

# The Public Sector Comparator of PPP: An empirical evaluation in the Healthcare Sector

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Incomplete. Comments Welcome.

## ABSTRACT

The public sector comparator (PSC) is an official estimate of how much a project would cost if it was carried out by government in the usual way, that is with production by public sector entities or with traditional procurement. The PSC defines the advantage in the formation of a public private partnership (PPP) since it is the comparison between this parameter and the cost that emerges as the outcome of competitive bidding by potential private partners that provides an estimate of the economic advantages of a PPP project.

Typically the definition of the PSC is the result of a complex process that hinders its transparency, making it difficult to demonstrate that mistakes, biases and manipulation did not contaminate official PSC values. The aim of this work is to suggest a general approach to providing an external benchmark for the PSC using public data and to illustrate that approach using the case of health sector PPPs. We obtain estimates for the PSC of the first two hospitals built using PPP in Portugal (Braga and Cascais) and we compare them to the official PSC values.

We find that the official PSCs for construction costs in both cases were close to the upper limit of our prediction confidence intervals but that the PSC for operations were very different: in Braga they were well above the upper limit of our prediction and in Cascais they were close to the lower limit of our prediction. As it turned out, the bidding process in Braga lead to a winning bid substantially below the PSC, proving that competition eliminated at least partially the upper bias in the PSC estimate.

Keywords: PPP, Public sector comparator, Cost function

JEL codes: D24, H43, L32, L33

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## 1. INTRODUCTION

There are multiple reasons for the use of Public Private Partnerships (PPP), ranging from a benevolent belief that PPP are more efficient than traditional procurement or direct public sector production to a more cynical view that PPP may shelter governments and politicians' from accountability obligations by conveniently using off budget financing or turning PPP into instruments to provide rents to powerful interest groups.

The efficiency advantage of PPP can be gauged by comparing costs incurred by society when governments carry out projects in a traditional way to the costs for society of developing an otherwise similar project using a PPP. The costs of a project carried out by government are usually known as the Public Sector Comparator (PSC). The PSC is a key parameter of the PPP process. This parameter defines whether or not there is an advantage in forming a partnership as it is the comparison between this parameter and the outcome of a competitive bidding process that provides an estimate of the economic advantages of a PPP project.

In practice the PSC is often used as a parameter in the bidding process, defining a hurdle that works as a ceiling on private firms' bids. A low PSC puts more pressure on firms to minimize costs but a higher PSC makes a given project more attractive to potential private partners. Given its central role it is not surprising that official values for the PSCs are often accused of being generated by processes that are too complex and not transparent enough. Since PSC are generated by a process that is tantamount to a "black box" they are often the subject of controversy. The bottom line is that it would be useful to have clear terms of comparison to the official values for the PSC.

The aim of this work is to provide an external view of the PSC, using public data to get estimates of their magnitude. This paper adds to the existing literature since we present, as far as we know for the first time, an empirical analysis of the value of the public sector comparator used in actual PPP. For that we will use data from the Portuguese National Health Service.

Portugal has an extensive experience using Public Private Partnerships (PPP) for roads, water management, energy production and distribution, among others areas. There were road projects in the 1970s that could be considered predecessors of PPP. The first initiatives that are formally PPP, also in the transportation area, date back to the 1990s (OPPP, 2011). According to Moreno [2010, p.100] Portugal is the European country with the highest use of PPP as measured by the ratio of expenditures on PPP to GDP or to the overall State Budget.

More recently, PPP have included projects in health, in particular projects including both the construction and in some cases the operation of hospitals integrated in the National Health Service. In this paper we concentrate on the first two hospital projects (Braga and Cascais) and provide estimates of their PSC based on publicly available data and contrast our estimates with the official values for the PSCs.

Since we are dealing with construction and operation the analysis is based on two distinct sets of data. The first dataset is small but crucial since it covers construction costs and basic characteristics of hospitals build by Government using traditional procurement. The second data set covers the outputs and operating costs for almost all hospitals in the National Health Service. From these datasets we estimate construction and operation cost functions that summarize and quantify public sector cost structures. We then use the data on hospitals characteristics and output of clinical services defined in the PPP contracts and the estimated cost functions to generate our estimates for the PSC.

We find that the official PSCs for construction costs in both cases were close to the upper limit of our prediction confidence intervals but that the PSC for operations were very different: in Braga they were well above the upper limit of our prediction and in Cascais they were close to the lower limit of our prediction. As it turned out, the bidding process in Braga lead to a winning bid substantially below the PSC, proving that competition eliminated at least partially the upper bias in the PSC estimate.

## 2. Public sector comparator

The PSC is usually the result of long and complex estimations. In the case of engineering projects the estimates mix unit costs from past experience with estimates by costing the separately a multitude of components of complex structures. Sometimes input requirement lists can be quite long and it may not be obvious what the relevant market prices are or even what are the right amounts for some of these inputs, ranging from very specialized types of labor to energy and raw materials. Similar problems arise for complex services, as it is the case in the provision of hospital based healthcare. Oftentimes the public sector costs are not explicit as when a project involves the use of scarce land already in the public domain or the use of funds from public sector capital budgets. The bottom line is that the usual way to arrive at a PSC estimate is long, complex and not at all transparent to the public.

It is not difficult to picture situations where government officials introduce biases in an estimate, pushing it above or below the right value. One can think of circumstances where government officials arrive at a PSC that is too high, because they want to favor private sector interests or because they want to make sure a PPP project that may not be socially desirable but is politically convenient moves ahead, particularly if it can be done off budget.

