ESTIMATION MODEL FOR THE IMPACT OF DELAYS ON THE COSTS OF A PROJECT

EXTENDED ABSTRACT

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1 – Introduction

The building sector in the majority of the European countries, including Portugal, takes on a role of the utmost importance in their economy. It represents a high percentage of those countries’ Gross Domestic Product and it is responsible for a high employment rate (Euroconstruct, 2010; AECOPS, 2009).

With the increasing competitiveness in this sector, there has been a reduction of the profit margin and a greater demand on the side of the client. Notwithstanding, there are still serious errors being registered throughout the projects; errors that hinder the competitiveness of the companies and among which we can find construction delays, cost overruns and, sometimes, the poor quality of the final product.

The present research paper intends to contribute to the better understanding of the causes and effects of construction delays. Thus, two major goals are established: to present a Microsoft Excel model that allows estimating the impact of the delays on the costs of a construction project and to define a set of recommendations that allow reducing the occurrence of such delays.

The research methodology was based on a set of four stages, interconnected and progressively executed, as shown in Figure 1.

![Figure 1 – Stages of the research methodology.](image)

2 – Theoretical Background

The success of a construction undertaking is defined as the fulfillment of goals determined during the planning stage. As stated before, projects keep suffering critical delays that cause the postponement of their conclusion and the increasing of the estimated costs. The bibliographical research of the present paper was based on the analysis of several recent national and international studies on this matter. The sheer amount of such studies corroborates the awareness regarding this issue. Among the analyzed studies, the emphasis goes towards the most recent and relevant ones. Moura and Teixeira (2005) have analyzed a group of projects carried out between 1998 and 2002 and they have concluded that the total of indemnities due to complaints represented 11% of the initial cost of the projects. They have also concluded that the average increase of the costs was of 25% and the duration of the projects was around 85% longer.

Couto (2006) has identified the main causes of delay in our country. Based on surveys, the results of his research have shown that the modifications made to the project are the most common cause of delays, and the closer these occur to the end of the works, the bigger the consequences.
A study conducted by Assaf and Al-Hejji (2006) revealed an opinion divergence among the parties. As far as the client is concerned, the main causes of delay are related to the contractor, while to contractors, clients are the main causers of delays. Sambasivan and Soon (2007) have studied the relationship between the consequences of delays and their causes. The authors concluded that the increased duration of the project is caused by factors related both to the client and to the contractor – things such as bad planning, poor site management and overdue payments. On the other hand, the cost overrun is related with factors inherent to the contract, like changed orders and errors or discrepancies. Sambasivan and Soon have also concluded that the cost overrun is closely related to the project’s duration.

Through conducted surveys, Branco (2007) concluded that the main causes mentioned by the parties were unavoidable and hard to predict changes, unrealistic and optimistic deadlines, equipment and material delivery delay, difficulties in obtaining permits and licenses, as well as the delay to furnish and deliver the construction site. Along with his study, Branco provided a set of recommendations where he stresses the need for a behavioral change, a better communication between the parties and an investment in the quality of the projects and in labor training.

Cabrita (2008) has identified the factors and the parties most likely to cause delays and which cause the biggest impact on the overall project delay. The most conditioning factors are due to aspects external to the contractor, such as late decisions, delays in the manufacturing of the construction materials, weather conditions and task changes. As for the parties, the sub-contractor has proved to be the least influential aspect. Causes such as the client’s alterations, the interpretation of the project, the requirement of further clarification or the lack of communication between the parties were considered the most influential ones.

Delays correspond to a work postponing beyond the date explicit in the contract and agreed by the different parties (Assaf e Al-Hejji, 2006).

According to Trauner et. al (2009), delays may be categorized in: critical and non-critical delays; excusable and non-excusable delays; compensable and non-compensable delays; and concurrent and non-concurrent delays.

Critical delays correspond to delays in the critical activities of the project which will directly affect the project’s final deadline. Non-critical delays are not so constraining since they occur in activities with a much looser execution deadline.

Excusable delays earn the contractor some extra time to conclude the work because they are caused by unpredictable events that cannot be controlled. If the delay is caused by acts or omissions of the client, the contractor is entitled to a financial compensation. If the delay is none of the parties fault, there will be no financial compensation.

