Cost modelling of buildings from the Promoter's Point of View

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1. INTRODUCTION

The construction sector comprises certain risks due uncertainty arising out of the construction works, which is something that cannot be quantified in detail. The risk in construction depends on several variables, such as: safety; weather conditions; deadlines; costs; and others. Currently, risk management is pivotal for all those involved in the construction sector, in particular for promoters. In the variables associated with risk, cost deviation stands out as a key-factor for promoters and is present in all constructions. This issue has been studied by several international authors and some national ones, but most times from the owner’s perspective. Actually, contractors rarely share the bill off of quantities and closing accounts which makes almost impossible the access to the relevant information for an accurate calculation of cost deviation.

A study over 70 buildings conducted in Ethiopia by (Nega, 2008) identified 96% of developments with positive cost deviation and 4% of developments with negative cost deviation. Other international study (Al-Momani, 1996) analyzed 125 schools in Jordan, and found an average cost deviation of 30%. Also in Jordan (Al-Hazim et al., 2017) they studied 14 infrastructures and found an average cost deviation of 114%, which is very high due to the size and complexity of the developments. In Malaysia (Shehu et al., 2014) they investigated 59 residential buildings, obtaining an average cost deviation of -2.5%, where 40% of the buildings had positive cost deviation and 56% of the buildings had negative deviation. In Portugal, (Pinheiro Catalão et al., 2019) they analysed 4305 public infrastructures erected between 1980 and 2012, reaching an average deviation among constructions developed by local and central administration of 19%, a very high value that influences the Portuguese economy. This type of studies aims to help governments and local authorities, such as municipalities, understand the factors that may influence this excess of costs. Notwithstanding, as mentioned, all these quantitative studies, listed above, were prepared based on the owner's point of view.

Most of the international studies describe the causes for such deviation on a broad and general way, meaning that they are based on questionnaires addressed to specialists from the 3 entities involved in the development (contractors, owner and designers – architect and technical engineers) and then list the causes without distinguishing to whom they are attributed separately.

The following authors: (Abusafiya & Suliman, 2017; Aziz, 2013; Cheng et al., 2013; Derakhshanalavijeh & Teixeira, 2017; Frimpong et al., 2003; Iyer & Jha, 2005; Mahamid, 2013; Odeck, 2004; Priyantha et al., 2011; Shane et al., 2009) analyzed the causes of cost deviation, and reached the most relevant for each of the entities involved: **(i) contractor**: price variation of materials, equipment or workforce; additional works; errors during construction and inefficiencies; **(ii) owner**: size, nature and complexity of the project; increased project requirements; financing scheme and payment of completed works; **(iii) designer**: changes, errors and poor quality of projects; wrong method of estimating costs.

This dissertation has the purpose of studying the costs in construction works from the promoter's point of view, as there are practically no studies about this issue, and aims to help them to have more support tools for the estimation of construction budgets in the future. As such, this dissertation has 3 main objectives. Firstly, this analysis is made in relation to (i) the cost deviation and (ii) the cost weight allocated by different categories, notably: structure; architecture; special facilities; building site for two types of buildings, residential and offices, and at a later stage, the development of cost functions for each of the mentioned types of buildings. To this end, this study is based on historical data referring to the real estate projects developed by - Teixeira Duarte Real Estate- as from 2000 until 2015.

2. CASE STUDY

As a case study for this dissertation, one of the largest Portuguese real estate companies was chosen, the Teixeira Duarte Real Estate. Based on empirical data, it was possible to have access to the job quantity maps and closing accounts of the construction contracts referring to intra-group transactions in which both the contractor and the promoter, which in this case was the real estate company of the Group, corresponded to companies of the Teixeira Duarte Group.

This study is based on a sample of 22 construction contracts: 13 for residential buildings and 9 for office buildings, executed as of 2000 until 2015.

2.1 Residential buildings

The residential buildings were one of the two typologies chosen for this analysis. Out of the 13 contracts analysed, 11 projects were located in Portugal and 2 in Africa (Mozambique and Angola).

