe_{it} + \sum_{j=1}^{n} \alpha_j log\,Z_j + 0,5 \sum_{j=1}^{n} \sum_{k=1}^{n} \delta_{ij} log\,Z_j log\,Z_k + \sum_{t=2005}^{2011} \gamma_t t + \epsilon_{it} \tag{4.2}$$

Where, for each hospital i in year t, tc_{it} represents total costs (in thousands of euros) and $alos_{it}$ the average length of stay (in days). X, Z and t are vectors. X is measured by inpatient episodes, outpatient visits, emergencies, outpatient services, day surgeries and case-mix index; Z comprises inpatient episodes and case-mix index; and t includes the time variables, representing the years 2004 to 2010. ϵ_{it} is the error term. This estimation assumes that selection into the treatment is independent from the transitory idiosyncratic effect ϵ_{it}, and that the treatment and control groups would have been subject the same time effects in the non-treatment scenario.

For both equations, there is an effect specific to each hospital (α_i). The hospital heterogeneity may be correlated with the dependent variables, but they may also be independent of the regressors. In order to help decide whether to use a fixed effects estimator—in the former situation—or a random effects estimator—in the latter case—, a Hausman[18] test was ran. According to this test, it is the fixed effects estimator that should be used for both equations 4.1 and 4.2.

[18] Results are shown in tables A.3 and A.4.

5. Analysis

5.1. Stylized facts

Computing differences of averages is one way of analysing the effects of a treatment experiment, although it does not control for the hospital's production or the passage of time, nor does it consider the hospitals unobserved effects. First, for the treatment group, the average of one variable[19] is computed twice, for the periods before and after the treatment. Then, the difference between the averages of the two periods is calculated. The same method is repeated for the control group and, finally, the average difference for the treatment group is subtracted from the control group's.

Table 5.1.: Difference-in-Differences of log of total costs and average length of stay

		LTC	**ALOS**
Before	(1) Control	11,360	7,410
	(2) Treat	11,909	6,724
After	(3) Control	11,377	7,640
	(4) Treat	11,955	7,385
Δ	(5) Control	0,017	0,230
	(6) Treat	0,046	0,661
	(7) Δ	0,029	0,431

Notes: The items (1) through (4) represent, in the LTC case, average logarithm of total costs, and in the ALOS case, average length of stay.
For both variables, the items (5) and (6) represent the percentual difference between the after and before periods of each group, whereas the item (7) represents the DiD over each of the variables.
The Δ denotes the difference. The table was calculated in the following way: (5)=(3)-(1) | (6)=(4)-(2) | (7)=(6)-(5)

[19] Such as total costs.

The difference of means in the case of the average length of stay is of 0,431 days—approximately half a day—, the most substantial result. On the other hand, the calculated average difference of the log of total cost's observes an increase of 2,9%. These results suggest that merging might have had an important increasing effect over both the average length of stay, as it rose almost half a day, and the expenditure, which rose close to 3%.

Regarding the treatment's impact on the production variables, decreases were observed for inpatient episodes, outpatient visits and emergencies. Contrariwise, outpatient services and day surgeries registered a volume increase. The most significant change happened for day surgeries, with an average difference of 19% more surgeries.

Table 5.2.: Difference-in-Differences of the production variables

		IE	**OV**	**OS**	**DS**	**EM**
Before	(1) Control	9,618	11,740	9,487	7,427	11,647
	(2) Treat	10,180	12,478	10,044	7,717	12,140
After	(3) Control	9,573	11,925	9,553	8,152	11,653
	(4) Treat	10,120	12,609	10,170	8,632	12,057
Δ	(5) Control	-0,045	0,185	0,066	0,725	0,006
	(6) Treat	-0,060	0,131	0,126	0,915	-0,083
	(7) Δ	-0,105	-0,054	0,060	0,190	-0,089

Notes: The variables exhibited in this table were transformed into logarithms.
Items (1) through (4) respectively represent the average logarithm of the following variables: Inpatient Episodes, Outpatient Visits, Outpatient Services, Day Surgeries and Emergencies.
For all variables, the items (5) and (6) represent the percentual difference between the after and before periods of each group, whereas the item (7) represents the DiD over each of the variables.
The Δ denotes the difference. The table was calculated in the following way: (5)=(3)-(1) | (6)=(4)-(2) | (7)=(6)-(5)

5.2. Analysis of the distribution

This section replicates the analysis of the previous section, this time separating the data into five percentiles, focusing on what has happened on hospitals with different cost dimensions and different efficiency levels. It should return some evidence on what happened with the hospitals with the smallest and biggest expenditures, as well as the hospitals with the shortest and longest average lengths of stay, for instance.