Non-excusable delays are of the contractor’s responsibility and they earn him no extra time or financial compensation. However, these delays may entitle the client to a financial compensation.

If there is only one isolated delay, then we can say we are in the presence of a non-concurrent delay. In such cases it is easy to assign responsibilities. In situations where two or more critical delays occur simultaneously, these are called concurrent delays.

Most of the times, assigning responsibilities may become a tricky task since delays are caused by two or more of the parties.

Delays may lead to an increase in the duration of the project and in its costs, to disagreements between the parties and to fines, and they may cost the contractor his reputation (Cabrita, 2008). The existence of delays represents losses to all of the parties: the loss of income to the client; increased costs to the contractor; and the non-utilization of the facilities by the population.
Project delays are almost always accompanied by an increase of the initially stipulated costs. This estimate depends on the resources necessary to complete all of the project’s activities (PMBOK) and its accuracy relies on several aspects that cause an increase both of the uncertainty and of the error risk (Sousa, 2008).

The first factor to influence the estimate corresponds to the moment of the project when this is calculated. Lock (1997) concluded that the most accurate figures are obtained in face of the most recent and detailed data.

Other influential factors are related to the uncertainties regarding the prices of the resources, errors and omissions in the project that may lead to extra work, changing of the planning, natural phenomena, among others.

The costs of a project are divided into direct and indirect costs. Direct costs include every charge resulting directly and exclusively from a certain activity and they contemplate labor, materials, equipments and subcontracts. Indirect costs include the remaining charges that do not arise directly and exclusively from the execution of an activity and they contemplate expenses related to the construction site, insurances, studies and projects.

3 – Case Study

The present research paper was developed with the support of Soares da Costa (SDC), a reference company in the Portuguese construction sector and that may be considered as representative of the national reality.

This partnership allowed for the following of a company project throughout the study – a project called “Concepção e Construção do Parque de Estacionamento em Altura no Antigo Mercado do Chão do Loureiro”.

This project proved to be a great case study due to its high quantity of critical activities and high percentage of subcontracted works. Such factors increase the risk of delay.

The case study provided relevant data to the fulfillment of the proposed goals. The data gathering consisted in the analysis of the project documents and control procedures of the company, in the conduction of surveys among several project collaborators and company employees and in the direct observation and recording of the work progress.

The preparing and controlling of a project are well defined and implemented stages in SDC. Planning and budgeting are executed by specialized departments, using appropriate software tools such as Microsoft Project and CCS Candy. These documents constitute the basis of the project and are crucial to its success.

Another important step towards the success of a project is the effective control throughout the contract, as a way of assuring its conclusion within the stipulated deadlines and costs.

The monthly deadline control is based on estimates of the percentage of work carried out so far – estimates given by the site management. This data is then inserted in the Microsoft Project planning file which automatically calculates the schedule deviation of the project and of each of its activities.

The surveys were conducted near a group of 17 employees from several departments of SDC, evaluating their opinion on the control procedures of the company and the main reasons of delay and cost deviations in construction projects.

The results were then analyzed using the Likert psychometric scale, with five levels of agreement, punctuated from 1 to 5. This scale allows for the calculation of relative indexes.

The majority of the inquired individuals think the control procedures are very important to the company’s success and were satisfied with the implemented procedures. Cost
control obtained a relative index of importance of 0.95, while scheduling obtained a relative index of importance of 0.94 and a relative index of satisfaction of 0.83.

To the inquired people, the main reasons of cost deviations are the project changes and/or extra work, with a relative index of impact of 0.86. The occurrence of critical delays was the second major cause pointed out, with a relative index of impact of 0.77. Other reasons were also mentioned, such as poor initial calculations, resource prices variations, weak project preparing and financial aspects – all with a relative index of impact under 0.65.

Causes were categorized into the following ten major groups: contract related factors, project related factors, client related factors, contractor related factors, labor related factors, equipment related factors, material related factors, consultant related factors, design team related factors and other related factors.

In Table 1 and Table 2 it is possible to observe the results of the surveys regarding the causes of delay pointed out as the most frequent ones and those with the highest impact on the overall delay of the project, respectively.

