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 ensure 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.

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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 that PPP may be turned into instruments to provide rents to powerful interest groups.

The efficiency advantage of PPP can be gauged by comparing costs to society when governments carry out projects in a traditional way to the costs 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 and 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 the subject of controversy with accusations of being generated by "black box" processes that are too complex and not transparent enough. 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 Government 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 PPP 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 both 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 the 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 data on hospitals characteristics, the 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. As for Cascais, the press has reported that the hospital is having financial difficulties. It could be that the PSC was quite low and that the even lower bid that won the contest may have be an example of the winner's curse.

2. Public sector comparator

The PSC is usually the aggregate result of large numbers of partial estimates. In the case of engineering projects the estimates combine unit costs from past experience with estimates that cost 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 should be 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 it is the case when a project involves the use of scarce land already in the public domain or the use of earmarked 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. All these cases are examples of strategic misrepresentation (Flyvbjerg, 2008).

It is also possible to think of biases leading to a PSC that is too low with the purpose of extracting larger surpluses 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[2]. In fact, it is optimal to 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 and using expert opinions. All in all, this is basically the same philosophical approach to problem solving that was defended by Meehl (1954) and Tversky and Kahneman (1974).

On top of all the hypothetical political reasons for introducing biases, we cannot forget that mistakes might occur naturally. Thus, public officials may make significant mistakes just because "to err is human". Kahneman and Tversky (1979) introduce the planning fallacy, human beings are prone to error and sometimes committees can also produce estimates that are very far from reality. Flyvbjerg (2008) explains the dangers of relying solely on engineering expertise to generate project forecasts and documents a series of errors to avoid in public projects. He emphasizes that mistakes are not due to poor data or models but instead take the form of systematic biases, such as the "optimism bias", that do not tend to disappear with experience.

3. METHODOLOGY

The approach chosen was to use hedonic regressions to model the costs of infrastructures and estimates of hospital cost functions to obtain estimates of the expected costs of the new clinical services in hospitals, breaking them down into their operational characteristics (number of inpatient stays, outpatient visits, outpatient services, day surgeries and emergency care). Hedonic models do not replace the traditional costing methods because they use little information. On the other hand hedonic models allow a synthesis of modeled and quantified historical data and they can be used conveniently to carry out predictions, as is the case with this paper.

The baseline methodology is based on the hospitals' characteristics defined in the PPP terms of reference. In a first step, we estimate econometrically the model using historical data on costs and characteristics. In a second step, we predict the mean and a confidence interval for the PSC, i.e., the cost for the Government to build and operate the projects.

[2] 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 these 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.

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

We searched for historical data on public hospitals. We collected information on costs, project characteristics including multiple size measures. As for clinical services, we have collected data on the operational costs of the two types of National Health Service (NHS) hospitals: administrative sector institutions (SPA) and government owned corporations (EPE). The data takes into account the main production lines: inpatient admissions, outpatient visits, outpatient services, day surgeries and emergency care. We also have data on the average complexity of hospital care measured by a case mix index.

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

We were able to find data for 10 hospitals. The available measures common to all these hospitals were the built up area (m^2) and number of beds. A description of the data can be found in Tables 1 and 2.

Table 1: Relevant dates, beds and built up area

Hospital	Bid Opening Date	Date of delivery / Inauguration	Number of Beds	Built up Area ($m^{2)}$
Fernando da Fonseca Hospital	24-Jul-87	1-May-97	644	71,948
Hospital N ª Sr ª 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 (€).

Hospital	Wining bid	Total additional	TOTAL WORK	Equipment Costs	Other Costs	TOTAL COST HOSPITAL
Fernando da Fonseca Hospital	27,985,760	28,712,786	56,698,546	27,082,097	7,593,111	91,373,754
Hospital N ª Sr ª da Graça - Tomar	23,379,089	7,995,586	31,374,675	13,134,502	484.383	44,993,560
Pedro Hispano Hospital - Matosinhos	20,878,463	31,305,856	52,184,319	15,759,209	4,898,870	72,842,398
Hospital Santo Andre - Leiria	19,377,081	26,999,700	46,376,781	19,092,681	3,514,463	68,983,925
Hospital S. Teotonio - Viseu	35,916,527	8,471,624	44,388,151	17,941,257	3,560,358	65,889,766
Hospital Santa Maria da Feira	29,527,599	6,716,868	36,244,467	5,495,304	3,226,452	44,966,223
Hospital Barvalento Algarve	22,255,577	4,046,785	26,302,362	19,340,360	2,471,975	48,114,697
Hospital Centre Cova da Beira	24,792,889	6,183,159	30,976,048	16,677,238	2,452,952	50,106,238
Vale do Sousa Hospital	36,565,003	6,617,562	43,182,565	27,858,761	2,707,040	73,748,366
Rainha Santa Isabel Hospital - Torres Vedras	16,500,231	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 and the volume of:

- inpatient admissions;
- day surgeries;
- outpatient visits:
- outpatient services
- emergencies;

We used data on operating costs of hospitals from 2000 to 2007, a total of 58 hospitals or hospital centers, followed over an average of 7.8 years.[3] A description of the data can be found in Tables 3 and 4.