Table 5.3.: Difference-in-differences on the log of total costs, by percentiles

	LTC	**10**	**25**	**50**	**75**	**90**
Before	(1) Control	10,284	11,099	11,316	11,791	12,676
	(2) Treat	11,352	11,454	11,603	12,539	12,987
After	(3) Control	10,312	10,552	11,416	11,835	12,097
	(4) Treat	11,155	11,442	11,780	12,519	12,921
Δ	(5) Control	0,029	-0,547	0,100	0,044	-0,579
	(6) Treat	-0,197	-0,012	0,176	-0,019	-0,066
	(7) Δ	-0,226	0,536	0,076	-0,063	0,513

Notes: The items (1) through (4) represent the average logarithm of total costs, for different percentiles of expenditure.
For both variables, the items (5) and (6) represent the percentual difference between the after and before periods of each group, whereas the item (7) represents the DiD over of the variable, along the different cost percentiles.
The Δ denotes the difference. The table was calculated in the following way: (5)=(3)-(1) | (6)=(4)-(2) | (7)=(6)-(5)

According to table 5.3, three percentiles have positive mean differences, 25, 50 and 90. Percentile 50, or the median, shows a shy difference, whereas the 25 and the 90 difference show more relevant results, respectively about 54% and 51%. Oppositely , for percentiles 10 and 75 there is a negative difference of means, with the first percentile assuming the biggest decrease in costs; the results are nearly -23% and -6%, respectively.

The percentile average effect of the treatment for the average length of stay is observed in Table 5.4. For all percentiles, except the 10, the effects are greater than zero. Actually, as the percentiles increase, so do the average differences. It appears that, the most efficient hospitals observed efficiency gains, as institutions in the percentile 10 register an average length of stay decrease in 0,135 days. At the

Table 5.4.: Difference-in-differences on the average length of stay, by percentiles

	ALOS	**10**	**25**	**50**	**75**	**90**
Before	(1) Control	5,940	6,560	7,405	8,200	9,100
	(2) Treat	5,400	5,850	6,655	7,700	8,240
After	(3) Control	6,480	7,060	7,700	8,120	8,700
	(4) Treat	5,805	6,510	7,300	8,410	9,230
Δ	(5) Control	0,540	0,500	0,295	-0,080	-0,400
	(6) Treat	0,405	0,660	0,645	0,710	0,990
	(7) Δ	-0,135	0,160	0,350	0,790	1,390

Notes: The items (1) through (4) represent the mean average length of stay, for different percentiles of expenditure.
For both variables, the items (5) and (6) represent the percentual difference between the after and before periods of each group, whereas the item (7) represents the DiD over of the variable, along the different cost percentiles.
The Δ denotes the difference. The table was calculated in the following way: (5)=(3)-(1) | (6)=(4)-(2) | (7)=(6)-(5)

same time, it seems that, the more inefficient hospitals are, the more their efficiency fell with the treatment. Hospitals in percentile 75 show a difference of 0,790 days, and hospitals in percentile 90 observe an increase 1,390 days, almost a day and a half.

5.3. Regression results

The results of the econometric analysis of equation 4.1 are shown in table 5.5. The merger effect is measured by the *aftertreat* variable, which lacks statistical significance. Its coefficient is very close to zero, which, together with a large p-value, means that there is evidence that the mergers produced no changes in the financial performance of the hospitals. The *epe* variable is significant with a coefficient of -0,04. This suggests that the adoption of the enterprise management model was a success, contributing to a cost decrease of 4%, on average.

The production variables return the expected results, with the exception of inpatient episodes and the case-mix index, whose signals are negative. There is no obvious explanation for the signal of inpatient episodes' coefficient, especially given its very large p-value. Still, one possible explanation for the case-mix index's coefficient sign might be that, hospitals more exposed to complex medical situations, which bring higher costs, feel a greater need for controlling their expenditure, becoming this way economically more efficient. Of the seven year variables, only four have statistically significant coefficients, going from a 5,4% average cost increase in 2005, to a 6,2% average rise in 2010.

