

Direct Costs Variance Analysis in Construction-Contribution for the Management of Economical Risk in Construction Companies-

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ABSTRACT

Today, cost variances in construction contracts have a huge impact on economic players in the construction sector, particularly on contractors. Given this situation, it is imperative to intervene in order to minimize the risks associated with these cost variances. Thus, it is essential that operators are aware of their responsibilities and their ability to influence the direction of the construction industry.

Thus, in order to ensure the sustainability of construction companies, risk management is an increasingly important tool and source of differentiation in a more and more competitive market. Risk management is henceforth aimed at minimizing any negative impact, at the company level, and assess and enhance return relations.

This master's thesis contributes to the development of risk management in the construction sector, in particular in regards to the Contractor's perspective. To this end, the cost variances were quantified by typologies and tools were created that allow the decision-making entities to make proactive decisions.

INTRODUCTION

1.1 General framing

Risk is part of the everyday life of the construction sector, being uncertainty present during almost all of the life cycle of a project (Domingues, Almeida, & Sousa, 2012).

We all manage risks in our day to day activities. However, this management is done empirically and not in a planned, systematic and conscious way. For those involved in construction projects, including contractors, management of these uncertainties is of particular relevance and should be used as a tool for differentiation and competitiveness increase in the sector. Control of adverse factors enables companies to optimize the control of their activities and thus reduce costs and improve overall productivity (Santos, 2013).

A construction contract's cost variance is thus one of the parameters that concerns contractors, which is often used as an indicator of successful construction. In this way, cost variances should be assessed, quantified and treated.

This master's thesis contributes to the development of risk management in the construction sector, in particular according to the perspective of the Contractor. To this end, cost variances were quantified by types and tools were created that allow the decision-making entities to make proactive decisions.

1.2 Objectives and methodologies

Through the media, we are often confronted with news that account for contracts in which the costs expected in the budgets were exceeded. In this sense, there are, at first, two questions: Why is it that budgets are exceeded in almost all construction works? And where did these cost variances come from? Given the scarcity of scientific studies on cost variances, particularly in the view of the contractor, the need to conduct this study arose. Thus, given the importance of the problem, this study aims to analyze and quantify cost variances in different types of work from the contractor's point of view. This work falls within the framework of a doctoral thesis in progress at the Instituto Superior Técnico, whose goal is to create a tool that allows the management bodies of construction companies make more informed decisions based on data and facts. Thus, we intend to create a quantitative basis to assist risk



management, in relation to the costs of deviations in general and, in what concerns this thesis in particular, in relation to direct costs variance. The goal is to enable proactive decision making, done in an informed and conscious way, to reduce or even eliminate any variances that would change what was originally planned. These decisions will be made based on the analysis of data gathered from company history, since this is the reality that better reflects the company's identity.

In order to achieve this overall objective the following specific objectives were outlined:

- Quantification of the actual direct and indirect costs in the constructions value by construction typologies.
- Identificação da variação dos desvios de custos do valor de obra e dos custos diretos finais reais das empreitadas por tipologias de obra.
- Identification of the construction value's cost variances and of the contract's real final direct costs by construction typologies.
- Analysis of the progress of the direct costs and of the profits over the duration of the construction, by construction typologies
- Verification of which of the initially estimated direct costs is closer to the real direct costs by construction typologies.
- Quantitative study of the costs variation of the activities of a construction of the communication routes typology.

2 CASE STUDY

2.1 Company characterization

In order to achieve the proposed objectives, a study on a national construction company was carried through. It is a medium-sized company which has the contribution of 293 employees and an annual turnover of around 370 million euros. The main areas of activity of the company in question are construction and public works, taking in course the most diverse projects, such as airports, dams, housing, hospitals, hotels, offices, ports, roads, viaducts and bridges.

2.2 Sample characterization

From this company a selection of a few construction works was made, with the purpose of evaluating their behavior, as well as to quantify the variations at the level of direct costs, and assess the respective causes.

This company has made a selection of some works, in order to evaluate their behavior, and to quantify the changes at the level of direct costs and their causes.