Table 3: Descriptive Statistics of data on activity of Hospitals

Variable	Observations	Mean	Standard Deviation
Log (Total Cost)	461	17.5	1.1
EPE	464	0.6	0.5
Log (Inpatient Episodes)	464	9.2	1.0
Log (Day Surgeries)	464	6.1	1.8
Log (Emergencies)	464	10.8	2.7
Log (Outpatient Visits)	464	11.3	1.1
Log (Outpatient Services)	464	7.8	3.1
Log (Case Mix)	461	0.0	0.2

[3] See the Appendix for the list of hospitals used.

Table 4: Hospitals activity per year.

Year	2000	2001	2002	2003	2004	2005	2006	2007
Means								
Log (Total Cost)	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 (Inpatient Episodes)	9.1	9.2	9.2	9.2	9.2	9.3	9.3	9.2
Log (Day Surgeries)	5.3	5.6	5.8	6.2	6.2	6.2	6.4	6.8
Log (Emergencies)	10.8	10.9	10.9	10.9	10.8	10.9	10.9	10.5
Log (Outpatient Visits)	11.1	11.2	11.2	11.3	11.3	11.4	11.4	11.5
Log (Outpatient Services)	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 allow for some precision in estimates, there was no comparable access to information on the various PPP contracts. In order to estimate reference values that could be used as PSCs we used information for the specific cases of the new Hospitals of Cascais and Braga.

5. Econometric estimates of costs for infrastructure

Using the data in Tables 1 and 2 we estimate the regressions underlying Figures 1 and 2. Figure 1 shows the relationship between the number of beds and construction costs. Figure 2 shows the relation between equipment costs and the hospital built up area.

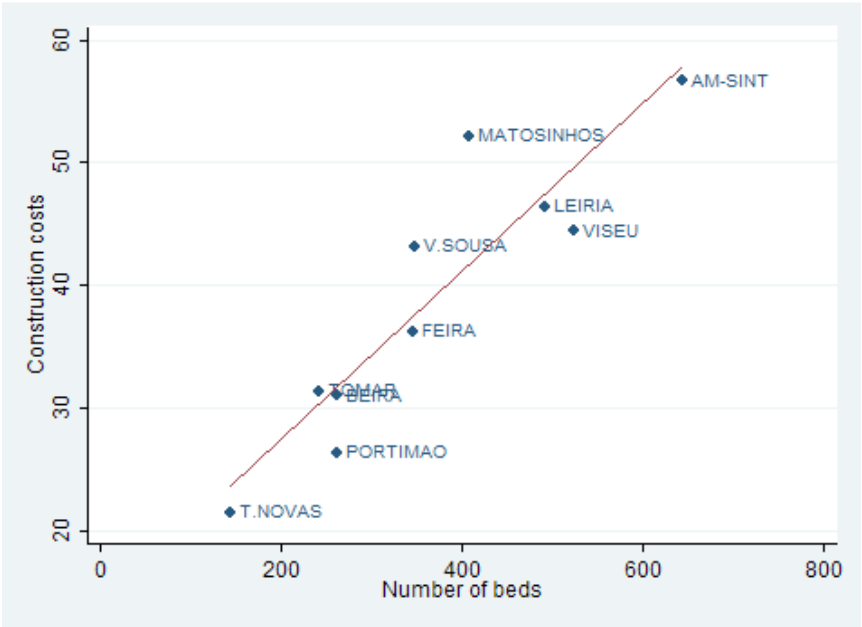


Figure 1: Costs of construction and number of beds

Figure 1 indicates that although the number of observations is small, the regressions has a good fit.[4]

Figure 2 shows that in the case of equipment data there is an "outlier", i.e. 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 used to run the regression predicting equipment costs.