Table 5.6 displays the output of equation 4.2. The *aftertreat* variable has statistical significance, with a positive coefficient of 0,348. This is evidence the treatment induced an increase in the hospitals' average lengths of stay, in one third of a day—approximately eight hours. The regressor *epe* shows a statistically significant coefficient of -0,511, suggesting a positive effect of the new management model, reducing the hospitals' average length of stay in half a day, on average.

None of the production variables comes off statistically significant. These coefficients reveal the expected signs, as the number of inpatient episodes and the case-mix index are both likely to increase the length of hospitalizations. In addition, the year variables' coefficients are not statistically significant, meaning that the analysed hospitals have not benefited from efficiency gains over time.

Table 5.5.: Equation 4.1 — Treatment effect over the log of total costs

Log (total costs)	Coefficient	P>|t|
after	-0,013	0,366
aftertreat	-0,001	0,960
epe	-0,040	0,040*
log(inpatient episodes)	-0,195	0,921
log(outpatient visits)	1,768	0,175
log(emergencies)	1,747	0,253
log(outpatient services)	0,024	0,932
log(day surgeries)	0,383	0,128
case-mix	-3,239	0,090**
log(in. episodes) ^{2}	0,100	0,452
log(out. visits) ^{2}	0,080	0,028*
log(emergencies) ^{2}	0,052	0,421
log(out. services) ^{2}	-0,011	0,034*
log(day surgeries) ^{2}	0,009	0,181
case-mix ^{2}	0,050	0,787
log(in. episodes)*log(out. visits)	-0,200	0,289
log(in. episodes)*log(out. services)	0,158	0,010*
log(in. episodes)*log(emergencies)	-0,115	0,547
log(in. episodes)*log(day surgeries)	0,032	0,528
log(in. episodes)*case-mix	0,293	0,149
log(out. visits)*log(out. services)	-0,043	0,312
log(out. visits)*log(emergencies)	-0,074	0,722
log(out. visits)*log(day surgeries)	-0,030	0,381
log(emergencies)*log(out. services)	-0,066	0,012*
log(emergencies)*log(day surgeries)	-0,032	0,377
log(out. services)*log(day surgeries)	-0,006	0,736
2005	0,054	0,000*
2006	0,040	0,016*
2007	-0,002	0,915
2008	0,016	0,524
2009	0,068	0,013*
2010	0,062	0,043*
2011	-0,042	0,188
constant	-10,284	0,368
Observations	203	
F(29,29)	—	
corr(u_i, Xb)	0,6042	
Prob > F	—	
	Within	0,6699
R-squared	Between	0,6483
	Overall	0,6022

Notes: Fixed effects regression estimation (unobserved and observed permanent characteristics).
Since the fixed effects estimator controls for time-invariant effects, the *treat* variable cannot be estimated.
In. episodes stands for inpatient episodes, out. means outpatient.
* Coefficient significant at a 5% significance level .
** Coefficient significant at a 10% significance level.

Table 5.6.: Equation 4.2 — Treatment effect over the average length of stay

Average length of stay	Coefficient	P>|t|
after	0,101	0,410
aftertreat	0,348	0,021*
epe	-0,511	0,002*
log(inpatient episodes)	1,499	0,429
log(in. episodes) ^{2}	-0,130	0,422
case-mix	6,832	0,423
case-mix ^{2}	-1,620	0,278
log(in. episodes)*case-mix	-0,262	0,785
2005	-0,138	0,204
2006	-0,099	0,510
2007	0,081	0,653
2008	0,024	0,881
2009	0,112	0,535
2010	0,277	0,174
2011	0,346	0,139
constant	2,853	0,666
Observations	228	
F(14,29)	22,27	
corr(u_i, Xb)	-0,5985	
Prob > F	0,0000	
	Within	0,3893
R-squared	Between	0,0197
	Overall	0,0008

Notes: Fixed effects regression estimation (unobserved and observed permanent characteristics).
Since the fixed effects estimator controls for time-invariant effects, the *treat* variable cannot be estimated.In. episodes stands for inpatient episodes.
In. episodes stands for inpatient episodes.
* Coefficient significant at a 5% significance level .
** Coefficient significant at a 10% significance level.