<table>
<thead>
<tr>
<th>Delay Factors</th>
<th>Relative Index of Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unrealistic imposed contract duration (Client)</td>
<td>0.86</td>
</tr>
<tr>
<td>Inevitable and hard to predict changes to the project (Project)</td>
<td>0.80</td>
</tr>
<tr>
<td>Changing orders (Client)</td>
<td>0.74</td>
</tr>
<tr>
<td>Incomplete and ambiguous projects, with errors and omissions (Design Team)</td>
<td>0.72</td>
</tr>
<tr>
<td>Lowest bid contracting system (Contract)</td>
<td>0.72</td>
</tr>
<tr>
<td>Waiting time for approval of tests and inspections (Consultant)</td>
<td>0.70</td>
</tr>
<tr>
<td>Slow decision making by owners (Client)</td>
<td>0.67</td>
</tr>
<tr>
<td>Unskilled labor (Labor)</td>
<td>0.67</td>
</tr>
<tr>
<td>Weather conditions (Other)</td>
<td>0.67</td>
</tr>
<tr>
<td>Delay in analyzing complaints (Client)</td>
<td>0.65</td>
</tr>
</tbody>
</table>

**Table 1** – Most frequent causes of delay according to the inquired people.

<table>
<thead>
<tr>
<th>Delay Factors</th>
<th>Relative Index of Impact</th>
</tr>
</thead>
<tbody>
<tr>
<td>Suspension of works (Client)</td>
<td>0.93</td>
</tr>
<tr>
<td>Unrealistic imposed contract duration (Client)</td>
<td>0.93</td>
</tr>
<tr>
<td>Weather conditions (Others)</td>
<td>0.89</td>
</tr>
<tr>
<td>Inevitable and hard to predict changes to the project (Project)</td>
<td>0.87</td>
</tr>
<tr>
<td>Unforeseen ground contions (Project)</td>
<td>0.87</td>
</tr>
<tr>
<td>Unskilled labor (Labor)</td>
<td>0.85</td>
</tr>
<tr>
<td>Delay in analyzing project complaints (Design Team)</td>
<td>0.85</td>
</tr>
<tr>
<td>Shortages of labor supply (Labor)</td>
<td>0.83</td>
</tr>
<tr>
<td>Slow decision making by owners (Client)</td>
<td>0.80</td>
</tr>
<tr>
<td>Low productivity (Labor)</td>
<td>0.80</td>
</tr>
<tr>
<td>Waiting time for approval of tests and inspections (Consultant)</td>
<td>0.80</td>
</tr>
<tr>
<td>Difficulties in obtaining permits (Other)</td>
<td>0.80</td>
</tr>
</tbody>
</table>

**Table 2** – Causes with the highest impact in the overall delay of the project according to the inquired people.
The causes relating to the client obtained higher indexes of probability and impact than those relating to the contractor. Regarding the causes related to the client, the indexes of probability obtained were between 0.50 and 0.86, while the indexes of impact were between 0.73 and 0.93. Regarding the causes related to the contractor, the indexes of probability obtained were between 0.33 and 0.53, and the indexes of impact were between 0.53 and 0.73.

Inquired individuals were also asked to indicate preventive measurements, as to minimize the occurrence of project delays. The most referred ones were the communication improvement between the several parties, the establishment of more realistic deadlines on the side of the client and the quality improvement of the projects.

4 – Proposed Model

The model was developed in Microsoft Excel, based on the analysis of the project’s documents, such as budget, work schedule and labor and equipments plans. The model was applied monthly, based on the results of the deadlines control procedure implemented by SDC.

For the construction of this model, only the indirect costs related to the costs of the construction site were taken into account. This summand has a great influence over the costs deviations when delays occur, due to the need to extend all of those project’s resources. This is also the most measurable summand.

The construction of the model has had two main stages: the analysis of the charges of the construction site with the purpose of understanding its calculus in this specific project, and, later, the definition of a time/cost relation for each one of these resources.

From the analysis of the construction site costs, based on the budget, derived the initial division of the resources into two types. Type I resources, allocated to the project since its beginning and until its conclusion, and Type II resources, allocated to the project for periods of time inferior to the total duration of the project.

The time/cost relation for Type I resources depends on the project’s conclusion date and it is given through the following equation:

\[ DC \text{ (Type I Resources)} = Pu \text{ (Type I Resources)} \times DPf \text{ (Activity 1)} \]  (1)

Where:

\( DC \) – Costs deviation;
\( Pu \) – Unit cost;
\( DPf \) – Activity finish variance.