In order to better understand the cost breakdown of the works, the initial budget value of the works was divided into 4 categories: structure; architecture; special installations; construction site (**Table 1**).

Architecture dominates in what concerns the proportion it represents in the cost of the works, around 45%-50% of the global price due in most cases. This result is consistent with the fact that these buildings are high-end, with high quality standards in relation to finishings, comfort, equipment and mainly due to the great compartmentalization.

Table 1: Location of construction works and general indexes of residential buildings.

Nº	Localization	Structure(%)	Architecture (%)	Special installations (%)	Construction site (%)	Budget price index updated (%)	Total area index (%)
1	Queijas	29,1%	34,5%	23,8%	12,6%		130%
2	Oeiras	17,1%	49,5%	18,9%	14,5%	18%	21%
3	Vila Nova de Gaia	28,2%	51,4%	12,2%	8,2%	107%	122%
4	Oeiras	22,3%	47,3%	17,0%	13,4%	37%	49%
5	Lisbon	23,0%	45,0%	20,0%	12,0%	34%	39%
6	Vila Nova de Gaia	24,2%	50,4%	13,9%	11,5%	94%	142%
7	Amadora	18,8%	46,3%	24,2%	10,7%	48%	76%
8	Vila Nova de Gaia	27,9%	44,1%	9,5%	18,5%	104%	148%
9	Vila Nova de Gaia	16,3%	54,7%	20,1%	8,9%	123%	203%
10	Angola	25,0%	43,0%	12,0%	20,0%	234%	109%
11	Mozambique	20,9%	46,1%	25,5%	7,5%	256%	
12	Oeiras	12,7%	50,1%	26,0%	11,2%	34%	46%
13	Restelo	23,5%	43,0%	22,4%	11,1%	110%	116%
Average		**22,2%**	**46,6%**	**18,9%**	**12,3%**		
Median		**23,0%**	**46,3%**	**20,0%**	**11,5%**		
Mode			**43,0%**				
Standard deviation		**5,0%**	**5,0%**	**5,6%**	**3,7%**		
Maximum		**29,1%**	**54,7%**	**26,0%**	**20,0%**		
Minimum		**12,7%**	**34,5%**	**9,5%**	**7,5%**		

2.2 Office buildings

This study was also prepared taking into consideration buildings erected for a different use, i. e., for office purposes. Based on the sample of 9 contracts at stake, 7 developments are located in the Oeiras region, the remaining 2 are located in Vila Nova de Gaia and in Amadora.

It should be noted that in this type of buildings the area below ground is larger than the area above ground (**Table 2**), given that the offices were built in the shape of a closed block with a patio in the middle of the upper ground.

Such as in the residential buildings, the initial budget value of the works was divided into 4 categories: structure; architecture; special installations; construction site (**Table 2**).

Table 2: Location of construction works and general indices of office buildings.

Nº	Localization	Structure(%)	Architecture (%)	Special installations (%)	Construction site (%)	Budget price index updated (%)	Total area index (%)
1	Oeiras	24,0%	32,5%	34,4%	9,1%	104%	87%
2	Oeiras	25,9%	31,3%	32,5%	10,3%	101%	100%
3	Oeiras	24,8%	32,0%	32,7%	10,5%	102%	98%
4	Vila Nova de Gaia	27,4%	35,9%	27,8%	8,9%	160%	121%
5	Oeiras	32,7%	33,2%	24,9%	9,2%	117%	122%
6	Amadora	17,7%	44,9%	27,0%	10,4%	34%	34%
7	Oeiras	29,9%	32,1%	27,2%	10,8%	85%	101%
8	Oeiras	30,4%	34,1%	24,8%	10,7%	142%	166%
9	Oeiras	27,4%	29,6%	29,9%	13,1%	55%	71%
Average		**26,7%**	**34,0%**	**29,0%**	**10,3%**		
Median		**27,4%**	**32,5%**	**27,8%**	**10,4%**		
Mode		**27,4%**					
Standard deviation		**4,4%**	**4,5%**	**3,5%**	**1,3%**		
Maximum		**32,7%**	**44,9%**	**34,4%**	**13,1%**		
Minimum		**17,7%**	**29,6%**	**24,8%**	**8,9%**		