6. Robustness

6.1. Use of 2011

In the present section, the issue of the lack of data for ten hospitals in 2011 is analysed. Either this happened because some hospitals had not yet released their annual reports, or their data for the year was removed due to the design of the treatment group (see section 2.2.1). Amongst these hospitals without data for 2011, there are four institutions with very large expenditures[20]: *Centro Hospitalar Lisboa Norte*, *Centro Hospitalar do Porto*, *Hospital de São João* and *Hospitais da Universidade de Coimbra*. The first two hospitals belong to the treatment group, while the two last are included in the control group.

The absence of data for some of the hospitals with the largest expenditures may influence the results. In order to establish whether this year should be maintained in the data set, the models were ran excluding the data for 2011. This analysis generated similar econometric outputs, with the results pointing in the same direction as those presented in chapter 5. In spite of slight coefficient changes, and some interaction effects gaining and losing significance, removing the year 2011 did not yield different results. For equation 4.1, the variables *after*, *aftertreat* still did not have statistical significance, where the *epe* maintained it. As for equation 4.2, the variable *after* was again deemed not significant, and the *aftertreat* and *epe* dummies kept the statistical significance.

6.2. Quantile regression

Although equation 4.2 identified an effect of the treatment, equation 4.1 did not. Was this caused by the actual inexistance of such effect, or because the mergers

[20] Respectively, the hospitals with the first, sixth, third and fourth largest expenditures in the sample.

differently impacted hospitals with small or big expenditures?

In order to find an answer, a quantile regression of equation 4.1 was ran. It measures the treatment effect according to the dimension of the hospital's costs, allowing to see if there was a merger effect in the hospitals with small—or the smallest—costs, or in the hospitals with large—or the largest—costs. Additionally, a quantile regression of equation 4.2 was also done, allowing to see if hospitals with short, or the shortest lengths of stay, were impacted differently by the mergers, as well as hospitals with long, or the longest lengths of stay.

Table 6.1.: Quantile regression

The examined percentiles are 10, 25, 50, 75 and 90. The quantile regressions include the same dependent and explanatory variables as equations 4.1 and 4.2, and are as follows:

$$Q_{ltc}\left(p \mid X\right) = X'_{itq}\beta_{itq}\left(p\right) \tag{6.1}$$

$$Q_{alos}\left(p \mid Z\right) = Z'_{itq}\beta_{itq}\left(p\right) \tag{6.2}$$

$$p = (10, 25, 50, 75, 90)$$

Where $p \, \epsilon \, (0,1)$ and represents the p^{th} percentile of the respective dependent variable. X is measured by inpatient episodes, outpatient visits, emergencies, outpatient services, day surgeries and case-mix index, and Z by inpatient episodes and case-mix index.

The quantile regression of equation 4.1 did not yield different results from the fixed effects estimator, which is evidence of the treatment not producing different effects, regardless of the cost dimension of the hospitals. As for the quantile regression for equation 4.2, the *aftertreat* regressor of the percentile 75 was statistically significant, with a coefficient of 0,832. This means that, on average, hospitals with the 75% largest average lengths of stay observed an increase in this indicator of about 0,8 days—approximately 19 hours. These results reveal that the effect captured by equation 4.2 was mainly boosted by these less efficient hospitals—with higher lenghts of stay—, whose efficiency decreased even further.

7. Conclusions

This thesis proposed to evaluate the consequences of mergers between public hospitals in Portugal. A central objective of the mergers was reducing the expenditure of the hospitals, therefore the impact of merging on the institutions' financial performance was studied. The analysis did not identify any effect of the mergers on this indicator, which is evidence that, as a result from the management changes, neither did the hospitals' costs increase, nor did they decrease.

Secondly, the objective was to analyse if the hospital mergers caused the hospitals' efficiency to increase or to decrease, or even to stay constant despite the changes. The evidence points to an efficiency decrease, particularly caused by the hospitals that were mostly inefficient to begin with, which suffered a further increase in the average lengths of stay. The increases in the lengths of stay happen due to a decrease in the capacity of the hospitals of working in a way that allows patients to be discharged faster—medical integrity is assumed, meaning that patients are assumed to be discharged only when healed.