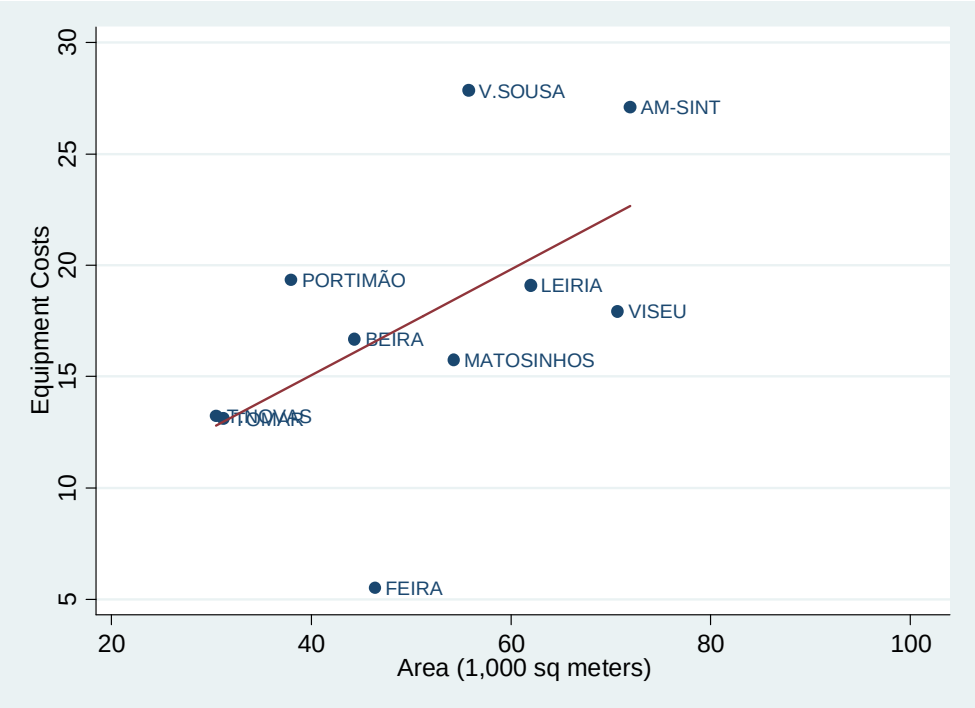


Figure 2: Cost of equipment and the hospital area.

Once when we exclude the Feira Hospital, the equipment costs are explained better by the construction area of the hospital than by the number of beds. Thus, we will use the area regression to predict equipment costs.

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.

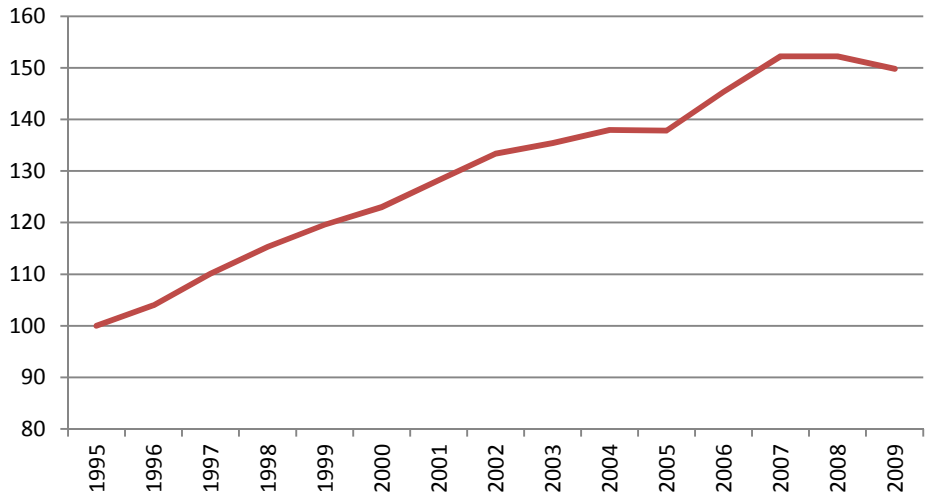
Finally, we estimate a statistically significant regression explaining total costs for the built up area.

[4] See the Appendix for results of all regressions.

CPI correction Health

The predicted cost values were corrected by the Consumer Price Index (CPI) for the health sector. In Figure 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 1.453 and 1.378, respectively.

Figure 3: Consumer Price Index for the health sector.



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 carried out 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[5] 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 variables "area" and "number of beds" in the regression, and we choose the area built because it is the best variable in terms of goodness of fit.