3. ANALYSIS AND RESULTS

3.1 Residential buildings

This sample is composed of 13 works built between 2002 and 2017, however 2 of the developments are located in Africa, and in relation to 1 of the projects that was carried out in Portugal, we were not able to access the initial budget prepared by the contractor and approved by the owner. That said, the analysis of the offices construction contracts was divided into two parts: (i) on one hand, the 10 contracts regarding developments carried out in Portugal and (ii) the other hand, the 2 contracts regarding developments carried out in Africa, as the costs incurred in each location were completely different, and the final results would be adulterated.

The total updated initial budget in Portugal is approximately 56 million euros, this was updated to 2019 based on construction inflation. **Table 3** presents some statistics of the most relevant available variables of this study. The updated budget unit prices range from 507 €/sqm to 794 €/sqm.

The total updated initial budget in Africa is approximately 39 million euros, which is limited to the sum of the referred 2 buildings, and this was also updated to 2019 based on construction inflation and converted from dollars to euros at the applicable exchange rate over those years. Only if the updated unit price of one of the developments was available, this development has a cost of 1,798 €/sqm.

By comparing the details of the works performed in Portugal and in Africa one can clearly identify that the difference between the costs incurred is notorious, as the cost variation is around 1,000 €/sqm between the two locations.

Some works have significant cost deviations due to the implementation of solutions different from those initially budgeted.

Table 3: Descriptive statistics of residential buildings in Portugal.

		Updated initial budget (euros)	Current final sales value (euros)	Cost variance (%)	Duration (days)	Buried floors	Floors above ground	Total floors	GCA (below ground)	GCA (above ground)	Total area	Current unit budget price (euros)
N	Valid	10	8	7	11	8	8	8	11	11	11	10
	Silent	1	3	4	0	3	3	3	0	0	0	1
Average		5576784	6943310,78	4,7%	331	3	6	9	3401	5899	9300	645
Standard average error		987214	915349,91	4,3%	22	0	1	1	652	997	1608	32
Median		5558586	7623732,40	3,9%	320	3	6	8	3400	6444	10881	636
Mode		1443659	2746436,00	-13,4%	320	3	4	7	420	1557	1977	507
Deviation Error		3121845	2589000,51	11,4%	72	1	3	3	2162	3306	5335	102
Variance		9745916783369	6702923632204,39	12904,1%	5229	2	7	10	4675938	10927115	28458012	10424
Asymmetry		0	-0,89	31,0%	1	-1	0	1	0	0	0	0
Standard asymmetry error		1	0,75	79,4%	1	1	1	1	1	1	1	1
Kurtosis		-2	-0,59	207,2%	1	-1	-1	-1	-1	-1	-1	-2
Standard curtose error		1	1,48	158,7%	1	1	1	1	1	1	1	1
Range		8187600	6916899,03	38,1%	240	3	7	9	6688	10342	17030	288
Minimum		1443659	2746435,50	-13,4%	240	1	3	5	420	1557	1977	507
Maximum		9631259	9663334,53	24,7%	480	4	10	14	7108	11899	19007	794
Sum		55767839	55546486,26	33,0%	3640	23	50	73	37409	64894	102303	6454

In the Levene test below, if the significance is greater than 0.05, the equal variances assumed in the T-test are considered, and conversely, if it is lower than 0.05 the non-equal variances assumed in the T-test are considered. Therefore, none of the 3 variables: updated budget unit price; updated sales unit price; cost deviation were impacted by the 2008 crisis, since the significance is higher in the three cases than 0.05. In relation to the contracts executed for developments located in Africa, these tests were not carried out due to the lack of data.

As expected, the exogenous variables have no effect on costs and cost deviation. For this sample, the positive correlations (**Table 4**) between the variables found were the most expected: duration for the execution of the works within the areas below and above ground; total area with the initial budget updated and the final sales value updated and the total number of floors with the number of floors above ground, which makes all sense given that they are residential buildings, so with more than twice as many floors above ground than below ground, on average (**Table 3**). Due to the lack of information it was not possible to correlate the residential buildings located in Africa.