In the first phase, a sample of sixty completed construction works was collected from the history of the company, relating to the time period between 2004 and 2011. The contract work values studied varies in the range of one million to one hundred million euros. In this initial sample / base there were nine different types of work

In the second phase, after analyzing the set of information that was available about each work, this sample had to be reduced in size. This was so because the method of storage of data, including the accounting movements of some of these works, did not allow a detailed analysis of the direct costs and income. The collection of this information would be too time consuming, and therefore it was decided to use only the company's own works, having been excluded from the sample consortium and ACES works. In order to examine the works in which it would be possible to carry out this study within a

reasonable time, we ended up with a sample of thirty-eight works, on which the number of existing work typologies is much lower.

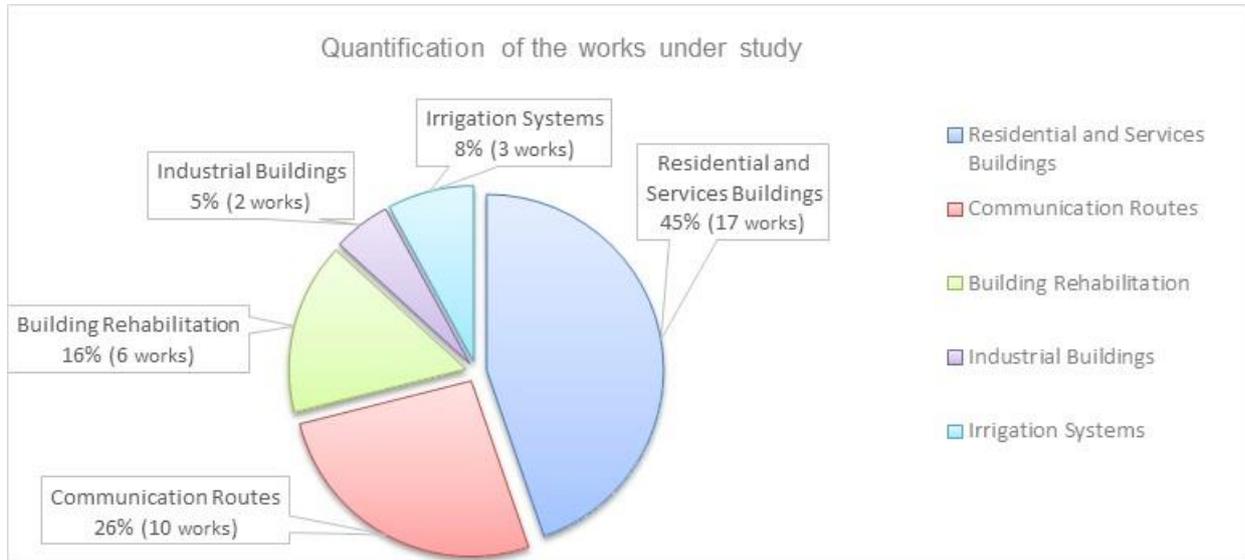


Figure 1- Quantification of the works under study

In the third phase, in order to study variations between initially estimated direct costs and the real direct costs, a further reduction of the sample was taken into course. This further reduction of the sample had to be executed, since the information on the initially estimated direct cost of some works were not present in the closure sheet.

