

## Analysis of cost deviations in public works

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The construction sector represents a capital sector of the Portuguese economy, directly and indirectly. It is vital to analyze and quantify deviations (cost overrun, and time overrun), incurred in public work contracts in Portugal. The main goal of this dissertation is to analyze the cost deviations incurred in public works in Portugal, whether due to the existence of additional works or errors and omissions, and/or due to less works, to draw conclusions about possible reasons for its occurrence. The international articles show that the mean cost deviation is approximately 14% and that the most common causes are related to the size of the project, the type of work and with the optimism in project planning and cost estimation. In order to study the national panorama, data were collected on 2690 completed public work contracts, analyzed by the Court of Audit through the realization of Audit Reports. It was thus possible to compile a database that, after being properly analyzed, allowed to draw conclusions about the average cost deviations over time, by region, by size of the project, by sector, by contracting authority and by type of work. Of the sample studied, 48% feature cost deviation, and the overall average cost deviation is 0,12%, so it's possible to conclude that in the national case the average deviation is much lower than the deviation resulting from the analysis of international articles (14%). From the work carried out, it can be concluded that the larger the project size, the greater the average deviations, that changes in the contracts have been decreasing over time (2007-2016) and, that the typologies with the highest average cost deviations are construction and rehabilitation of buildings, hydraulic projects and transport projects.

**Keywords:** Public Works, Cost Deviation, Cost Overrun, Court of Audit, Audit Report

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### 1. Introduction

This thesis intends to make an analysis to a set of public works, with Audit Report already elaborated by the Court of Auditors, in order to perceive the causes for the occurrence of cost deviations. The study of this thesis focuses on two summary reports made by the Court, one on the additional works to public contracts sent to the Court during the 2011-2013 triennium and the other resulting from additional acts/contracts, communicated to the Court of Auditors, during the year 2016.

It was initially intended to also make an analysis of the time deviations in public works, however, due to the shortage of information on deadlines for all the works analyzed, it was decided to study only the cost deviations that, in many cases, may be related to the changes in the initially planned deadlines. A

database was developed that allows conclusions to be drawn, relating works that feature changes in the initially planned works and those that exhibit the greatest cost deviations. It was decided to do the following analyzes: time, geography, construction dimension, sector, contracting entity and typology and sub typology of the work. Despite the different types of analysis, I also tried to understand if there are similarities with the results obtained in international studies.

The concept of cost overrun is used to translate the difference between the planned value and the final value of a given project or activity. The cost of a project is finite and therefore requires strict management, as it can compromise the whole project, even make it unfeasible or interrupt it (PMBOK Guide). The concept of time overrun translates the non-fulfillment of the term originally planned or contracted in each project or activity.

The main causes for the occurrence of cost and time deviations are common to the vast majority of studies already performed. Deviations are due to one or more of the following reasons:

- Delays in the various design phases of the project, which translate directly into exceeding the deadlines and, consequently, the occurrence of cost deviations (Morris, 1990);
- Project design flaws, such as omissions and errors (Morris, 1990);
- Inefficient planning of the tasks, regarding their duration and the possible occurrence of conflict of work teams (Morris, 1990);
- Existence of bureaucracy that delays the process (Morris, 1990);
- Lack of work coordination, which makes it disorganized and consequently increases the probability of errors and delays in the completion of tasks (Morris, 1990);
- Excessive optimism in cost estimation (Skamris & Flyvbjerg, 1997);
- Non-existence of quality assurance measures (Magnussen & Olsson, 2006);
- Sudden changes in the project due to unforeseen factors found on site or due to changes requested by the developer (Creedy, Skitmore, & Wong, 2010);
- Inflation and government interference in the country (Kaliba, Muya, & Mumba, 2009);
- Occurrence of workers' strikes (Kaliba, Muya, & Mumba, 2009);
- Existence of technical difficulties or challenges only detected on the field (Kaliba, Muya, & Mumba, 2009);
- Weather factors (Kaliba, Muya, & Mumba, 2009);
- The need to comply with environmental protection measures (Kaliba, Muya, & Mumba, 2009);
- Existence of contractual and institutional failures (Singh, 2010);
- Incomplete contracts leading to future problems regarding responsibilities and work to be carried out (Singh, 2010);
- If it involves a year of elections, which often leads to a need to accelerate the work, thus implying more costs (Sarmiento & Renneboog, 2017).

Of the articles analyzed, it should be noted that major deviations in costs and deadlines occur in large-scale projects with short deadlines, because there is a high degree of risk involved.