Method 2 uses three partial models. A first sub-model explains the cost of the building by the number of beds (the best specification found). A second submodel explains the cost of equipment by the built up area. A third submodel explains the other costs (including costs overruns, extra charges etc..) also as a function of the built up area. This

[5] See the Appendix for detailed results.

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 cannot be done using *standard* techniques. In this case the problem has been solved by *bootstraping predictions,* an approach to statistical inference which builds a distribution of estimates based on the construction of multiple samples taken with replacement from the original sample available, treated as a population.

Method 2 has a slightly better fit to the historical data than method 1 (lower mean squared error of prediction), but we will show results using both methods.

From methods 1 and 2 we generated forecasts and a confidence interval (95%), and subsequently all values were multiplied by the CPI-Health to generate the estimates that can be seen in Table 5.

Table 5: Infrastructure Costs Estimates for the hospitals of Cascais and Braga (€ million)

		Prediction 95% Confidence Interval			
		Mean Estimate	Lower Limit	Upper Limit	Official PSC
Method 1 (model area in $m^{2)}$	Cascais (P 2005)	75.61	68.13	83.92	80.70
	Braga (P 2006)	156.88	118.58	207.55	200.00
Method 2 (partial models with *bootstrap)*	Cascais (P 2005)	68.65	65.61	72.91	80.70
	Braga (P 2006)	146.14	121.77	184.32	200.00

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 CPI-Health). Using Method 1, the PSC are inside 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 higher costs for the infrastructure.

6.2 Estimating the Cost of Clinical Services

There are many functional forms in the literature that allow an econometric estimation of the relationship between costs and *outputs*. One of the best known and most often used cost function is the *translog*. In our case this takes the following form,

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

where C is the total costs, Y is the output vector measured by inpatient admissions, outpatient visits, outpatient services, emergency episodes, day surgeries, and the case mix index. H and T are sets of dummy variables, for hospitals and years respectively.

The results obtained from the regression are given in Tables 7. The results are statistically significant and the independent variables show predictive power.

Table 7: Estimates of the regression of the logarithm of the total operating cost.

Log (Total Cost)	Coefficient	Robust Std. Deviation	t	P> t
Indicator EPE	0.033	.027	1.23	.225
Year 2001	0.117	.015	7.62	.0
Year 2002	0.160	.016	9.87	.0
Year 2003	0.213	.022	9.66	.0
Year 2004	0.261	.028	9.17	.0
Year 2005	0.298	.024	12.39	.0
Year 2006	0.315	.025	12.76	.0
Year 2007	0.323	.027	12.00	.0
Log (Episodes)	0.807	.160	6.5	.0
Log (Amb Surgery.)	0.100	.047	2.11	0.040
Log (ER)	0.009	.003	2.91	0.005
Log (Consultations)	0.562	.136	4.15	.0
Log (Hosp. Day)	-0.319	.051	-6.21	.0
Log (Case Mix)	1.925	.854	2.25	0.028
Log (Epis.) * Log (Case Mix)	-0.197	.093	-2.12	0.038
Log (Hosp. Day) ^{2}	-0.005	.002	-2.69	0.009
Log (Epis.) * Log (Consultations)	-0.069	.016	-4.34	.0
Log (surgical) * Log (ref.)	-0.008	.004	-1.92	0.059
Log (Hosp. Day) * Log (Consultations)	0.036	.006	5.58	.0
Constant	10.125	1.221	8.29	.0

Notes: This regression used 458 observations, with 58 groups. The overall R-square is 0.7901.

Cascais - Clinical Services

Using the regression estimates presented above, we compared the model prediction for the hospital in Cascais with PSC. The PPP in Cascais involved operating the old hospital for two years and then moving into the new hospital and operating there for 8 years.

We generated two predictions for the operating costs of the Cascais PPP. The first prediction uses the cost function for the average public hospital. The second prediction uses the cost function estimated for the former hospital in Cascais, i.e. it uses the historical Cascais fixed effect, which generates above average costs. The results can be seen in Table 8.

Table 8: Cascais Comparison

Against Average Hospital				
	Estimated Average	Lower Limit	Upper Limit	PSC
First 2 years	45.62	42.638	48.83	
Last 8 years	49.72	46.81	52.81	
Present Value for 10 years	345.06	324.27	367.18	328.05
Against Cascais in the past				
	Estimated Average	Lower Limit	Upper Limit	PSC
First 2 years	50.18	47.90	52.56	
Last 8 years	54.69	51.07	58.56	
Present Value for 10 years	379.52	356.32	404.27	328.05

The values of the official PSC 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 infrastructure.