It is also possible to think of biases leading to a PSC that is too low with the purpose of extracting more surplus from private partners. This last case is usually not the one causing most concerns because nothing prevents the Government from using a bidding process where the ceiling on private sector bids is below the PSC<sup>2</sup>. In fact, it is optimal to

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<sup>2</sup> There may be special situations, for example when governments or key decision makers change and the new authorities do not feel ownership of the PPP projects or that they work to their political advantage. In these cases they may try to shut down the process in an expedient way by imposing an artificially low PSC.

design a bidding process where the ceiling is strategically chosen to maximize the gains from using PPPs. The optimal choice of the ceiling should be a function of the PSC but also of the Government's beliefs about the distribution of efficiency levels in the private sector.

Given the temptation Governments may have to manipulate the PSC as well as the margin for unintended error or bias, there is some value in coming up with a methodology to provide reasonable estimates of the PSC that have low costs and make use of publicly available information. The solution to this problem is to use historical data and some econometrics to come up with a statistically based estimate rather than then relying on costly procedures using intensively estimates and opinions by experts. All in all, this basically the same philosophical approach to problem solving that was defended by Ian Ayres in his popular book *Supercrunchers*.

### 3. METHODOLOGY

The approach chosen was based on Hedonic regressions to model the costs of infrastructure and estimates of cost functions which allows to obtain estimates, from historical data, of the expected costs of the new clinical services in hospitals, breaking them down into their operational characteristics (number of outpatient visits, hospitalizations, emergency room, outpatient surgery, etc.). Hedonic models will never replace the traditional costing methods because they use little information, but they allow you to explore possibilities and configurations before settling on a more specific design. On the other hand hedonic models allow a synthesis of modeled and quantified historical data and their use to carry out predictions, as is the case with this paper.

Due to availability of data, the baseline methodology was quite specific since it is based on the hospitals's characteristics defined in the PPP terms of reference. We estimate econometrically the model using data on historical costs. Estimate an average cost and a confidence interval for the PSC, ie, the cost to the state do the same.

The projects had two components: hospital construction and hospital operation over a given number of years. The official PSC were presented separately. Similarly, we will also present separate estimates for each component.

### 4. Data

Historical information on the construction of hospitals was collected from records concerning public hospitals in order to obtain the final costs. Information on characteristics of the investment, its size and complexity were also surveyed. Specifically, we sought information on estimates and overruns in the initial budgets, estimated durations, initially overruns and completion times, content revisions and project size, etc..

As for clinical services, we have tried to clarify the operational costs of hospitals in the government sector (SPA) as well as public corporations (EPE) of the National Health Service, taking into account the various levels of production lines: inpatient, outpatient, etc..

Data available for the study of the costs of infrastructure are very scarce. Ideally we would have at our disposal data on a large number of cases of constructing and equipping new hospitals as well as their characteristics. Relevant characteristics could be the construction area, the total number of beds, the number of intensive care beds, the number of operating rooms, the existence of transplant units, etc.. In practice the data found were well below expectations.

We were only able to find data for 10 hospitals. As for the available features common to all these hospitals end up with only the area (m<sup>2</sup>) and number of beds.

**Table 1: Relevant dates, beds and built up area**

Name of Enterprise	Bid Opening Date	Date of delivery / Inauguration	Number of Beds	Built up Area (m <sup>2</sup> )
Fernando da Fonseca Hospital	24-Jul-87	1-May-97	644	71,948
Hospital N <sup>a</sup> Sr <sup>a</sup> da Graça - Tomar	09-Feb-93	9-Aug-01	242	31,202
Pedro Hispano Hospital - Matosinhos	12-Apr-87	1-Apr-97	407	54,279
Hospital Santo Andre - Leiria	03-Jun-89	1-Apr-95	492	61.98
Hospital S. Teotonio - Viseu	23-Oct-91	01-Jul-97	524	70,697
Hospital Santa Maria da Feira	11-Sep-92	01-Jan-99	345	46,405
Hospital Barvalento Algarve	11-Aug-94	9-Apr-99	262	38,005
Hospital Centre Cova da Beira	03-Sep-93	1-Dec-99	262	44,342
Vale do Sousa Hospital	07-Jan-93	10-Aug-01	347	55,743
Rainha Santa Isabel Hospital - Torres Vedras	18-Apr-94	1-Sep-00	144	30,493

**Table 2: Costs of construction of the project, supply of the building (medical equipment, IT and others) and additional costs (€).**

Name of Enterprise	Wining bid	Correction of Prices	Correction of VAT	Revision Prices	Additional Works	Total additional	TOTAL WORK	Equipment Costs	Other Costs	TOTAL COST HOSPITAL
Fernando da Fonseca Hospital	27,985,760	8,343,623	2,819,020	10,234,376	7,315,767	28,712,786	56,698,546	27,082,097	7,593,111	91,373,754
Hospital N <sup>a</sup> Sr <sup>a</sup> da Graça - Tomar	23,379,089	4,527,349	-	147,091	3,321,146	7,995,586	31,374,675	13,134,502	484,383	44,993,560

Pedro Hispano Hospital - Matosinhos	20,878,463	8,043,568	2,303,345	6,669,738	14,289,205	31,305,856	52,184,319	15,759,209	4,898,870	72,842,398
Hospital Santo Andre - Leiria	19,377,081	8,034,412	2,554,294	8,830,678	7,580,316	26,999,700	46,376,781	19,092,681	3,514,463	68,983,925
Hospital S. Teotonio - Viseu	35,916,527	2,535,709	135,937	3,273,646	2,526,332	8,471,624	44,388,151	17,941,257	3,560,358	65,889,766
Hospital Santa Maria da Feira	29,527,599	1,575,688	-	3,392,220	1,748,960	6,716,868	36,244,467	5,495,304	3,226,452	44,966,223
Hospital Barvalento Algarve	22,255,577	2,173,159	-	421,909	1,451,717	4,046,785	26,302,362	19,340,360	2,471,975	48,114,697
Hospital Centre Cova da Beira	24,792,889	3,541,580	-	1,118,180	1,523,399	6,183,159	30,976,048	16,677,238	2,452,952	50,106,238
Vale do Sousa Hospital	36,565,003	3,960,888	-	1,637,650	1,019,024	6,617,562	43,182,565	27,858,761	2,707,040	73,748,366
Rainha Santa Isabel Hospital - Torres Vedras	16,500,231	1,392,145	-	709,789	2,873,075	4,975,009	21,475,240	13,224,807	1,281,691	35,981,738

We also collected systematic information regarding the operating costs of public facilities and data on key measures of its production. ACSS annually disclose, for each hospital and hospital, the operating costs of public hospitals:

- Number of episodes of hospitalization;
- Number of outpatient visits;
- Number of emergency;
- Number of sessions of hospital days;
- Number of outpatient surgeries.