Accordingly, the central result of this study is that hospital mergers are yet to produce significant gains, namely on the financial performance in the institutions, which is the state's priority. Nonetheless, mergers between hospitals can still be valuable and there are some policies that can be implemented in order to enhance the consolidations, such as the ones that follow. First of all, there should be back office concentration. In other words, merged hospitals should share administrative services, such as, accounting, IT and human resources, as well as legal, which will allow greater economies of scale and better management efficiency. In the same fashion, the top management of these institutions should be as consolidated as possible, in order to produce savings and, at the same time, promote better overseeing and control. Furthermore, hospital business plans should be drawn with the complementarity of the different institutions in mind, as a way to reduce redundancies in administrative and medical services, and use technical, as well as human resources in a more efficient manner. Correspondingly, personnel mobility and sharing across institutions of the same hospital, according to the needs and the demand for health services, should be encouraged, as it promotes financial and operational efficiency.

A. Appendix

Table A.1.: Detailed output of equation 4.1

```
. xtreg ltc after aftertreat epe lie lov lem los lds cmi lie2 lov2 lem2 los2 l
> ds2 cmi2 lie_ov lie_os lie_em lie_ds lie_cmi lov_os lov_em lov_ds lem_os lem
> _ds los_ds i.t, fe robust

Fixed-effects (within) regression               Number of obs      =       203
Group variable: i                               Number of groups   =        30

R-sq:  within  = 0.6699                         Obs per group: min =         2
       between = 0.6483                                        avg =       6.8
       overall = 0.6022                                        max =         8

                                                F(29,29)           =         .
corr(u_i, Xb)  = 0.6042                         Prob > F           =         .

                                    (Std. Err. adjusted for 30 clusters in i)
------------------------------------------------------------------------------
             |               Robust
         ltc |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
       after |  -.0133133   .0144978    -0.92   0.366    -.0429645     .016338
  aftertreat |  -.0011218   .0221431    -0.05   0.960    -.0464095     .044166
         epe |  -.0403663   .0187873    -2.15   0.040    -.0787906    -.001942
         lie |  -.1947881   1.936891    -0.10   0.921    -4.156176    3.766599
         lov |   1.767653   1.272105     1.39   0.175    -.8340929    4.369399
         lem |   1.746788   1.496637     1.17   0.253    -1.314178    4.807753
         los |   .0243556   .2819396     0.09   0.932    -.5522757    .6009869
         lds |   .3828595   .2441721     1.57   0.128    -.1165285    .8822475
         cmi |  -3.239123   1.845427    -1.76   0.090    -7.013445    .5351996
        lie2 |   .1004334   .1316212     0.76   0.452    -.1687621     .369629
        lov2 |   .0803485   .0348329     2.31   0.028     .0091072    .1515898
        lem2 |   .0515968   .0632178     0.82   0.421    -.0776981    .1808916
        los2 |  -.0113481   .0050971    -2.23   0.034    -.0217728   -.0009233
        lds2 |   .0092928   .0067851     1.37   0.181    -.0045843      .02317
        cmi2 |   .0503915   .1849136     0.27   0.787    -.3277992    .4285821
      lie_ov |  -.2000164   .1850856    -1.08   0.289    -.5785588    .1785261
      lie_os |   .1580789   .0574269     2.75   0.010     .0406278      .27553
      lie_em |  -.1152301   .1890864    -0.61   0.547    -.5019553     .271495
      lie_ds |   .0316445     .04959     0.64   0.528    -.0697784    .1330674
     lie_cmi |   .2929159    .197466     1.48   0.149    -.1109474    .6967791
      lov_os |  -.0433908   .0421924    -1.03   0.312    -.1296839    .0429023
      lov_em |  -.0744998   .2074165    -0.36   0.722    -.4987141    .3497146
      lov_ds |  -.0299834   .0337091    -0.89   0.381    -.0989263    .0389594
      lem_os |  -.0663297   .0248641    -2.67   0.012    -.1171825   -.0154768
      lem_ds |  -.0323744   .0360516    -0.90   0.377    -.1061082    .0413594
      los_ds |  -.0058752   .0172684    -0.34   0.736    -.0411929    .0294426
             |
           t |
       2005  |   .0537657   .0130231     4.13   0.000     .0271303     .080401
       2006  |   .0403792    .015857     2.55   0.016     .0079481    .0728104
       2007  |  -.0020026   .0186345    -0.11   0.915    -.0401144    .0361093
       2008  |   .0155599   .0241235     0.65   0.524    -.0337782    .0648979
       2009  |   .0682497   .0257219     2.65   0.013     .0156424     .120857
       2010  |   .0617655   .0292321     2.11   0.043     .0019792    .1215519
       2011  |  -.0417046   .0309381    -1.35   0.188    -.1049802    .0215709
             |
       _cons |  -10.28357   11.25678    -0.91   0.368    -33.30627    12.73913
-------------+----------------------------------------------------------------
     sigma_u |  .58224883
     sigma_e |  .04413208
         rho |   .9942878   (fraction of variance due to u_i)
```