Table 4: Correlations between variables of residential developments in Portugal.

		Updated initial budget (euros)	Updated final sales amount (euros)	Cost variance (%)	Duration (days)	Buried floors	Floors above ground	Total floors	GCA (below ground)	GCA (above ground)
Duration (days)	Pearson correlation	0,63	0,49	-0,47	1,00	0,10	0,28	0,27	,783**	,751**
	Sig. (2 ends)	0,05	0,22	0,29		0,81	0,51	0,51	0,00	0,01
	Sum of squares and cross products	1338906533,10	653494981,62	-2549,65	52290,91	65,00	390,00	455,00	1224921,82	1794474,98
	Covariance	148767392,57	93356425,95	-424,94	5229,09	9,29	55,71	65,00	122492,18	179447,50
	N	10,00	8,00	7,00	11,00	8,00	8,00	8,00	11,00	11,00
Total floors	Pearson correlation	0,04	0,03	0,27	0,27	0,54	,923**	1,00	0,31	0,35
	Sig. (2 ends)	0,93	0,95	0,56	0,51	0,16	0,00		0,46	0,40
	Sum of squares and cross products	2430553,66	1557728,55	61,84	455,00	15,13	55,75	70,88	13530,13	26048,53
	Covariance	347221,95	259621,43	10,31	65,00	2,16	7,96	10,13	1932,88	3721,22
	N	8,00	7,00	7,00	8,00	8,00	8,00	8,00	8,00	8,00
Total area (GCA)	Pearson correlation	,944**	,904**	-0,44	,783**	0,31	0,26	0,34	,963**	,984**
	Sig. (2 ends)	0,00	0,00	0,32	0,00	0,45	0,54	0,41	0,00	0,00
	Sum of squares and cross products	146657366667,36	82815565109,61	-164458,72	3019396,80	14151,43	25427,23	39578,66	111034172,92	173545947,98
	Covariance	16295262963,04	11830795015,66	-27409,79	301939,68	2021,63	3632,46	5654,09	11103417,29	17354594,80
	N	10,00	8,00	7,00	11,00	8,00	8,00	8,00	11,00	11,00

For the developments in Portugal, considering the preliminary analysis of the data, multiple linear regression models were developed, with the initial budget always being updated to estimate the initial budgets foreseen for the residential buildings. The auxiliary variable Aux2 was chosen as total areas of buildings started before the 2008 crisis, the value of 1 was also chosen for buildings started before the crisis and 0 for those started after the crisis. For the following models, i) the influence of the crisis was considered; and ii) linearity. That said, 5 regression models were constructed: base model; linear model; linear model with constant; linear model with crisis; linear model with crisis and constant. The most precise model is presented below:

Linear with crisis and constant: $\mathbf{Expected\ initial\ budget} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} \times \mathbf{Area\ below\ ground} + \boldsymbol{\beta_2} \times \mathbf{Above\ ground\ area} + (\boldsymbol{\beta_3} \times \mathbf{Crisis} + \boldsymbol{\beta_4} \times \mathbf{No\ crisis}) \times \mathbf{Total\ area}$

Table 5: Linear model with crisis and constant for residential buildings.

Linear model with crisis and constant		
Coefficient		β
1	Constant	537627,04
2	GCA (below ground)	906,06
3	GCA (above ground)	627,56
4	Aux2	-199,81

Figure 3.1 shows the forecasting performance of the models, crossing the updated initial budgets and those forecast by the models listed above. The Base and Linear models with and without constant have an R2 of 0.89, are the least accurate. The Linear models with crisis and with crisis and constant have an R2 of 0.94, being the most accurate.