We used data on operating costs of hospitals from 2000 to 2007, a total of 58 hospitals or hospital, followed over an average of 7.8 years.<sup>3</sup>

**Table 3: Descriptive Statistics of data on activity of Hospitals**

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
<b>Log (Total Cost)</b>	461	17.5	1.1	15.2	19.7
epe	464	0.6	0.5	0.0	1.0
<b>Log (Episodes)</b>	464	9.2	1.0	6.2	10.9

<sup>3</sup> See the Appendix for the detailed list of used hospitals.

Log (Amb Surgery.)	464	6.1	1.8	0.0	9.0
Log (ER)	464	10.8	2.7	0.0	12.5
Log (Consultations)	464	11.3	1.1	8.6	13.4
Log (Hosp. Day)	464	7.8	3.1	0.0	11.5
Log (Case Mix)	461	0.0	0.2	-0.5	0.7

**Table 4: Descriptive Statistics of Hospitals activity per year.**

Year	2000	2001	2002	2003	2004	2005	2006	2007
<b>Means</b>								
<b>Log (Total Cost)</b>	17.2	17.3	17.4	17.5	17.5	17.6	17.6	17.6
epe	0.0	0.0	0.0	0.4	0.4	0.4	0.5	0.6
Log (Episodes)	9.1	9.2	9.2	9.2	9.2	9.3	9.3	9.2
Log (Amb Surgery.)	5.3	5.6	5.8	6.2	6.2	6.2	6.4	6.8
Log (ER)	10.8	10.9	10.9	10.9	10.8	10.9	10.9	10.5
Log (Consultations)	11.1	11.2	11.2	11.3	11.3	11.4	11.4	11.5
Log (Hosp. Day)	7.3	7.4	7.4	7.8	8.1	8.1	8.1	8.2
Log (Case Mix)	-0.012	-0.104	-0.090	-0.083	-0.060	-0.037	-0.015	0.010

Although data on operating costs of National Health System hospitals are allowing some relatively detailed precision in estimates, there was no easy access to information from various PPP contracts. In order to estimate a comparable value to the PSC we used information for the specific cases of the Hospitals of Cascais and Braga.

## 5. Econometric estimates of costs for infrastructure

With the data in Tables 1 and 2 we estimate the regressions underlying Figures 1 and 2, which show the relationship between the number of beds and construction costs between the hospital and the cost of equipment and the hospital area.

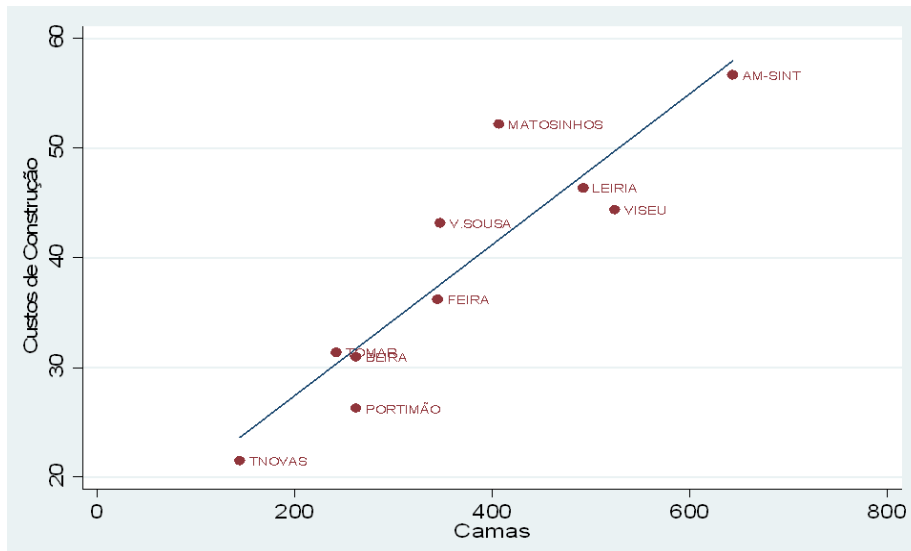


Figure 1: Costs of construction and number of beds

Figure 1 indicates that although the number of observations is small, there is a good quality of the regression adjustment.<sup>4</sup>

Figure 2 shows that in the case of equipment there is an "outlier" observation, ie an extreme and misaligned observation: the case of the Feira Hospital, where equipment costs are well below the statistical norm. For this reason, the Feira Hospital was not included in the sample to estimate the regression with explanatory equipment costs.