Table A.2.: Detailed output of equation 4.2

```
. xtreg alos after aftertreat epe lie lie2 cmi cmi2 lie_cmi i.t, fe robust

Fixed-effects (within) regression               Number of obs      =       228
Group variable: i                               Number of groups   =        30

R-sq:  within  = 0.3893                         Obs per group: min =         7
       between = 0.0197                                        avg =       7.6
       overall = 0.0008                                        max =         8

                                                F(15,29)           =     22.27
corr(u_i, Xb)  = -0.5985                        Prob > F           =    0.0000

                                  (Std. Err. adjusted for 30 clusters in i)
```

alos	Coef.	Robust Std. Err.	t	P>|t|	[95% Conf.	Interval]
after	.1007612	.1206111	0.84	0.410	-.1459163	.3474387
aftertreat	.347757	.1429446	2.43	0.021	.0554025	.6401116
epe	-.510984	.1510649	-3.38	0.002	-.8199464	-.2020217
lie	1.499201	1.869156	0.80	0.429	-2.323652	5.322053
lie2	-.1301599	.1598254	-0.81	0.422	-.4570396	.1967199
cmi	6.83159	8.400364	0.81	0.423	-10.34908	24.01226
cmi2	-1.620288	1.465677	-1.11	0.278	-4.617934	1.377359
lie_cmi	-.2620452	.9524002	-0.28	0.785	-2.209922	1.685832
t						
2005	-.1384294	.1064681	-1.30	0.204	-.3561811	.0793223
2006	-.0989716	.148303	-0.67	0.510	-.4022854	.2043422
2007	.0806918	.1776744	0.45	0.653	-.2826931	.4440767
2008	.0235428	.1558184	0.15	0.881	-.2951416	.3422273
2009	.1119093	.1782199	0.63	0.535	-.2525914	.47641
2010	.2770154	.1985626	1.40	0.174	-.1290906	.6831214
2011	.3455725	.2271214	1.52	0.139	-.1189429	.810088
_cons	2.853439	6.54919	0.44	0.666	-10.54116	16.24804
sigma_u	1.3892538					
sigma_e	.3969448					
rho	.92452297	(fraction of variance due to u_i)				

Table A.3.: Hausman test for equation 4.1

```
. hausman FE RE, sigmamore

Note: the rank of the differenced variance matrix (22) does not equal the
        number of coefficients being tested (26); be sure this is what you
        expect, or there may be problems computing the test.  Examine the
        output of your estimators for anything unexpected and possibly
        consider scaling your variables so that the coefficients are on a
        similar scale.
```

	Coefficients (b) FE	(B) RE	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
after	-.0168724	-.0555332	.0386608	.0080447
aftertreat	.0022648	-.0102543	.0125191	.0095925
epe	-.0533827	-.0529213	-.0004614	.0069172
lie	-.6653101	-2.922568	2.257258	2.784381
lov	2.332801	5.386767	-3.053967	.7249893
lem	1.151434	2.969073	-1.817639	.8449836
los	.0989758	.2577157	-.1587399	.236657
lds	.3191233	-.2869755	.6060987	.2464403
cmi	-4.095271	.2794672	-4.374738	2.300896
lie2	.1090098	-.201113	.3101228	.1117105
lov2	.0697769	.2518887	-.1821118	.0275118
lem2	.0947857	.1364103	-.0416246	.0608476
los2	-.0040511	.0109145	-.0149656	.00506
lds2	.0068991	.0011397	.0057593	.0030438
cmi2	-.0430609	-.6115165	.5684557	.1537789
lie_ov	-.2103285	.0778985	-.288227	.1128393
lie_os	.219921	.087751	.13217	.033841
lie_em	-.1172809	.4063761	-.523657	.196353
lie_ds	.0104246	.0659273	-.0555027	.026908
lie_cmi	.3973711	.1963221	.201049	.229694
lov_os	-.077373	-.0716032	-.0057699	.0335745
lov_em	-.0807247	-.8492935	.7685688	.1452855
lov_ds	-.002848	-.1481917	.1453437	.0300849
lem_os	-.0986528	-.0535615	-.0450913	.0199338
lem_ds	-.0305286	.0989269	-.1294555	.0283997
los_ds	-.0090147	.025325	-.0343397	.0130208

```
                          b = consistent under Ho and Ha; obtained from xtreg
           B = inconsistent under Ha, efficient under Ho; obtained from xtreg

    Test:  Ho:  difference in coefficients not systematic

                  chi2(22) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                           =       87.71
                Prob>chi2 =      0.0000
```