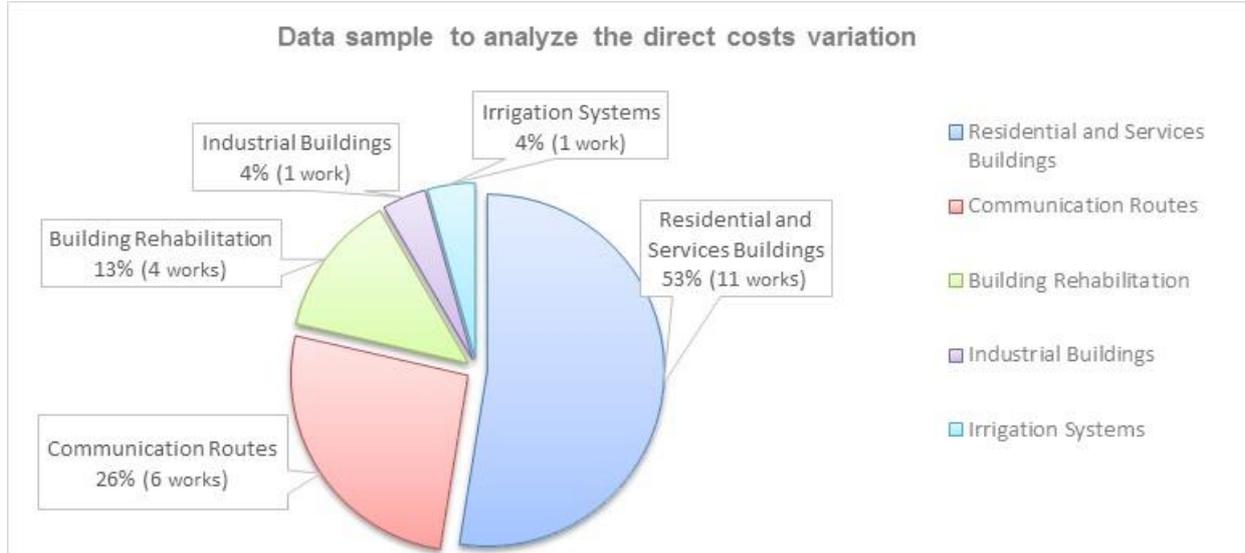


Figure 2- Sample of the direct costs variation for analysis

3 PRESENTATION OF THE RESULTS AND DISCUSSION

3.1 Quantification of the real direct and indirect costs on the work value

In order to quantify the direct and indirect costs, the data was grouped by type and their ranges as well as the mean and standard deviation were obtained. In the chart below it is shown the average percentage of direct and indirect real costs on the work value divided by type and the total average.



Figure 3- Average percentage of direct and indirect costs by typology and total

Extreme cases in the percentage distribution of direct costs (minimum 70% and maximum 95%), referred to in the analysis of Figure 17, only appeared reflected in the communication routes typology.

On average, direct costs represented 85% of the work value.

3.2 Variation of the work value

One of the key parameters that is important to take into account is the analysis of the change in the work value in relation to what was originally budgeted. To this end, the variation of the work values, by typologies and types of clients, as illustrated below, was verified.

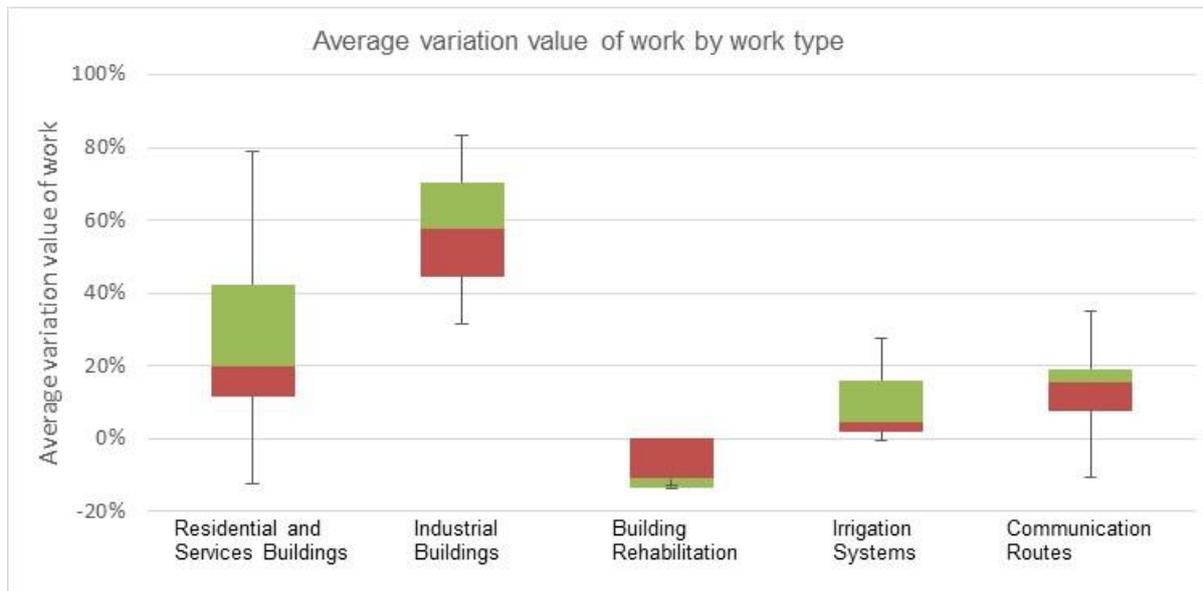


Figure 4- Percentage variation of the work value in relation to the initially predicted