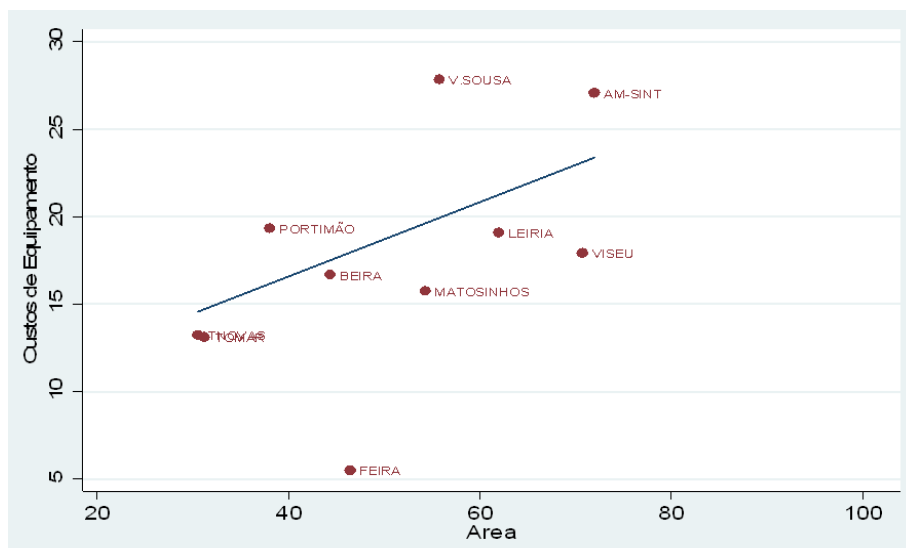


Figure 2: Cost of equipment and the hospital area.

The equipment costs are significantly explained by the construction area of the hospital when we exclude the Feira Hospital. Thus, we can use the regression estimates to predict costs.

<sup>4</sup> See the Appendix for results of all regressions. Interestingly the variable time is never statistically significant.

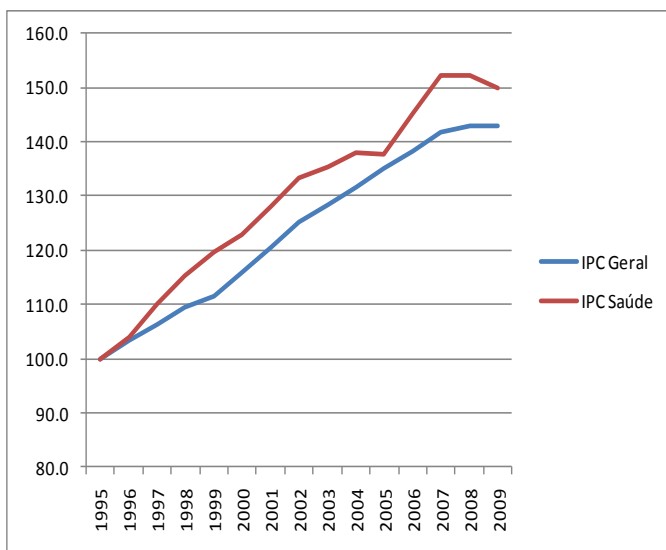


Less important but still modeled are the other costs. In this case it was possible to obtain a statistically significant model explaining "Other Costs" based on the built up area. Finally, we estimate a statistically significant regression explaining total costs for the building area.

### CPI correction Health

The cost values were corrected by the Consumer Price Index (CPI) for the health sector. In [Figure 3](#) and Table 3 we present their values in recent years. Data values collected from the PSC to hospitals in Braga and Cascais are at 2005 and 2006 prices. Thus, for comparability reasons they are corrected by factors 1.378 and 1.453, respectively.

Figure 3: Changes in the CPI and in the health sector prices.



## 6. RESULTS

### 6.1 Estimating the Cost of Infrastructure

We predict the costs of new hospitals in Braga and Cascais as if they were built by the public sector. To compare these predictions with the PSC used, we tested two different estimation methods. All regressions reported below were made in logarithmic form, which not only allows appropriate functional specifications but also helps to minimize any heteroskedasticity problems.

Method 1 is based on a single univariate regression<sup>5</sup> in which the total cost of construction and equipment is explained by the built area of the hospital. The high collinearity prevents the simultaneous use of the area and the number of beds as explanatory variables, and we choose the area built because it is the best variable in terms of measures of goodness of fit.

<sup>5</sup> See the Appendix for detailed results.

Method 2 uses three partial models. A first sub-model explains the cost of the building only by the number of beds (the best specification found). A second submodel explains the cost of equipment for the building area. A third submodel explains the other costs (including costs overruns, extra charges etc..) also as a function of constructed area. This method 2 provides the final costs as the sum of the predictions of each of the submodels. Since it is an aggregation of forecasts of different regressions, the construction of the confidence interval can not be done using *standard* techniques. In this case this problem has been overcome by *bootstrapping predictions*, an approach to statistical inference in which builds a distribution of estimates based on the construction of multiple samples taken with replacement from the original sample available, which is treated as a population.

From methods 1 and 2 we generated forecasts and a confidence interval (95%), and subsequently all values were multiplied by the CPI to generate the estimates that can be seen in Table 4.

Table 6: Estimates obtained for the hospitals of Cascais and Braga, using two different methods.

(€ million)			Prediction Interval 95% Confidence			Official PSC
			Estimated Average	Lower Limit	Upper Limit	
<b>Method 1</b> (model area in m <sup>2</sup> )	Cascais (P 2005)	75.61	68.13	83.92	<b>80.70</b>	
	Braga (P 2006)	156.88	118.58	207.55	<b>200.00</b>	
<b>Method 2</b> (partial models with <i>bootstrap</i> )	Cascais (P 2005)	68.65	65.61	72.91	<b>80.70</b>	
	Braga (P 2006)	146.14	121.77	184.32	<b>200.00</b>	

The estimated costs suggest that the values of the public comparators are greater than the average estimates using historical construction data (even after using the health CPI). Using Method 1, the PSC are within the 95% confidence prediction interval. However, in Method 2 the PSC are above the upper limit of the confidence interval. It should be noted that the estimates use limited data, depend on the CPI - Health and do not account for the teaching hospital status in Braga, something that may justify a higher cost for the construction and other infrastructure.