Construction in less developed countries is often associated with high cost and time variances, not only due to government interference and bureaucracy, but also due to incomplete contracts and delays.

There are some types of structures that are more likely to be costly, such as transport infrastructure projects (roads, railways, bridges and tunnels). Studies reveal that the error of underestimating costs is significantly more common than the error of overestimating costs. Underestimating costs at the time of the construction decision is a rule and not an exception for most transport infrastructure projects, resulting in substantial and frequent cost increases (Flyvbjerg, Skamris Holm, & Buhl, 2002).

In the scope of the dissertation 35 articles were studied, however in two of them it was verified that it was made a separate analysis for two different data sets, thus there are 37 samples to analyze the average cost deviation. The break with the highest sample frequency is [0% - 10%], with 15 of the 37 samples. Samples of the most frequent range of results include the three articles on marine infrastructure construction, five articles on road and rail infrastructure as well as two articles that contain works on buildings. Table 1 presents the mean cost deviation of the studied articles, as well as the respective calculation formula.

Table 1: Mean cost deviation of the studied articles.

<b>Mean cost deviation (<math>\bar{x}_p</math>)</b>	$\bar{x}_p = \frac{x_1p_1 + x_2p_2 + \dots + x_np_n}{p_1 + p_2 + \dots + p_n}$	<b>13,86%</b>
<b>x: Mean deviation; n: number of studied samples; p: Number of contracts each sample/ article has analyzed.</b>		

The set of articles analyzed shows that the occurrence of cost and time deviations in public works is high, since all the articles report the occurrence of deviations, being the average cost deviation of 14%.

## 2. Public Works Market in Portugal

The construction sector is one that contributes the most to boost the national economy, since it moves several sectors, directly and indirectly, throughout its production cycle. It's intervention in the creation of wealth and employment makes this activity essential for the growth of the economy. In this way it is possible to relate the growth of the construction sector in Portugal with the growth of the Gross Domestic Product (GDP) and with the increase of the investment and production of the country.

Portugal experienced a reduction in GDP in 2003, however, followed by a slight recovery, with the highest growth rate of the 21st century in 2007 (2.5%). In 2009, the country has gone through a period of recession, with a drop of 3.0% of GDP. However, as can be seen in Table 2, in 2010 it has recovered, with growth of 1.9% of GDP.

Between 2011 and 2013, Portugal was affected by a long period of economic crisis, having even resorted to an external financial aid program. Examining the values of GDP for this period, negative growth figures are evident, with 2012 the most penalized year, with the economy falling 4.0%. Since 2014, Portugal has been experiencing positive GDP growth rates, which consequently lead to increased investment in the construction sector.

Table 2: GDP rate between 2004 and 2017.

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
<b>GDP (%)</b>	1,8	0,8	1,6	2,5	0,2	-3,0	1,9	-1,8	-4,0	-1,1	0,9	1,8	1,6*	2,6*

Source: INE

The Public Contracts Code (CCP), which began its application on July 29, 2008, aims to regulate the procurement activity in Portugal and was designed with the main purpose of guaranteeing market competition and equal opportunities, as well as to promote access to the market of public purchases by Small and Medium Enterprises. With the approval of the CCP, specific rules were created for the execution phase of contracts, in order to reduce the possibility of cost deviations. This document thus sets out a set of instructions and rules to make the procurement process simpler, less bureaucratic and more transparent to promote good governance.

The public procurement portal, better known as the *portal BASE*, is a virtual space that makes publicly available information on the formation and execution of public contracts, thus enabling them to be monitored. With the creation of this portal it is intended to fulfill one of the objectives of the CCP, dematerialize the public procurement, serving this space to gather information regarding all pre-contractual procedures.

In the scope of the dissertation, the Court of Auditors was used to analyze the Audit Reports that were made to public work contracts. The reports provide an investigation of the justification and legality of the additional work and identify any financial liabilities.

Although the direct adjustment contracts were significantly higher in number, compared to the public tenders and other procedures, in terms of the total amount this is well below the amount of the other procedures. In 2011 there is a significant reduction in the completion of new public procurement contracts compared to the previous year (including procurement of goods and services and public works contracts), bringing total national procurement from € 11 billion to around € 4,7 billion, representing a fall of 56%. This decrease is due to the decrease in the volume of public works contracts.