It was observed that the works pertaining to the residential buildings and services and communication routes typologies were the ones that had both positive and negative variations. In the building rehabilitation typologies, only negative variations of the work value and very close to that were observed. As for the irrigation networks and industrial buildings typologies, these only had positive variations in the

work values. It is interesting to note that 50% of the sample of each typology almost don't overlap with each other, each typology having almost its own range of variation.

The typology of residential buildings and services recorded the greater range of variation. This one showed an average change in the work value in relation of the initially predicted of 25.3%, a maximum variation of 79.0% and a minimum variation of -12.5%

The maximum variation of the work value took place in the industrial buildings typology, 83.3%, and the minimum in the rehabilitation of buildings typology, - 12.9%.

Another analysis to take into account for the variation of the work value is the one according to the customer. The following graph shows that same variation.

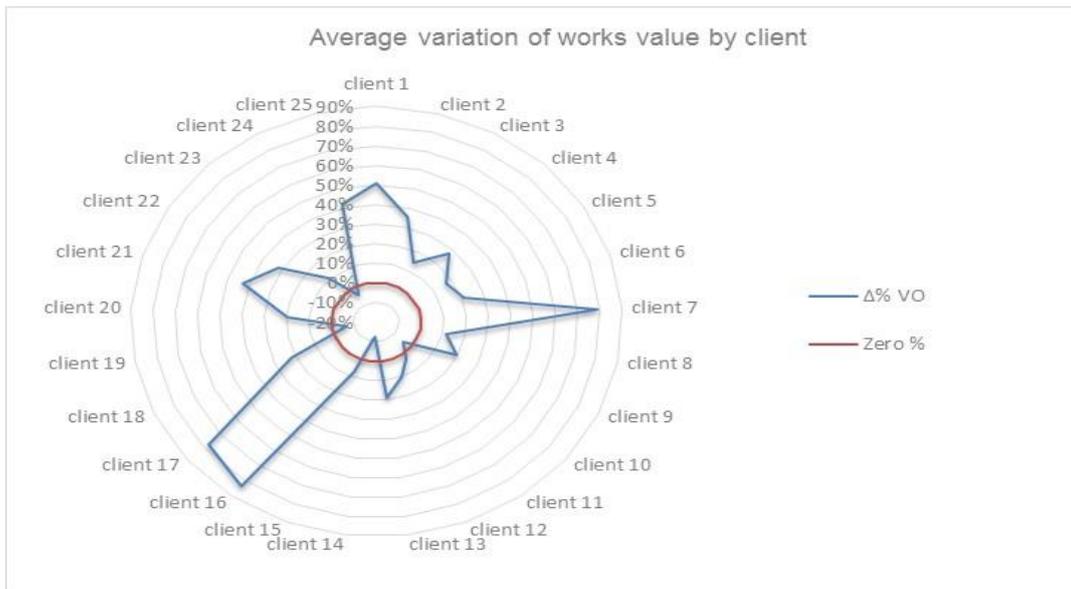


Figure 5- Variation of the work value by client

Firstly, it is important to note the huge amount of different customers in just thirty-eight contracts. It can be seen that the variation in the value of work is quite different from customer to customer, being able to range from 83% (client 16), to less 13% (client 18). Note that there are customers whose behavior is similar. This same fact is demonstrated when these plots are organized by work typology.

Finally, another analysis that was made was that of the variation of the work value by type of client. The following table illustrates this same variation.

Tabela 1- Variation of the work value by type of client

| Type of client | Average variation of the work value | Average percentage variation of the work value |
|----------------|-------------------------------------|--|
| Private | 2845128 | 31% |
| Public | 1627440 | 5% |

An enormous difference between the values of the variation of the work value of the private and of the public sector was observed. In fact, the private sector's works had a variation of 31%, while the public sector's works only had a variation of 5%.