Braga - Clinical Services

The PPP in Braga involved operating the old hospital for one year and then moving into the new hospital and operating there for 9 years.
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 Braga Hospital (Table 9).

Table 9: Braga Comparison

Against Average Hospital				
	Estimated Average	Lower Limit	Upper Limit	PSC
First year	57.74	51.77	64.40	
Last 9 years	59.19	50.94	68.79	
Present Value for 10 years	418.25	361.91	483.51	986.00
Against Braga in the past				
	Estimated Average	Lower Limit	Upper Limit	PSC
First year	97.08	92.48	101.90	
Last 9 years	99.51	92.17	107.45	
Present Value for 10 years	703.16	653.66	756.49	986.00

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

6.3 Discussion

Table 10 presents the overall results of the estimates for the two scenarios: one where the costs are given by the lower estimates (both for construction and operation) and another where costs are given by the higher estimates.

Table 10: Overall results of the estimates for Braga and Cascais

			Prediction Interval 95% Confidence		
(€ million)		Estimated Average	Lower Limit	Upper Limit	PSC
High	Cascais Infrast	75.61	68.13	83.92	80.70
	Cascais Services	379.52	365.32	404.27	328.05
	Total Cascais	455.13	434.12*	476.14*	408.75
	Braga Infrast.	156.88	118.58	207.55	200.00
	Braga Services	703.16	653.66	756.49	986.00
	Total Braga	860.04	792.05*	928.03*	1186.3
Low	Cascais Infrast	68.65	59.93	78.84	80.70
	Cascais Services	345.06	324.27	367.18	328.05
	Total Cascais	413.71	390.26*	437.16*	408.75
	Braga Infrast	146.14	121.77	184.32	200.00
	Braga Services	418.25	361.91	483.51	986.00
	Total Braga	564.39	496.02*	632.76*	1186.3

* asymptotical approximate 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 the PSC for clinical services was well above the upper limit of our prediction. In Cascais the same PSC was closer to the lower limit of our prediction. Since

the operational costs of the clinical services are much larger than the infrastructural costs, they dominate the final results. Therefore we find that the overall PSC for Braga is well above the upper limit of our estimates whereas for Cascais the overall PSC is inside the prediction confidence interval, near its lower limit.

7. CONCLUSIONS

The results show that the PSC for infrastructures are above the average of the estimates based on historical data.

The PSC for clinical services seem to be in a substantially different situation. In the case of the new hospital in Braga the official PSC value is clearly above average and even above the upper limit of the forecast range, while for the case of Cascais the PSC value is below average and close to the lower limit of the forecast range.

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 upward bias in the PSC estimate. This is good news since competition in this case seems to have worked.

The case of Cascais is also interesting.

The firm that won the Cascais bid is said to be suffering losses and the press has reported that it is trying to sell the concern and extricate itself from the PPP contract (Expresso newspaper July 9, 2011). Given the low PSC initially defined, by comparison with our estimates, these results are not entirely surprising.

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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
-------------+------------------------------           F(  1,     8) =   53.88
       Model |  .765679554     1  .765679554           Prob > F      =  0.0001
    Residual |  .113687639     8  .014210955           R-squared     =  0.8707
-------------+------------------------------           Adj R-squared =  0.8546
       Total |  .879367193     9  .097707466           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 Feira)

```
reg  LCEquip  LArea if CEquip>5.5

      Source |       SS       df       MS              Number of obs =       9
-------------+------------------------------           F(  1,     7) =    6.41
       Model |  .278139393     1  .278139393           Prob > F      =  0.0391
    Residual |   .30381083     7  .043401547           R-squared     =  0.4779
-------------+------------------------------           Adj R-squared =  0.4034
       Total |  .581950223     8  .072743778           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              Number of obs =      10
-------------+------------------------------           F(  1,     8) =   19.04
       Model |  3.60294957     1  3.60294957           Prob > F      =  0.0024
    Residual |  1.51415821     8  .189269776           R-squared     =  0.7041
-------------+------------------------------           Adj R-squared =  0.6671
       Total |  5.11710778     9  .568567532           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              Number of obs =      10
-------------+------------------------------           F(  1,     8) =   31.21
       Model |  .617003611     1  .617003611           Prob > F      =  0.0005
    Residual |  .158146185     8  .019768273           R-squared     =  0.7960
-------------+------------------------------           Adj R-squared =  0.7705
       Total |  .775149796     9  .086127755           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

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

                                    (Std. Err. adjusted for 58 clusters in id)
------------------------------------------------------------------------------
             |               Robust
     lcustot |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
         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)
```