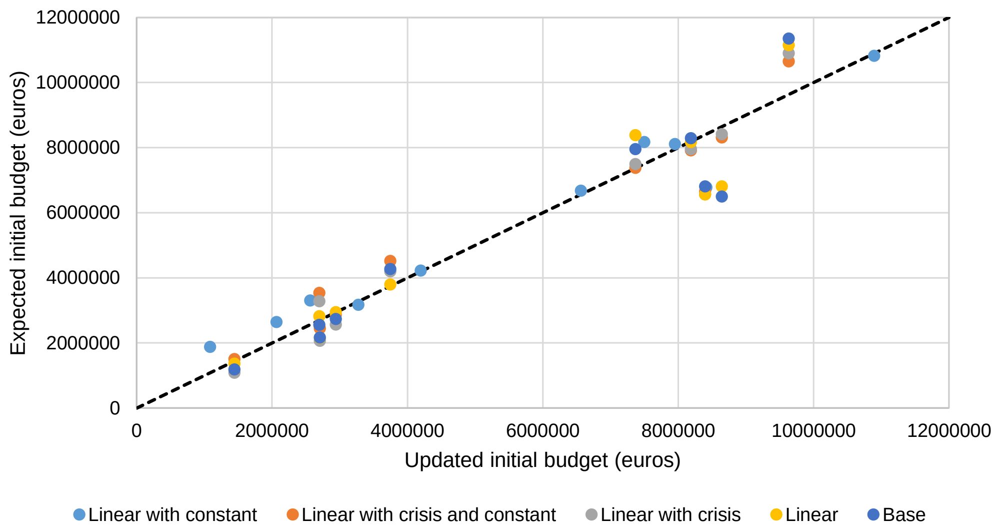

Figure 3.1: Model of estimated initial budgets for residential buildings.

3.2 Office buildings

The sample of office buildings consists of 9 construction contracts executed between 2000 and 2015. The updated initial budget is just over 82 million euros, as the initial budget was updated to 2019 based on construction inflation.

Table 6 presents some of the statistics of the most interesting information available in this study. The updated unit prices range from 419 to 714 €/sqm, with a clear difference before and after the 2008 economic crisis. It should be noted that the average budget unit price per square meter for office buildings is, at least, 100€/sqm lower than the average for residential buildings, due to the type of finishings underlying each type of use.

Some works have significant cost deviations due to the implementation of solutions different from those initially budgeted.

Table 6: Descriptive statistics of office buildings.

		Updated initial budget (euros)	Current final sales value (euros)	Cost variance (%)	Duration (days)	Buried floors	Floors above ground	Total floors	GCA (below ground)	GCA (above ground)	Total area	Current unit budget price (euros)
N	Valid	9	5	5	9	9	9	9	9	9	9	9
	Silent	0	4	4	0	0	0	0	0	0	0	0
Average		9171094	10603592	2,1%	284	4	6	10	9501	7476	16977	539
Standard average error		1200786	1916850	2,7%	17	0	1	1	1339	872	2056	31
Median		9358289	10718214	1,7%	260	3	5	9	9765	6880	16930	529
Mode		3078278	4767121	-6,1%	240	3	4	7	1989	6880	5820	419
Deviation Error		3602357	4286207	6,1%	50	1	4	4	4018	2616	6168	94
Variance		12976976283336	18371574500071	3744,1%	2478	1	18	20	16147975	6842389	38046258	8793
Asymmetry		0	0	10,1%	0	1	2	2	0	0	0	1
Standard asymmetry error		1	1	91,3%	1	1	1	1	1	1	1	1
Kurtosis		0	-1	73,2%	-2	0	7	6	3	-1	1	0
Standard curtose error		1	2	200,0%	1	1	1	1	1	1	1	1
Range		11627851	10191285	16,7%	120	2	13	14	15324	7874	22293	295
Minimum		3078278	4767121	-6,1%	240	3	4	7	1989	3831	5820	419
Maximum		14706129	14958406	10,6%	360	5	17	21	17313	11705	28113	714
Sum		82539846	53017958	10,5%	2560	32	57	89	85505	67285	152790	4854

In the Levene test, as mentioned above for residential buildings, if the significance is greater than 0.05, the equal variances assumed in the t-test are considered, if it is lower than 0.05, the non-equal variances assumed in the t-test are considered. Given this context, of the 3 variables that are included in **Table 7**, only the updated unit prices (budget) have an impact before and after the 2008 crisis, as the significance is 0.021, which is lower than 0.05.