3.3 Variation of the real direct costs

Variations of the direct costs relative to the habitation and services, rehabilitation of buildings and roads typologies were observed.

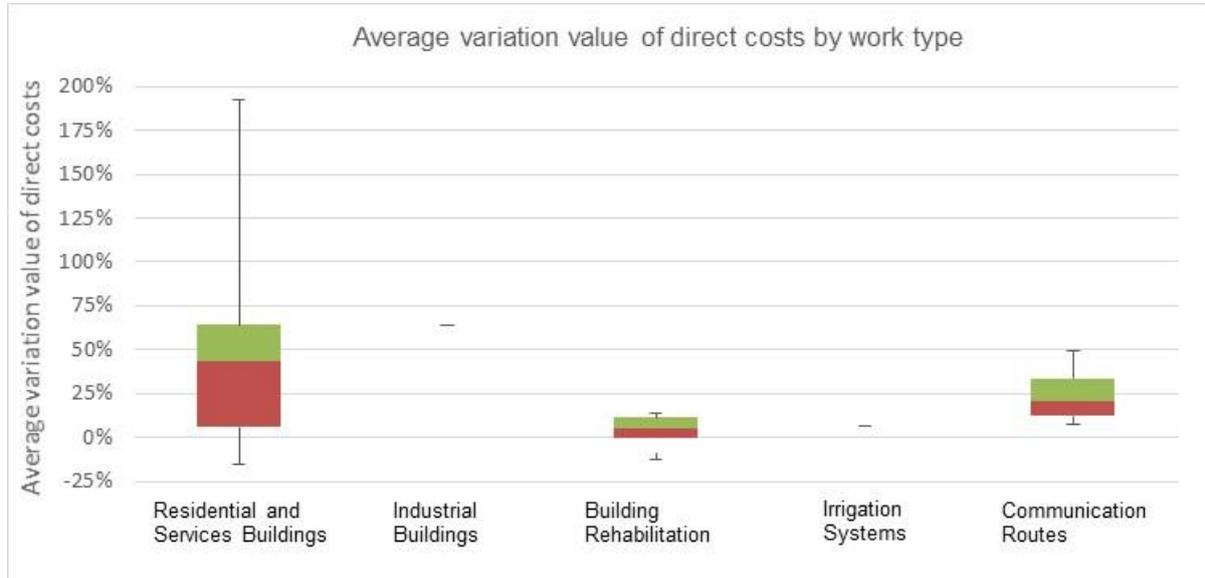


Figure 6- Average percentage variation of the direct costs in relation to the initial prevision

From the above graph it can be concluded that the residential buildings and services typology is the one that shows the greater dispersion of data. This variation of the direct costs ranges from a maximum of 193% to a minimum of -15%. However, 50% of the sample concentrates its variation in the range that goes from 6% to 64%. Thus, it was observed that the average percentage variation of actual direct costs, in this typology, was of 50%. In the rehabilitation of buildings typology, both positive and negative variations were observed, having the maximum variation of the direct costs been of 4% and the minimum of 12%. Finally, on what accounts the roads typology, there were only positive changes. This typology thus showed an average variation of 25%. The range of direct costs variation in this typology went from 7% to 49%.



Figure 7- Comparison between the real direct costs and the real income

It can be observed that, with the exception of works number 6, 15 and 30, all the works had a total income higher than direct costs. The fact that the direct costs were higher than the income does not appear to be related to the typology in question, since these three works belong to three different typologies of work (roads, housing services and buildings rehabilitation respectively). On average, revenues were higher than the direct costs by 12%. So, since direct costs on average are lower than income, there are about 12% of the sale value available for indirect costs, in order not to incur in a situation of loss in the contract.

3.4 Variation of the direct costs and income over the work duration

Regarding the progress of the direct costs and income over the work duration, there were three distinct behaviors. Next, we present the graphs of the variation of the direct costs and income over the work duration and the respective cumulative chart.