## 6.2 Estimating the Cost of Clinical Services

In economic analysis it is usual to establish an econometric relationship between costs and *outputs*, the cost functions. There are many functional forms in the literature and

one of the best known and most often used is the *translog* function. In our case this takes the following form,

$$\ln(C) = \alpha + \sum_{i=1}^n \beta_i \ln Y_i + 0.5 \sum_{i=1}^n \sum_{j=1}^n \delta_{ij} \ln Y_i \ln Y_j + \sum_{h=1}^H \phi_h H_h + \sum_{t=1}^T \theta_t T_t$$

where C is the total costs, Y is the output vector measured by inpatient discharges, outpatient consultations, emergency episodes, day hospital sessions, and ambulatory surgery episodes, and H and T are dummy variables, for hospitals and years respectively.

The results obtained by a regression model with fixed effects are given in Tables 7 and 8. The results are statistically significant and the independent variables show predictive power.

Table 7: Regression statistics and number of observations.

<b>Regression of fixed effects (<i>Within</i>)</b>	
Note Number	458
Number Groups	58
Note by Group	Min = 5
	Average = 7.8
	Max = 8
F (19.57)	84.19
Prob> F	0
R-sq:	<i>Within</i> = 0.8354
	<i>between</i> = 0.8836
	<i>overall</i> = 0.7901
corr (ui, Xb)	0.8022

Table 8: Estimates of the regression of the logarithm of the total operating cost.

Log (Total Cost)	Coefficient	Deviation Pad.	t	P> t
Indicator EPE	0.033	0027	1.23	0225
Year 2001	0.117	0015	7.62	0
Year 2002	0.160	0016	9.87	0
Year 2003	0.213	0022	9.66	0
Year 2004	0.261	0028	9.17	0
Year 2005	0.298	0024	12:39	0
Year 2006	0.315	0025	12.76	0
Year 2007	0.323	0027	12:00	0
Log (Episodes)	0.807	0160	6.5	0
Log (Amb Surgery.)	0.100	0047	2.11	0040
Log (ER)	0.009	0003	2.91	0005
Log (Consultations)	0.562	0136	4.15	0
Log (Hosp. Day)	-0.319	0051	-6.21	0
Log (Case Mix)	1.925	0854	2.25	0028
Log (Epis.) * Log (Case Mix)	-0.197	0093	-2.12	0038
Log (Hosp. Day) <sup>2</sup>	-0.005	0002	-2.69	0009
Log (Epis.) * Log (Consultations)	-0.069	0016	-4.34	0
Log (surgical) * Log (ref.)	-0.008	0004	-1.92	0059
Log (Hosp. Day) * Log (Consultations)	0.036	0006	5:58	0
Constant	10,125	1221	8.29	0

### Cascais - Clinical Services

Using the regression estimates presented above, we compared the model predictions with the cost of PSC for the hospital in Cascais. We compared the predictions against the average of public hospitals for which we have historical data on construction and against the former hospital in Cascais (Table 9).

Table 9: Cascais Comparison

**Against Average Hospital**

	Estimated Average	Lower Limit	Upper Limit	PSC
2 years - Subs	45.62	42.638	48.83	
8 years - New	49.72	46.81	52.81	
VAL 10 years	345.06	324.27	367.18	<b>328.05</b>

**Against Cascais in the past**

	Estimated Average	Lower Limit	Upper Limit	PSC
2 years - subs	50.18	47.90	52.56	
8 years - new	54.69	51.07	58.56	
VAL 10 years	379.52	356.32	404.27	<b>328.05</b>

The values of the comparator for the public hospital in Cascais are below the average prediction and near the lower limit of the forecasting interval. These estimates indicate a higher level of cost pressure on clinical services than what was found for the the infrastructure.

**Braga - Clinical Services**

Using the same methodology applied for the Cascais Hospital, we compared the predictions of the cost of PSC to the hospital in Braga against the average of hospitals and against the former Hospital of St. Marcos (Table 10).

Table 10: Braga Comparison

**Against Average Hospital**

	Estimated Average	Lower Limit	Upper Limit	PSC
1 year - subs	57.74	51.77	64.40	
9 years - new	59.19	50.94	68.79	
VAL 10 years	418.25	361.91	483.51	<b>986</b>

#### Against Braga in the past

	Estimated Average	Lower Limit	Upper Limit	PSC
1 year - subs	97.08	92.48	101.90	
9 years - new	99.51	92.17	107.45	
VAL 10 years	703.16	653.66	756.49	<b>986</b>

The comparator for the case of public Braga Hospital has values well above the upper limits of prediction, unlike the situation in Cascais. As noted, these estimates do not take into account the fact that Braga's new hospital is a teaching hospital.

## 6.3 Discussion

In [Table 11](#) presents the overall results of the estimates for two scenarios: one where the costs are given by the lower estimated values and another that allows data by values estimated costs higher.

Table 11: Overall results for the estimates obtained for the hospitals of Braga and Cascais

(€ million)		Prediction Interval 95% Confidence			PSC
		Estimated Average	Lower Limit	Upper Limit	
<b>High</b>	Infraest Cascais.	75.61	68.13	83.92	
	Cascais Services	379.52	365.32	404.27	
	Total Cascais	455.13	433.45	488.19	<b>408.75</b>
	Braga Infraest.	156.88	118.58	207.55	
	Braga Services	703.16	653.66	756.49	
	Total Braga	860.04	772.24	964.04	<b>1186.3</b>
<b>Low</b>	Infraest Cascais.	68.65	59.93	78.84	
	Cascais Services	345.06	324.27	367.18	
	Total Cascais	413.71	384.20	446.02	<b>408.75</b>
	Braga Infraest.	146.14	121.77	184.32	
	Braga Services	418.25	361.91	483.51	
	Total Braga	564.39	483.68	667.83	<b>1186.3</b>

We find that the official PSCs for construction costs in both cases were close to the upper limit of our prediction confidence intervals but that the PSC for operations were very different: in Braga they were well above the upper limit of our prediction and in Cascais they were close to the lower limit of our prediction.