Table A.4.: Hausman test for equation 4.2

```
. hausman FE RE, sigmamore
```

	Coefficients (b) FE	(B) RE	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
after	.279811	.1942993	.0855117	.0296163
aftertreat	.2836619	.3249845	-.0413226	.0357907
epe	-.4486592	-.5076284	.0589692	.0278193
lie	1.991429	-2.052176	4.043605	1.079332
lie2	-.1769627	.1002054	-.2771681	.0702352
cmi	5.893363	9.790404	-3.897041	3.852097
cmi2	-1.746364	-2.297833	.5514692	.3388156
lie_cmi	-.0894484	-.1890622	.0996139	.4202903

```
                     b = consistent under Ho and Ha; obtained from xtreg
      B = inconsistent under Ha, efficient under Ho; obtained from xtreg

  Test:  Ho:  difference in coefficients not systematic

               chi2(8) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                       =       22.72
             Prob>chi2 =      0.0037
```

Table A.5.: Difference-in-differences for the treatment group's hospitals

Treatment group		LTC	ALOS
	Before	11,427	5,920
CH Alto Ave	After	11,439	6,412
	Δ	0,013	0,492
	Before	11,475	7,728
CH Barreiro-Montijo	After	11,494	8,000
	Δ	0,020	0,272
	Before	11,532	5,596
CH Entre Douro e Vouga	After	11,500	4,867
	Δ	-0,032	-0,729
	Before	12,041	6,750
CH Gaia-Espinho	After	12,058	7,280
	Δ	0,018	0,530
	Before	13,032	7,970
CH Lisboa Central	After	12,891	9,120
	Δ	-0,142	1,150
	Before	13,011	8,160
CH Lisboa Norte	After	13,017	8,337
	Δ	0,006	0,177
	Before	12,621	8,070
CH Lisboa Ocidental	After	12,523	9,307
	Δ	-0,098	1,237
	Before	10,931	5,817
CH Médio Ave	After	10,943	6,034
	Δ	0,013	0,217
	Before	12,536	5,518
CH Porto	After	12,564	6,553
	Δ	0,028	1,036
	Before	11,725	7,400
CH Setúbal	After	11,746	7,620
	Δ	0,022	0,220
	Before	11,693	6,807
CH Trás-os-Montes/Alto Douro	After	11,806	7,442
	Δ	0,113	0,635
	Before	11,360	5,658
CH Tâmega-Sousa	After	11,366	6,650
	Δ	0,006	0,993

Table A.6.: Difference-in-differences for the control group's hospitals

Control group		LTC	ALOS
	Before	11,436	7,250
CH Barlavento	After	11,409	8,400
	Δ	-0,027	1,150
	Before	12,045	7,967
CH Coimbra	After	12,010	7,840
	Δ	-0,034	-0,127
	Before	11,118	6,867
CH Cova da Beira	After	11,109	7,700
	Δ	-0,009	-0,167
	Before	11,596	6,630
CH Médio Tejo	After	11,613	7,625
	Δ	0,016	0,995
	Before	10,320	5,567
CH Póvoa Varzim-Vila do Conde	After	10,176	5,628
	Δ	-0,144	0,061
	Before	11,794	10,600
H Curry Cabral	After	11,741	9,705
	Δ	-0,052	-0,895
	Before	11,311	7,687
H Espirito Santo	After	11,348	7,224
	Δ	0,037	-0,643
	Before	11,670	7,733
H Faro	After	11,881	8,126
	Δ	0,210	0,393
	Before	10,526	6,457
H Figueira Foz	After	10,486	7,198
	Δ	-0,039	0,741
	Before	11,986	7,420
H Garcia de Orta	After	12,027	7,884
	Δ	0,041	0,464
	Before	11,144	6,646
H Infante D. Pedro	After	11,289	6,765
	Δ	0,145	0,119
	Before	9,801	8,533
H Litoral Alentejano	After	10,420	7,994
	Δ	0,618	-0,539
	Before	10,239	5,567
H Santa Maria Maior	After	10,216	6,770
	Δ	-0,022	1,203
	Before	11,302	6,660
H Santarém	After	11,365	7,197
	Δ	0,063	0,537
	Before	11,195	6,520
H Santo André	After	11,256	6,510
	Δ	0,061	-0,010