Table 7: Levene test and T-test for unit costs and cost deviation of office buildings.

		Levene test for equality of variances				T-test for Average Equality			95% Difference Confidence Interval	
		Z	Sig.	t	df	Sig. (2 ends)	Average difference	Standard difference error	Bottom	Top
Updated budget unit price (euro)	Equal variances assumed	4,349	0,075	-2,971	7	0,021	-140	47	-252	-29
	Equal variances not assumed			-4,067	6	0,006	-140	34	-223	-57
Updated unit sales price (euros)	Equal variances assumed	8,755	0,060	-1,800	3	0,170	-162	90	-448	124
	Equal variances not assumed			-1,473	1	0,345	-162	110	-1064	740
Cost variance (%)	Equal variances assumed	2,915	0,186	0,338	3	0,758	2,1%	6,3%	-18,0%	22,3%
	Equal variances not assumed			0,431	2	0,706	2,1%	5,0%	-18,0%	22,2%

As in residential buildings, the exogenous variables have no effect on costs and cost deviation. Positive and statistically significant correlations were found between the number of above ground/total floors and the updated unit sales price, as detailed in **Table 8**.

The most relevant result was the positive and strong correlation between the cost deviation and the number of floors buried. This is a result, which confirms the uncertainty of the geotechnical works, and the risk attributed to them. It should be noted that office buildings have more floors below ground than housing, so it is another factor that explains the strong correlation between cost deviation and the number of floors buried.

Table 8: Correlations between office buildings variables.

		Updated initial budget (euros)	Updated final sales amount (euros)	Cost variance (%)	Duration (days)	Buried floors	Floors above ground	Total floors
Updated initial budget (euros)	Pearson correlation	1	,993**	0,607	0,349	0,643	0,438	0,519
	Sig. (2 ends)		0,001	0,278	0,357	0,062	0,238	0,152
	Sum of squares and cross products	1,0E+14	6,6E+13	5,8E+07	5,0E+08	1,3E+07	5,3E+07	6,7E+07
	Covariance	1,2977E+13	1,65417E+13	14439077	62651463	1682691	6650777	8333468
	N	9	5	5	9	9	9	9
Updated final sales amount (euros)	Pearson correlation	,993**	1	0,693	0,782	0,795	0,627	0,719
	Sig. (2 ends)	0,001		0,194	0,118	0,108	0,257	0,171
	Sum of squares and cross products	6,61669E+13	7,34863E+13	72721614,17	694025670	9643284,989	58208863,28	67852148,27
	Covariance	1,65417E+13	1,83716E+13	18180403,54	173506417,5	2410821,247	14552215,82	16963037,07
	N	5	5	5	5	5	5	5
Cost variance (%)	Pearson correlation	0,607	0,693	1	0,475	,965**	0,011	0,135
	Sig. (2 ends)	0,278	0,194		0,419	0,008	0,986	0,829
	Sum of squares and cross products	57756309,4	72721614,2	149,8	601,4	16,7	1,5	18,2
	Covariance	14439077	18180404	37	150	4	0	5
	N	5	5	5	5	5	5	5
Updated unit sales price (euros)	Pearson correlation	0,868	0,815	0,266	0,511	0,343	,953*	,981**
	Sig. (2 ends)	0,056	0,093	0,665	0,379	0,572	0,012	0,003
	Sum of squares and cross products	1660088469,3	1717431662,3	800,1	12999,4	119,2	2537,1	2656,3
	Covariance	415022117	429357916	200	3250	30	634	664
	N	5	5	5	5	5	5	5

For offices, multiple linear regression models were also developed, with the dependent variable always being the updated initial budget to estimate the expected initial office building budgets. The most accurate model is the following:

<u>**Linear with crisis and constant**</u>: $\mathbf{Expected\ initial\ budget} = \boldsymbol{\beta_0} + \boldsymbol{\beta_1} \times \mathbf{Area\ below\ ground} + \boldsymbol{\beta_2} \times \mathbf{Above\ ground\ area} + (\boldsymbol{\beta_3} \times \mathbf{Crisis} + \boldsymbol{\beta_4} \times \mathbf{No\ crisis}) \times \mathbf{Total\ area}$

Table 9: Linear model with crisis and constant for residential buildings.