## 7. CONCLUSIONS

The results show that the PSC infrastructure are above the average of the estimates for historical data.

The PSC for clinical services seem to be substantially different, as in the case of the new hospital in Braga values are presented clearly above average and even above the upper limit of the forecast range, while for the case of Cascais values are below average and close to or even below the lower limit of the forecast range.

The total value of the PSC seems to be dominated by clinical services.

As it turned out, the bidding process in Braga lead to a winning bid substantially below the PSC, proving that competition eliminated at least partially the upper bias in the PSC estimate. This is good news from the point of view that competition in this case seems to have worked.

The case of Cascais is also interesting. The rate of return on the project for the firm that won the Cascais bid is said to be lower than expectations and the press has reported that the owner is trying to sell the concern and extricate itself from the PPP contract (“add press reference”). Given the low PSC initially defined, by comparison with our estimates, these results may not be entirely surprising.

## References

(To be added)



## Statistical Appendix

This appendix reports the technical details on the methodology used.

Table A0. Data Base

Hospital	CEdif	CEquip	OutCus	Custos	Camas	Area	Ano
AMADORA-SINTRA	56.6985	27.0821	7.59311	91.3738	644	71.948	1987
Nª SRª DA GRAÇA - TOMAR	31.3747	13.1345	.484383	44.9936	242	31.202	1993
PEDRO HISPANO - MATOSINHOS	52.1843	15.7592	4.89887	72.8424	407	54.279	1987
SANTO ANFRÉ - LEIRIA	46.3768	19.0927	3.51446	68.9839	492	61.98	1989
S. TEOTÓNIO - VISEU	44.3882	17.9413	3.56036	65.8898	524	70.697	1991
SANTA MARIA DA FEIRA	36.2445	5.4963	3.22645	44.9672	345	46.405	1992
BARLAVENTO ALGARVIO PORTIMÃO	26.3024	19.3404	2.47198	48.1147	262	38.005	1994
HOSPITALAR COVA DA BEIRA	30.976	16.6772	2.45295	50.1062	262	44.342	1993
VALE DO SOUSA (INCLUI A PSIQUIATRIA)	43.1826	27.8588	2.70704	73.7484	347	55.743	1993
RAINHA SANTA ISABEL TORRES NOVAS	21.4752	13.2248	1.28169	35.9817	144	30.493	1994
Cascais	.	.	.	.	253	45.863	.
Braga	.	.	.	.	705	102.407	.

Costs in Millions €.

Table A.1. Regression of the Cost of Construction

reg LCEdif LCAM

Source	SS	df	MS	Number of obs =	10
Model	.765679554	1	.765679554	F( 1, 8) =	53.88
Residual	.113687639	8	.014210955	Prob > F =	0.0001
Total	.879367193	9	.097707466	R-squared =	0.8707
				Adj R-squared =	0.8546
				Root MSE =	.11921

LCEdif	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
LCamas	.6607523	.0900175	7.34	0.000	.4531716 .8683329
Constante	-.2278363	.5254787	-0.43	0.676	-1.439592 .9839198

Note that the time variable did not prove statistically significant in any of the regressions presented in this appendix.

### Forecasts for the logarithms of the costs of the hull and Braga

Threshold Limit forecast Hospital Inf Sup

Hospital	Forecast	Limit Inf	Limit Sup
		IC 95%	IC 95%
Cascais	3.428363	3.322732	3.533995
Braga	4.105508	3.929779	4.281237

Note: STAT command used was "predictnl LCEdhat = predict (), ci (lled ulEd) "

Table A.2. Regression of the equipment costs (excluding H Fair)

reg LCEquip LArea if CEquip>5.5

Source	SS	df	MS	Number of obs =	9
Model	.278139393	1	.278139393	F( 1, 7) =	6.41
Residual	.30381083	7	.043401547	Prob > F =	0.0391
Total	.581950223	8	.072743778	R-squared =	0.4779
				Adj R-squared =	0.4034
				Root MSE =	.20833

LCEquip	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]
LArea	.5663834	.223734	2.53	0.039	.0373367 1.09543
Constante	.7056202	.8719432	0.81	0.445	-1.356198 2.767438

### Forecasts for the logarithms of the costs of the equipment in Cascais and Braga

Hospital	Forecast	Limit Inf	Limit Sup
		IC 95%	IC 95%
Cascais	2.87241	2.705242	3.039577
Braga	3.327384	2.900844	3.753923

**Table A.3. Regression of Other Costs**

reg LCOu LArea

Source	SS	df	MS			
Model	3.60294957	1	3.60294957	Number of obs =	10	
Residual	1.51415821	8	.189269776	F( 1, 8) =	19.04	
Total	5.11710778	9	.568567532	Prob > F =	0.0024	
				R-squared =	0.7041	
				Adj R-squared =	0.6671	
				Root MSE =	.43505	

LCOu	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
LArea	2.036112	.4666735	4.36	0.002	.9599606	3.112262
Constante	-6.936749	1.815962	-3.82	0.005	-11.12437	-2.749132

**Forecasts for Other Costs of logarithms in Cascais and Braga**

Hospital	Previsão	Limite Inf IC 95%	Limite Sup IC 95%
Cascais	.8527182	.5301028	1.17533
Braga	2.488319	1.62225	3.354389

**Table A.4. Regression of Total Costs**

. reg LCustos LArea

Source	SS	df	MS			
Model	.617003611	1	.617003611	Number of obs =	10	
Residual	.158146185	8	.019768273	F( 1, 8) =	31.21	
Total	.775149796	9	.086127755	Prob > F =	0.0005	
				R-squared =	0.7960	
				Adj R-squared =	0.7705	
				Root MSE =	.1406	