Table A.7.: Difference-in-differences for the control group's hospitals (continuation)

Control group		LTC	ALOS
	Before	12,737	8,577
H São João	After	12,787	8,158
	Δ	0,050	-0,419
	Before	11,593	7,267
H São Teotónio	After	11,596	7,882
	Δ	0,003	0,615
	Before	12,678	8,850
H Universidade Coimbra	After	12,660	8,300
	Δ	-0,018	-0,550

Table A.8.: Merger dates of the treatment group's hospitals

Hospital	Year
CH Alto Ave	2007
CH Barreiro-Montijo	2010
CH Entre Douro E Vouga	2009
CH Gaia-Espinho	2007
CH Lisboa Norte	2008
CH Lisboa Central	2007
CH Lisboa Ocidental	2006
CH Médio Ave	2007
CH Porto	2008
CH Setúbal	2006
CH Tâmega-Sousa	2008
CH Trás-os-Montes/Alto Douro	2007

Notes: This table expresses the dates according to the method expressed in section 2.2.3. Therefore, the displayed years represent the first year each of the hospitals is in the after period, in other words, the first year of the institution as a merged hospital.

Table A.9.: Composition of the merged hospitals, as used in the sample

Merged hospital	Composition of the merged hospital
CH Entre o Douro e Vouga	H São Sebastião
	H São João da Madeira
	H São Miguel
CH Médio Ave	H Conde de São Bento
	H São João de Deus
CH Lisboa Central	H São José
	H Santo António dos Capuchos
	H Santa Marta
	H Dona Estefânia
CH Porto	H Santo António
	Maternidade Júlio Dinis
	H Pediátrico Maria Pia
CH Barreiro Montijo	H Distrital do Montijo
	H Nossa Senhora do Rosário
CH Setúbal	H Ortopédico Sant'Iago do Outão
	H São Bernardo
CH Vila Nova de Gaia/Espinho	H Eduardo Santos Silva
	H Distrital Vila Nova de Gaia
	H Nossa Senhora da Ajuda
CH Lisboa Ocidental	H Egas Moniz
	H São Francisco Xavier
	H Santa Cruz
CH Tâmega e Sousa	H Padre Américo
	H de Amarante
CH Lisboa Norte	H Santa Maria
	H Pulido Valente
CH Trás-os-Montes e Alto Douro	H Dom Luiz I
	H São Pedro de Vila Real
	H Chaves
	H Lamego
CH Alto Ave	H Fafe
	H Guimarães

Table A.10.: Correlation between the variables of the data set

	treat	after	aftertreat	epe	ltc	alos	lie	locv	lem	los	lds	cmi
treat	1.0000											
after	-0.0889	1.0000										
aftertreat	0.6470	0.4563	1.0000									
epe	-0.1486	0.4083	0.2699	1.0000								
ltc	0.3350	0.0066	0.2663	0.0299	1.0000							
alos	-0.2341	0.2853	0.0233	-0.0259	0.4065	1.0000						
lie	0.4239	-0.1386	0.2631	0.0333	0.8716	0.0765	1.0000					
lov	0.4944	0.0643	0.3849	0.0844	0.8660	0.1280	0.8409	1.0000				
lem	0.4942	-0.1213	0.2831	0.0456	0.6484	-0.0540	0.7951	0.6855	1.0000			
los	0.2852	0.0033	0.2286	0.0295	0.7359	0.3350	0.6737	0.6761	0.5500	1.0000		
lds	0.1725	0.4282	0.3724	0.3059	0.4677	0.0412	0.4065	0.5801	0.3605	0.3237	1.0000	
cmi	0.0019	0.2722	0.1453	-0.0749	0.5626	0.6624	0.2470	0.4424	0.1065	0.3387	0.3401	1.0000

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