Linear model with crisis and constant		
Coefficient		β
1	Constant	-1096938,7
2	GCA (abaixo solo)	169,8
3	GCA (acima solo)	1040,1
4	Aux	82,9

Figure 3.2 shows the forecasting performance of the models by cross-referencing the updated initial budgets and those forecast by the models listed above. The base model is the least accurate with R2 of 0.77. Linear models with and without constant have an R2 of 0.93. The Linear model with crisis has an R2 of 0.95, and finally balancing the precision, complexity and logic of the models, the linear model with crisis and constant seems to be the best choice with R2 of 0.96.

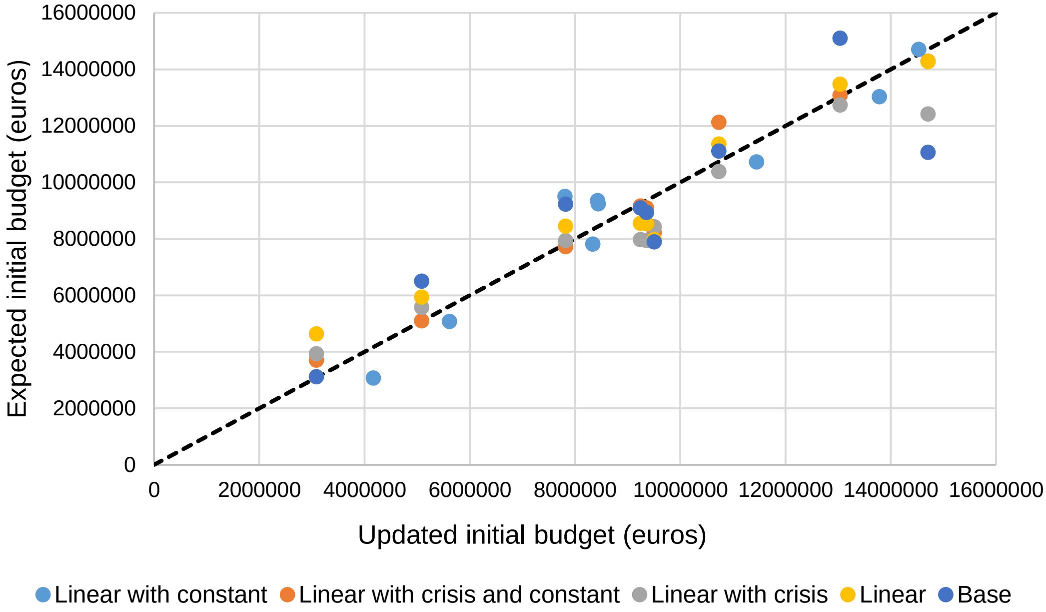

Figure 3.2: Model of estimated initial budgets for office buildings.

Based on the limited sample of buildings with information on the updated final sales value (euros), and the correlation observed between the cost deviation and the number of underground floors, the previous models can be corrected to estimate the final sales value assuming an increase of 0.72% per underground floor (**Table 10**). The results of the correction are presented only for the Linear model with crisis and constant (**Figure 3.3**).

Table 10: Linear model of cost deviation for office buildings.