LCustos	Coef.	Std. Err.	t	P> t	[95% Conf. Interval]	
LArea	.8425901	.1508193	5.59	0.001	.4948002	1.19038
_cons	.7815561	.5868817	1.33	0.220	-.5717956	2.134908

**Forecasts for the logarithms of the total costs in Cascais and Braga**

Hospital	Previsão	Limite Inf IC 95%	Limite Sup IC 95%
Cascais	4,005018	3,900755	4,109281
Braga	4,681868	4,401972	4,961763

Note: The exponential average of the residuals is 1.007816, so no need to use a correction in the forecast as the estimator is "smearing"

The list of hospitals or hospitals whose data were used in the estimation of operating costs is in Table A.5.

**Table A.5. Hospitals and medical centers**

**EPE hospitals in 2007**

1	CH Alto Ave
2	CH Alto Minho
3	CH Baixo Alentejo
4	CH Coimbra
5	CH Cova Beira
6	CH do Barlavento Algarvio

---

7	CH do Porto
8	CH Lisboa Norte
9	CH Lx Central
10	CH Lx Ocidental
11	CH Médio Ave
12	CH Médio Tejo
13	CH Nordeste
14	CH Setúbal
15	CH Tâmega e Sousa
16	CH Trás-os-Montes e Alto Douro
17	CH VN Gaia / Espinho
18	H de Nossa Senhora do Rosário, - Barreiro
19	H do Espírito Santo - Évora
20	H Garcia de Orta, - Almada
21	H Infante D. Pedro, - Aveiro
22	H S. Sebastião, - Vila da Feira
23	H S. Teotónio, - Viseu
24	H Santa Maria Maior, - Barcelos
25	H Santo André, - Leiria
26	H São João - Porto
27	HD da Figueira da Foz,
28	HD de Santarém,
29	IPOFG - CRO de Coimbra,
30	IPOFG - CRO de Lisboa,
31	IPOFG - CRO do Porto,
32	ULS de Matosinhos,
33	ULS Norte Alentejano

#### Outros Hospitais - SPA

1	CH da Póvoa do Varzim/Vila do Conde
2	CH das Caldas da Rainha
3	CH de Cascais
4	CH de Torres Vedras
5	H Amato Lusitano - Castelo Branco
6	H Curry Cabral - Lisboa
7	H da Universidade de Coimbra
8	H Distrital de Águeda
9	H Distrital de Faro
10	H Distrital de São João da Madeira
11	H Reynaldo dos Santos - Vila Franca de Xira
12	H São Marcos - Braga
13	H Sousa Martins – Guarda
14	H Bernardino Lopes de Oliveira - Alcobaça
15	H Cândido de Figueiredo - Tondela
16	H Distrital de Pombal
17	H do Litoral Alentejano - Santiago do Cacém
18	H do Montijo
19	H Dr Francisco Zagalo - Ovar
20	H José Luciano de Castro - Anadia
21	H Nossa Senhora da Assunção - Seia
22	H Nossa Senhora da Conceição - Valongo
23	H São Miguel - Oliveira de Azeméis
24	H São Pedro Gonçalves Telmo - Peniche
25	H Visconde de Salreu - Estarreja

---

**Table A.6. Estimation of the translog cost function, global**

```

xi: xtreg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia, fe robust
Fixed-effects (within) regression      Number of obs   =      458
Group variable: id                     Number of groups =      58

R-sq:  within = 0.8354                  Obs per group:  min =      5
        between = 0.8836                  avg =      7.9
        overall = 0.7901                  max =      8

corr(u_i, Xb) = 0.8022                  F(19,57)        =      84.19
                                                Prob > F         =      0.0000

```

(Std. Err. adjusted for 58 clusters in id)

	Coef.	Robust Std. Err.	t	P> t	[95% Conf. Interval]	
lcustot						
epe	.032704	.0266325	1.23	0.225	-.0206266	.0860347
_Iano_2001	.116951	.015347	7.62	0.000	.0862192	.1476828
_Iano_2002	.1600487	.0162081	9.87	0.000	.1275925	.1925049
_Iano_2003	.2132896	.0220761	9.66	0.000	.1690829	.2574962
_Iano_2004	.260832	.0284319	9.17	0.000	.2038982	.3177659
_Iano_2005	.298237	.0240756	12.39	0.000	.2500265	.3464475
_Iano_2006	.3153988	.0247204	12.76	0.000	.265897	.3649005
_Iano_2007	.3233487	.0269476	12.00	0.000	.2693871	.3773102
lepisodios	.8065344	.1595072	5.06	0.000	.4871267	1.125942
lciramb	.0998616	.0473955	2.11	0.040	.0049537	.1947694
lurgencias	.0089877	.0030901	2.91	0.005	.0027998	.0151755
lconsultas	.562371	.1356733	4.15	0.000	.2906899	.8340521
lhdia	-.3188826	.0513665	-6.21	0.000	-.4217422	-.2160229
licm_drgs	1.92486	.8538818	2.25	0.028	.2149911	3.634729
lepi_icmdrgs	-.1970473	.0929037	-2.12	0.038	-.3830837	-.0110108
lhdia2	-.0049511	.0018433	-2.69	0.009	-.0086423	-.0012599
lepi_cons	-.0685224	.0157956	-4.34	0.000	-.1001526	-.0368922
lcons_cir	-.0082819	.0043048	-1.92	0.059	-.0169021	.0003383
lcons_hdia	.0359034	.0064381	5.58	0.000	.0230113	.0487954
_cons	10.12548	1.220862	8.29	0.000	7.680741	12.57021

The two following tables contain the STATA code used to produce estimates of operating costs of hospitals. Note that on average, SPA hospitals are 57% of the sample and SPC hospitals the remaining 43%.