Between 2010 and 2015, the structure of public procurement follows a trend in which the weight of public works contracts has been decreasing in relation to the acquisition of goods and services. If in 2010 public works contracts accounted for 61% of the total value of registered public contracts, in 2014 its weight stood at 32%. In 2016 there is a slight reversal of this trend, but still far short of previous years, with the weight of public works contracts accounting for 26% of the total value of public contracts in 2016.

It is also important to note the differences between the public works under analysis and the private works. The main difference is related to the contracting entity involved, which may be public or private, and it is who decides to build and make the financial investment in a given project. However, analyzing Table 3 it is possible to perceive the weight of public and private works in investment in the construction sector. Public works represent on average 11% of the Gross Formation of Fixed Capital in construction and private works represent the remaining 89%.

Table 3: Weight of public and private works in investment in the construction sector (2012-2016).

	2012	2013	2014	2015	2016
<b>Gross Formation of Fixed Capital – Construction (Million Euros)</b>	15.226	13.368	12.941	13.474	13.449
<b>Amount Contractual Public Works (Million Euros)</b>	1.605	1.567	1.593	1.065	1.304
<b>Weight of public works in investment - Construction</b>	11%	12%	12%	8%	10%
<b>Weight of private works in investment - Construction</b>	89%	88%	88%	92%	90%

Source: INE

### 3. Data Analysis

Based on the data collected from the two summary reports drawn up by the Court of Auditors, two additional types of work (changes in work) were obtained to analyze: Overwork and errors and omissions and Less work.

One of the main difficulties in the elaboration of this work was that there was no main key (unique identification for each project). So, it was assumed that the number and year of the entry of the process in the Court of Audit would serve as the main key in this study. Thus, whenever more than one number and year of procedure were found to be the same, and after verification that it was the same contract (confirming that the initial contractual value and the summary description of the works were the same), their respective additional amounts were added. Thus, we have each line of the database corresponding to a different work contract.

In the analyzed sample, we have similar average values of additional work, both for additional jobs and for less jobs, making the balance of additional expenses small (2 657.76 €), although positive, which means that overall, additional work is predominant. Looking at the average values of the additional work, we are faced with relatively low numbers, however, if we look at the sum we are facing an expenditure of more than 7 million euros in the overall deviations, which should represent a concern for the country.

Table 4 represents the sample distribution by type of additional and respective mean values. Of the total of 2690 works contracts analyzed, it is verified that we have more "no additional", with a total of 1401 contracts (52% of the sample). Within the additional processes (representing 48% of the sample), a division was made by processes that presented only less jobs (31% of the sample with additional ones), which only present additional work and errors and omissions (23% of the sample with additional jobs) and that have less jobs and more jobs (46% of the sample with additional), the last ones having the largest volume within this class of processes.

Table 4: Mean values by type of additional.

Sample - Size	Cost initially planned	Extra work, E/O	%	Less work	%	Balance of additional expenses	%	
<b>No additional</b>	1401	1 079 022,45 €	0,00 €	-	0,00 €	-	0,00 €	-
<b>With additional</b>	1289	2 560 551,32 €	217 999,09 €	6,72	-212 452,63 €	-6,47	5 546,46 €	0,25
<b>With additional – only less work</b>	404	1 259 102,99 €	0,00 €	-	-62 977,77 €	-5,55	-62 977,77 €	-5,55
<b>With additional – only extra work, E/O</b>	291	1 875 330,70 €	110 068,54 €	7,34	0,00 €	-	110 068,54 €	7,34
<b>With additional - with less work and extra work, E/O</b>	594	3 781 400,35 €	419 142,90 €	10,98	-418 196,00 €	-10,27	946,90 €	0,71
<b>Total</b>	2690	1 788 944,64 €	104 461,27 €	3,22	-101 803,51 €	-3,10	2 657,76 €	0,12

It should be noted that, in this study, slightly more than half of the sample does not present any additional work, as such the break including the mean deviation of 0% always presents values much higher than the break immediately below and above, depending on the type of analysis.

Making a histogram of frequency of global mean deviation (overwork and errors and omissions minus less jobs) which, as one would expect, has its peak in the break ] -10% -0%], with 1954 results, since this includes all work without additional. The break ]-10% -0%] would continue to be the most frequent break, but the value would be 542, much closer to the interval immediately to the right ] 0% -10 %]. It is thus concluded that the most frequent interval in respect to the mean deviation is the range ] -10% -10%].

Although the frequency peak is in the range of ]-10% -0%], the overall mean cost deviation of the present study is 0.12%. This is a positive value, which implies that the excess work and errors and omissions, although they are smaller in number, have a higher weight.