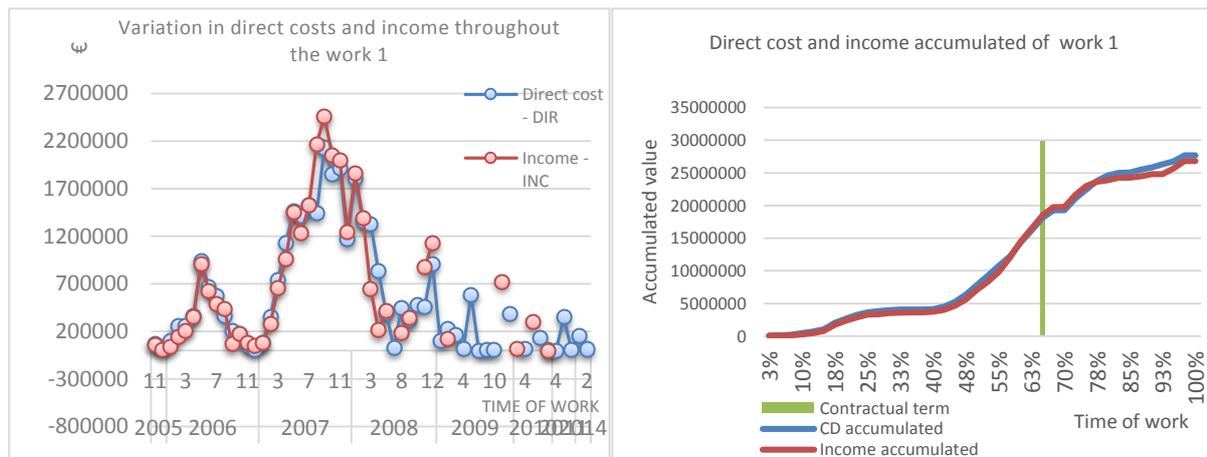


Figure 8- Plot of the direct costs and income and the respective cumulative plot of the communication routes typology

In order to summarize the information present in the cumulative plots and to facilitate an analysis by work typologies, so called boundary plots were created. Below, that same plot relative to the communication routes typology is shown.

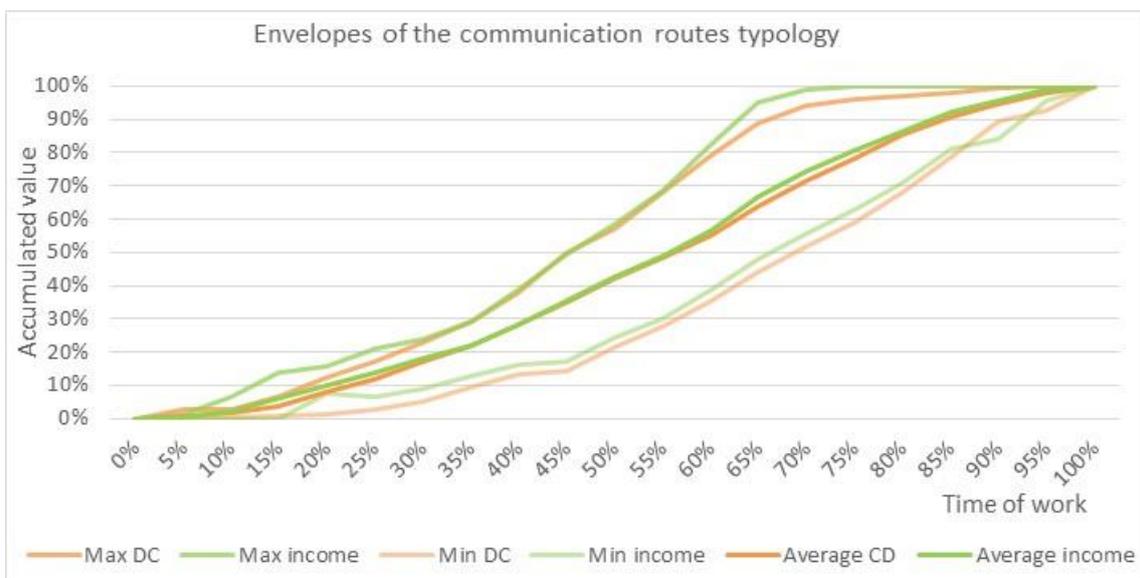


Figure 9- Envelopes of the communication routes typology

3.5 Variation of the direct costs and of the profits over the duration of the work

The initially estimated direct costs can be divided in three categories: (i) uncorrected direct costs; (ii) direct costs corrected with markup, discounts, optimizations, design optimizations and other corrections; (iii) Direct costs corrected just with markup. In order to verify that makes sense or not to add these "corrections" to the uncorrected price, we present graphs which compares this three costs with the actual final direct costs by types. Then, we present this chart to the typology of buildings housing and services.