**Table A.7. Procedures for comparing the expected costs with the PSC - Cascais**

1. Without fixed effects

a) 8 years

```
xi: xtreg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia, fe robust
adjust epe=0.57 _Iano_2001=0 _Iano_2002=0 _Iano_2003=0 _Iano_2004=0 _Iano_2005=0
_Iano_2006=0 _Iano_2007=1 lepisodios=9.669219857 lciramb=8.730690366
lurgencias=11.6086083 lconsultas=11.64302347 lhdia=9.199885914 licm_drgs=-
0.248461359 lepi_icmdrgs=-2.402427509 lhdia2=84.63790083 lepi_cons=112.5789537
lcons_cir=101.6516328 lcons_hdia=107.1144876, ci level(95)
```

b) 2 years

```
xi: xtreg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia, fe robust
adjust epe=0.57 _Iano_2001=0 _Iano_2002=0 _Iano_2003=0 _Iano_2004=0 _Iano_2005=0
_Iano_2006=0 _Iano_2007=1 lepisodios=9.224341892 lciramb=7.993957548
lurgencias=11.76951153 lconsultas=11.20279326 lhdia=8.609590041 licm_drgs=-
0.030459207 lepi_icmdrgs=-0.280966144 lhdia2=74.12504067 lepi_cons=103.3383952
lcons_cir=89.55465376 lcons_hdia=96.45145731, ci level(95)
```

2. With fixed effects

a) 8 years

```
xi: reg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia i.id, robust
adjust epe=0.57 _Iano_2001=0 _Iano_2002=0 _Iano_2003=0 _Iano_2004=0 _Iano_2005=0
_Iano_2006=0 _Iano_2007=1 lepisodios=9.669219857 lciramb=8.730690366
lurgencias=11.6086083 lconsultas=11.64302347 lhdia=9.199885914 licm_drgs=-
0.248461359 lepi_icmdrgs=-2.402427509 lhdia2=84.63790083 lepi_cons=112.5789537
lcons_cir=101.6516328 lcons_hdia=107.1144876 if id==12, ci level(95)
```

b) 2 years

```
xi: reg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia i.id, robust
adjust epe=0.57 _Iano_2001=0 _Iano_2002=0 _Iano_2003=0 _Iano_2004=0 _Iano_2005=0
_Iano_2006=0 _Iano_2007=1 lepisodios=9.224341892 lciramb=7.993957548
lurgencias=11.76951153 lconsultas=11.20279326 lhdia=8.609590041 licm_drgs=-
0.030459207 lepi_icmdrgs=-0.280966144 lhdia2=74.12504067 lepi_cons=103.3383952
lcons_cir=89.55465376 lcons_hdia=96.45145731 if id==12, ci level(95)
```

**Table A.7. Procedures for comparing the expected costs with the PSC - Braga**

1. Without fixed effects

a) 9 years

```
xi: xtreg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia, fe robust
adjust epe=0.57 _Iano_2001=0 _Iano_2002=0 _Iano_2003=0 _Iano_2004=0 _Iano_2005=0
_Iano_2006=0 _Iano_2007=1 lepisodios=10.04780432 lciramb=8.70582811
lurgencias=12.13539264 lconsultas=12.49375972 lhdia=10.31028511 licm_drgs=-
0.224394333 lepi_icmdrgs=-2.254670351 lhdia2=106.301979 lepi_cons=125.5348529
lcons_cir=108.7685246 lcons_hdia=128.8142247, ci level(95)
```

b) 1 year

```
xi: xtreg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia, fe robust
adjust epe=0.57 _Iano_2001=0 _Iano_2002=0 _Iano_2003=0 _Iano_2004=0 _Iano_2005=0
_Iano_2006=0 _Iano_2007=1 lepisodios=10.10016392 lciramb=8.517193191
lurgencias=12.06631045 lconsultas=12.3876189 lhdia=10.51417661 licm_drgs=-
0.052978925 lepi_icmdrgs=-0.535095825 lhdia2=110.5479098 lepi_cons=125.1169815
lcons_cir=105.5077434 lcons_hdia=130.2456129, ci level(95)
```

2. With fixed effects

a) 9 years

```
xi: reg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia i.id, robust
adjust epe=0.57 _Iano_2001=0 _Iano_2002=0 _Iano_2003=0 _Iano_2004=0 _Iano_2005=0
_Iano_2006=0 _Iano_2007=1 lepisodios=10.04780432 lciramb=8.70582811
```

```
lurgencias=12.13539264 lconsultas=12.49375972 lhdia=10.31028511 licm_drgs=-  
0.224394333 lepi_icmdrgs=-2.254670351 lhdia2=106.301979 lepi_cons=125.5348529  
lcons_cir=108.7685246 lcons_hdia=128.8142247 if id==8, ci level(95)
```

b) 1 year

```
xi: reg lcustot epe i.ano lepisodios lciramb lurgencias lconsultas lhdia  
licm_drgs lepi_icmdrgs lhdia2 lepi_cons lcons_cir lcons_hdia i.id, robust  
adjust epe=0.57 _Iano_2001=0 _Iano_2002=0 _Iano_2003=0 _Iano_2004=0 _Iano_2005=0  
_Iano_2006=0 _Iano_2007=1 lepisodios=10.10016392 lciramb=8.517193191  
lurgencias=12.06631045 lconsultas=12.3876189 lhdia=10.51417661 licm_drgs=-  
0.052978925 lepi_icmdrgs=-0.535095825 lhdia2=110.5479098 lepi_cons=125.1169815  
lcons_cir=105.5077434 lcons_hdia=130.2456129 if id==8, ci level(95)
```