### **Analysis of mean deviations**

The purpose of this chapter is to analyze the average positive and negative deviations as well as the balance of deviations that have occurred in all the works under study. In order to understand the reason for the occurrence of the deviations, I chose to make six different analyzes, starting with a more global analysis and successively specifying the study, starting with the analysis over time, followed by analysis by region, by size of work, by sector, by entity and by type of work.

This chapter seeks to highlight the maximum points obtained by studying the data for each of the six analyzes, to understand the reasons for its occurrence. It is also essential to understand if the national panorama under study in this dissertation is in accordance with the data collected in the Literature Review or if we are facing a different reality.

It should be noted that the average deviation in value (Euros) does not always allow us to perceive the size of the deviation, since a given average deviation in value has a higher weight if the work is small (greater percentage) than if the work is large scale (lower percentage). It can even happen, as it turns out, the existence of a positive balance average in value (Euros) and the average deviation in percentage relative to the balance of additions is negative or null. The opposite may also be true. Therefore, it was decided to place the average values (Euros) in the tables because it allows to have notion of the volume of money involved and in percentage in the figures, that allows to realize the effective size of the average deviation.

In order to try to understand whether this sample is in line with the information collected at national level in the previous chapters, an analysis was made of the average deviations by type of pre-contractual procedure. It is verified that of the sample under study most of the works used the public tender procedure (68%). Although the majority of the works have resorted to the public tender, it is verified that these are not the ones that present the greatest deviations. It is the restricted competitions with previous qualification that present positive and negative deviations of greater dimension, being the balance almost null. Direct adjustments have smaller deviations than the other two types of procedure.

Relating the analysis over time to the type of work in question displays that the year 2007 shows high positive and negative deviations, with negative deviations verified in works of communication (-18%) and positive deviations verified in works of communication (19%), building rehabilitation (5%) and infrastructure works (7%).

In the year 2008 we have a global deviation and a positive deviation of 10% and 13% in building works, 14% and 18% in building rehabilitation works, 11% and 13% in infrastructure works and 4% and 12% in communication. In 2006 there is a similar situation, with the overall deviation and positive deviation of 5% in buildings.

The year 2013 is also a highlight year in terms of positive and negative deviations, with negative impacts in the category of communication routes (-27%), rehabilitation of buildings (-4%) and infrastructures (-7%). Positive deviations are attributable to the categories of buildings (6%), building rehabilitation (6%), infrastructure (12%) and hydraulics (1%).

There is thus a relationship between the years with the highest deviations and the type of work involving high deviations (communication routes, building rehabilitation, hydraulic works and buildings).

Another connection that stands out, results from the relationship between the average contractual price and the occurrence of average deviations. In all analyzes, there is a strong tendency for works with higher average contractual prices to show greater deviation. However, there are exceptions mentioned in the appropriate chapters.

It is notorious that the works that involve buildings and communication routes are the ones that present the greatest volume. It is also verified that hydraulic works, which have a high average initial contractual price, are present in a larger number in Évora, a district with an equally high initial contractual price.

Relating the sectors involved to the typology of the work, it is observed that the typology with the highest overall mean deviation (building rehabilitation) presents a higher deviation value in the sector "other

works" (which includes associations and foundations), which is the sector that presents highest overall mean deviation.

#### **4. Conclusions and Future Developments**

It can be concluded that, of the sample studied, 48% of the public works feature changes in the work initially planned, which may be more work and errors and omissions or less work.

In the analyzed sample we have similar average values of additional work, both of additional jobs and errors and omissions, as well as of less jobs, making the balance of additional small (€ 2 657.76), although positive, which means that, on the whole, more jobs predominate.

The mean overall cost deviation of the present study is 0,12%. This is a positive value, which implies that the additional work and errors and omissions, despite being smaller in number, have higher values. Comparing with the results obtained in the literature review, with a weighted average deviation of 13.86%, we conclude that in the national case the mean deviation is much lower than the deviation obtained in the analyzed articles. This may not be entirely true, since the present database presents some information gaps.

If we focus on the result of the deviations that are due to overwork and errors and omissions, there is an average deviation of 3.22% for the entire sample. When making a similar reasoning to the previous one, if we consider only the works with alterations, this average deviation rises to 6,72%. By doing the same analysis for the deviations that occur due to less jobs, an overall mean deviation of -3.10% and an average deviation of -6.47% is reached if only those contracts which have undergone changes are considered.