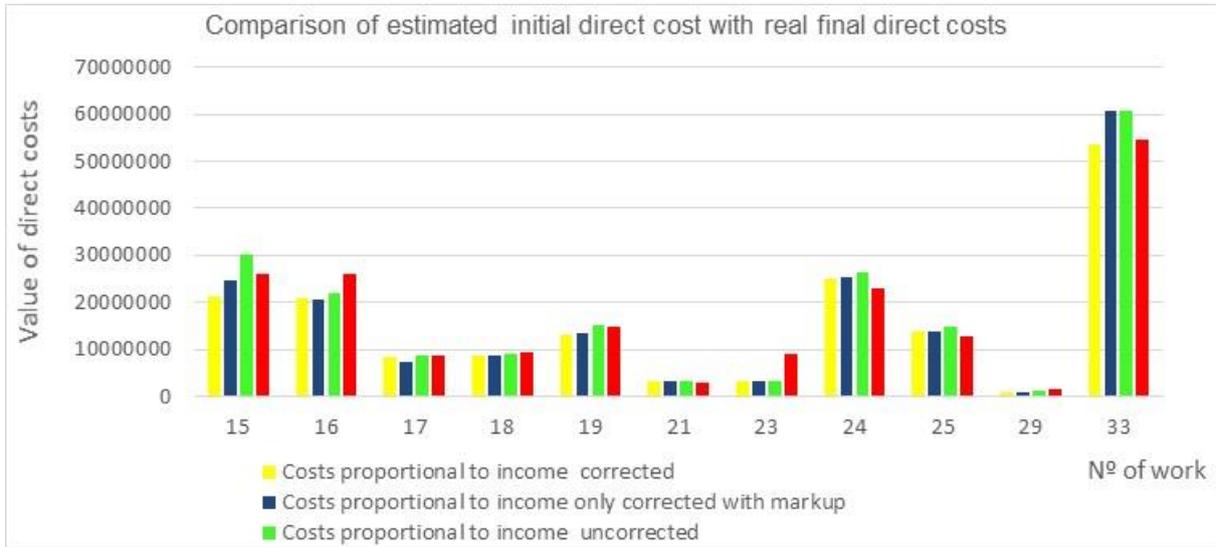


Figure 10- Comparison of the direct costs in habitation and service buildings typologies

3.6 Variations of the real direct costs by activities

In the table below are shown the variations of the real direct costs of the five activities with the highest weight, of work number 6, which belongs to the communication routes typology.

Table 2- Variation of the real direct costs of the five heavier activities in work 6

| Activities | Budget | Final Real | Variation % |
|----------------------|----------------|--------------|----------------|
| | DC with markup | | DC with markup |
| Pavimentação | 1 590 107.31 | 2 755 932.56 | 42% |
| Movimentos de terras | 958 150.14 | 1 960 218.67 | 51% |
| Betão | 517 028.76 | 838 340.07 | 38% |
| Barreiras acústicas | 469 499.14 | 266 987.71 | -76% |
| Aço | 371 653.81 | 152 422.36 | -144% |

In the three activities with the biggest weight the final costs were higher than the costs originally planned, belonging the greater variation in costs (51%) to the activity "earthworks". The other two activities, "noise barriers" and "steel", had a negative variation of -76% and -144%, respectively.

Analyzing all the activities, the activity "cuttings and nailing" is the one that shows a higher costs variation, of 69%. It is deem of note the fact that the activities that have greater weight are located in the middle of the table (fifth, sixth and seventh place), leading us to believe that, the fact that these have a bigger size / weight value-wise doesn't seems to cause a bigger percentage variation.