Linear model		
Coefficient		β
1	Buried floors	0,72
Dependent variable: Cost variance (%)		

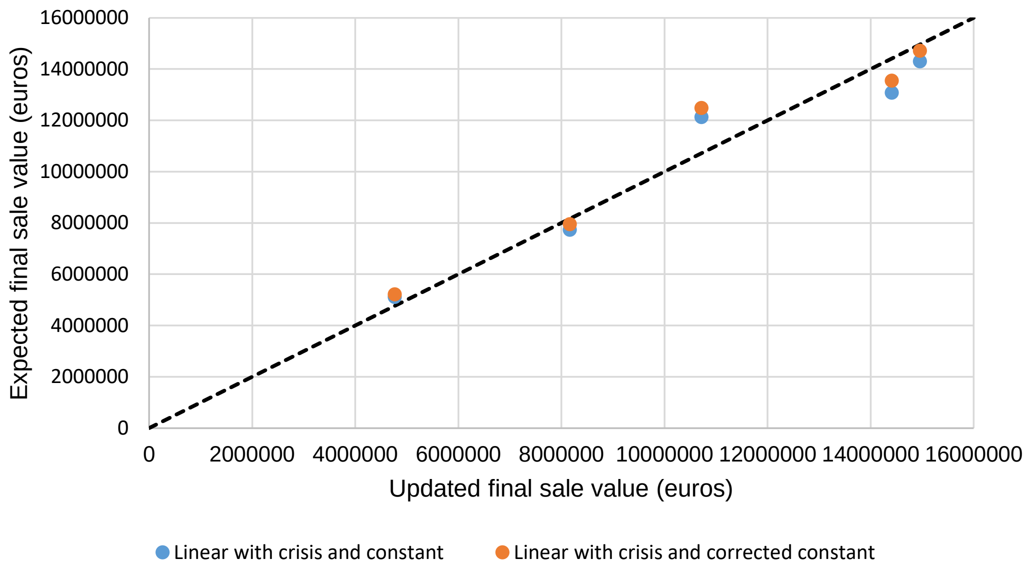

Figure 3.3: Model of expected final sale value of office buildings.

4. CONCLUSION

This dissertation’s purpose was to prepare a study with an analysis of the cost deviation in construction contracts, as well as to assess the cost breakdown by category weights of the works and the modelling of office and housing building costs, from the promoter's point of view.

The analysis of the cost deviation was limited due to lack of data, as one of the initial goals was to present the cost deviation for each part of the construction of an office or a residential buildings, i. e., to understand which extra works are usually required in relation for each separate category, notably: for architecture, structure, special installations and building site. This way it would be possible to detail the works that constantly cause these deviations.

Facing this adversity, a general analysis was made for each enterprise, even lacking some closing of accounts for certain works. Some interesting conclusions were reached, notably the fact that the number of underground floors has a direct effect on the deviation of costs, especially in office buildings, given that this typology contains more underground floors and fewer underground floors than residential buildings.

The second objective of the dissertation was the analysis of costs through the breakdown of costs by category weights: structure; architecture; special installations; construction site. Some interesting conclusions of correlations between each category type and the total cost, total cost deviation and unit price of the works were reached.

Finally, the last objective was the creation of cost functions that could help the promoters to have an extra tool for budgeting each enterprise. The adjudication budgets were chosen instead of the closing of accounts, due to the fact that there was a larger sample of the former.

It can be said that this objective was successfully achieved, as the correlations of the estimated models with the planned model were very consistent for both office and residential buildings.

To test the most accurate predicted model a work under construction was chosen and through the data of this one arrived at the estimated adjudication budget which was very close to the actual adjudication value, it was an excellent confirmation of the model created.

There are some paths that will help to complement and improve the study done in this dissertation.

In the future with the scope of developing this analysis it is suggested the creation of a more significant sample where all kinds of buildings are included such as: hotels; social housing; commercial buildings and with different locations. If there is a more complete and diversified database, this model can be used for all types of buildings and not only for office and housing buildings.

Regarding the analysis on cost deviation, there is much to complement this study. In this study the cost deviation was made from a general point of view due to the lack of data. In the future, it is suggested that an individual study be carried out for each type of contractor's costs: architecture; structure; special installations; building site. It is of great importance to perceive which additional works constantly exist in the works, in order to be able to draw more specific conclusions and to be able to improve the study made.

Finally, in relation to the distribution of costs it will be possible to implement the same analyses carried out in this dissertation, but with the addition of the weight of each work done in each category, with this, more precise conclusions will be reached and it will help in the decision making regarding the constructive methods to implement in the works.

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