It is also necessary to compare the results obtained in the present study with the results of the study carried out in the literature review about the international articles. It can be seen that the mean deviations, in the case of this analysis, are mainly in the range of frequencies] -10% -10%], and if the analysis is made only to the deviations that are due to additional positive works, the range with the highest number of results is the mean deviation between [0% -10%], there being a large discrepancy for the next break of ]10% -20%]. In the literature review, it was found that the highest sample frequency is also in the range [0% - 10%], with 15 of the 37 samples showing average deviations within the set, followed by the interval of ]10 % -20%], with 10 of the 37 samples having mean deviations within this second break.

With regard to the conclusions drawn from the analysis of international articles, there is a similarity in the divergences in the more developed countries (Europe, the USA, Japan and Australia), which includes Portugal, as well as the deviations in the least developed countries (India, Zambia, Malaysia and Palestine). The difficulties of the least developed countries, which are related to issues other than those observed in developed countries, such as government interference, high bureaucracy, adverse weather and lack of training, make it even more demanding to guarantee the quality of the projects, avoiding cost changes and originally planned deadline.

There are similarities between the national case (represented by a sample of 2690 public works contracts) and what was found in the nine articles that concern the United States of America. These articles are those with the lowest average cost deviation, approaching the value obtained in this work, and assume that this may be related to the contractor, the type of work, the increase in the size of the project / value of the contract and with the location, conclusions in part similar to those reached in the study carried out.

The fact that the increase in the size of the project is related to the existence of higher cost deviations may be due to bad planning, as this should be more rigorous in large projects, as well as lack of experience / training in carrying out larger works, leading to a greater probability of errors to occur.

One of the difficulties of this dissertation is related to the lack of data and complete information on the totality of the works, since the scope of the dissertation was to analyze contracts with Audit Report made by the Court of Auditors. The absence of a separate national identification code for each contract delays and avoid the obtaining of 100% reliable data on them, since the search is done by the name that has been assigned to it (there are sometimes differences). Through the study carried out, in order to understand which phase of the work the year used in the database corresponded to, it was concluded that some of the additional work had not yet been reported to the Court of Auditors at the time the Reports were made.

It is thus possible to conclude that the occurrence of cost and time deviations has been decreasing over the years and may be due to the concern of some entities in sharing the results of their studies as well as their concern in advising all the entities involved for a constant improvement of the entire public contracting sector in Portugal, mainly in the construction sector.

In order to provide easy and quality public access to information on the subject, a complete and constantly updated database with all the information on all public works in Portugal should be created. This work could be done through the creation of an online portal where information about each public work was placed, regardless of its initial contractual value (information on the initial contract, contracting authority, execution period, start and end date of the contract works, location, type of work, initial contractual value, information on the existence of changes in planned work and information on audits already carried out by the Court of Auditors).

Constant monitoring of public works and their possible alterations is essential. Thus, this type of work is crucial to understand the causes and to try to eliminate them in order to avoid the occurrence of similar deviations in the future.

## **5. Bibliography**

Creedy, G. D., Skitmore, M., & Wong, J. K. (2010). Evaluation of risk factors leading to cost overrun in delivery of highway construction projects. *Journal of Construction Engineering and Management*, 136, 528-537.

- Flyvbjerg, B., Skamris Holm, M. K., & Buhl, S. (2002). Underestimating costs in public works projects: Error or lie? *Journal of the American Planning Association*, 68, 279-295.
- Kaliba, C., Muya, M., & Mumba, K. (2009). Cost escalation and schedule delays in road construction projects in Zambia. *International Journal of Project Management*, 27, 522-531.
- Magnussen, O. M., & Olsson, N. O. (2006). Comparative analysis of cost estimates of major public investment projects. *International Journal of Project Management*, 24, 281-288.
- Morris, S. (1990). Cost and time overruns in public sector projects. *Economic & Political Weekly*, 15, 154-168.
- Sarmiento, J. M., & Renneboog, L. (2017). Cost Overruns in Public Sector Investment Projects. *Public Works Management & Policy*, 22, 140-164.
- Singh, R. (2010). Delays and cost overruns in infrastructure projects: Extent, causes and remedies. *Economic & Political Weekly*, 45, 43-54.
- Skamris, M. K., & Flyvbjerg, B. (1997). Inaccuracy of traffic forecasts and cost estimates on large transport projects. *Transport Policy*, 4, 141-146.