4 CONCLUSION

4.1 General considerations

Given this, the main conclusions are distributed over the following topics:

- **Quantification of the real direct and indirect costs on the work value**

A major step was taken with regard to quantification of direct and indirect costs in the work value. Once the data is grouped by typologies, this type of information becomes a support tool for decision making, allowing managers entities to make their decisions in a more conscious and informed way. This is true because, in advance, when placed before a budget, one can verify if the direct and indirect costs are within the expected range. Thus, before an anomalous situation, one can act proactively, asking, for example, for a design review.

- **Variation of the work values**

The maximum and minimum work value variations observed were 83% and 13% respectively.

We came to the conclusion that it would also be important to link the variation in the work value, not only to the work typology but also to the customer. In this regard, it was noted that within each typology there are differentiated "customer types", i.e., whose percentage variations of the work value resemble each other.

Variations of the value of the work in the private sector were higher than those observed in the public sector. The private sector works had a 31% variation, while the public sector works only had a variation of 5%.

- **Variation of the real direct costs**

Variations in real direct costs for residential buildings and services, rehabilitation of buildings and roads typologies were registered. It was thus noted that the direct costs ranged from a maximum of 193% to a minimum of -15%. The behavior of the variation of the direct costs was different in all the three typologies.

On average the variation of the direct costs is greater than the variation of the work value by 8%. This represents an average loss of at least 8% of the work margin.

It was also found out that 12% of the sale value on average can be spent on other charges (eg, indirect costs), so that the works do not incur in a loss situation.

- **Comparison between real direct costs with estimated budget's direct cost**

It was found that, since the real costs "exceed" the initially estimated costs, the costs that are closer to the real costs are those not corrected, as these minimize losses.

It was also observed that in most cases the starting point was a comfort situation, in which the estimated costs (uncorrected costs) were higher than the actual costs, going for a "worst-case" situation when markup was applied, decreasing income in relation to uncorrected costs. Later, situation of "discomfort" would arise, since the real costs were higher than the corrected costs. Of note is the fact that failure to apply these discounts could result in not winning the contract.

- **Variation of the direct costs and of the profits over the duration of the work**

The different behaviors of the works for the five typologies under study were characterized. The typologies routes of communication, rehabilitated buildings and industrial buildings behave similarly, in what regards the cumulative curve. Summarizing this type of work present rhythms that alternate between slow, fast and again slow. In these typologies, the fact of the contractual period having been exceeded, does not bring consequences at the level of the behavior of the level of costs and incomes.

The residential buildings and services typologies, with respect to the cumulative curves, show two different behaviors, as mentioned above:

- Behavior of cumulative plots type (i) of the residential buildings and services typology. This type of behavior was only registered in this work typology. It is characterized by an early pace of rather slow work, as had already been registered in the communication routes, rehabilitated buildings and industrial buildings typologies. However, this rate will gradually increase until the end of the work. In short, this type of work presents a very slow pace at the beginning of the work, and ends with a high rate.
- Behavior of cumulative plots type (ii) of the of residential buildings and services typology. This type of work despite very fast work rhythm at start, gets progressively slower, culminating in a slow end of the work. This type of behavior was also identified in the irrigation networks typology.

From the cumulative charts the boundary plots were created, which thus represent a summary of the behavior of all the works of this typology. By averaging costs and income and its proximity to both the upper boundary and the lower boundary minimum, the different occurring rhythms in the work can be described. In short, with the analysis of these plots, the same conclusions that would be obtained from the analysis of the plots of the direct costs and income variations, and from cumulative charts. However, these boundary plots still have the enormous advantage of letting us obtain the maximum and minimum values ever registered. This allows decision-making entities, prior to the realization of the contract, to input their estimated cost curves, and thus verify if these are within the boundary plot relevant to the work typology in question. Henceforth, if the curve fits, these entities may request a review of the project and thus proactively intervene in the resolution of any problems.

- **Variations of the real direct costs by activities**

With the largest percentage change in costs, comes the Cuttings and Nailing activity, with 69%. The activities with the highest weight, such as Earth moving, Paving and Concrete only show up in fifth, sixth and seventh place, with a cost variation of 51%, 42% and 38%, respectively.

5 BIBLIOGRAPHIC REFERENCES

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