For Type II resources it was necessary to identify, first of all, the period of allocation to the project. From the crossing of data taken from the work schedule, from the budget and from the labor or equipment plan, it was possible to establish the moment of entrance of the resource in the project and its exit moment.

The time/cost relation for Type II resources depends on its period of allocation and it is given through the following equation:

\[ DC \text{ (Type II Resources)} = Pu \text{ (Type II Resources)} \times DP \text{ (Period of Allocation)} \]  (2)

Where:
The equation (2) will suffer changes according to the resource in question. To those resources which period of allocation is defined by a continuous period of time in which the date of entrance in the project coincides with the beginning of works but its exit date is prior to the project's conclusion, the time/cost relation will only depend on the finish variance of the last activity in which it takes part.

In those resources which period of allocation is defined by a continuous period of time in which the date of entrance does not coincide with the beginning of works, the equation (2) will depend on the start variation of the first activity in which the resource participates and on the finish variation of the last activity it is allocated to.

Another possible scenario is the existence of resources which period of allocation is defined by a set of time intervals. In such cases, a set of continuous periods of time can be individually taken into account and the equation (2) will correspond to the sum of the costs deviations for each one of these time intervals. Sometimes, these sets of time intervals integrate intervals that refer only to a single activity. In this specific case, the equation (2) depends on the duration variance of that particular activity.

All of the data referring to the start variance, finish variance and duration variance of the activities has been taken from the monthly updated work schedule. The insertion of this data into the constructed model generates an estimate of the deviation of the construction site costs at the end of the project, depending on the work progress up until then.

5 – Recommendations

Establishment of more Reasonable Construction Deadlines

The very optimistic deadlines were considered by the inquired people as the most frequent cause of delay and one of those with the higher impact on the overall delay of the contract. Too optimistic and demanding deadlines can be explained by empirical estimates which are frequently executed according to financial or political agendas. It is necessary to promote the execution of more adequate deadlines estimates, early in the first stages of the competition.

Investing in the Quality of the Projects

The quality of the projects is crucial to assure the overall quality of the construction. The more detailed and developed the project, the higher the accuracy of the budget and the scheduling.

This measure may imply a higher cost during the competition stage, but it would profit each of the parties and could even contribute to a decrease of the complaints.

Improving the Communication and Relationship between the Several Parties

An efficient communication and coordination between the parties have been referred, in several studies, as one of the major factors of success of projects’ management. Every party must contribute to promote a good working relationship, which requires a behavioral change.
Clients must reveal a bigger appreciation for the study stage and must apply rigorous, transparent and objective awarding criteria. Consultants should play a role of counseling and prevention, as to help and assist the client and as to support the contractor in technical matters. A lot of times, consultants assume a policing role.

To Improve the Payment Deadlines

Payment delays may prevent the parties from financing the work and, therefore, may harm the production process. The lack of payment decreases the performance of the working teams and harms the relationship and communication between the several parties. In certain cases, conflicts may arouse that can only be solved through external entities, such as courts.

A More Rigorous Subcontractor Selection

This is an important measure considering that, nowadays, it is quite common to resort to subcontracting systems. Subcontracted work increases the coordination difficulty since the planning has to be passed on through more hierarchical levels. If the subcontractor proves to be unreliable, his replacement is the most obvious and immediate measure to be taken, and this may affect the previously stipulated costs and deadlines. This is why the selection criteria should not be based only on costs, but also on a set of other data, such as the subcontractor’s technical and productive abilities, his financial capability, his curriculum, etc.

To Promote a Good Construction Site Organization and to Improve the Starting Stage of the Project

A bad organization of the construction site can affect the productivity and the performance of the workers during the project. A good organization of the construction site consists in the material and equipment division into several sections, as to minimize the internal travelling of the workmen, material and equipment. To avoid surprises related to local circumstances that may generate time losses, it is important to carry out a study of the available area before the project begins.

Contractor’s Activity

The contractor must assure an efficient management of the project’s resources and guarantee a proper supervision of the work. To do so, he must analyze the project’s documents prior to its beginning, in order to identify highly probable to cause delays aspects. As a result of this analysis, he must be able to suggest measures to help partially recover from delay.

6 – Results

Table 3 shows the results obtained through the application of the constructed model and the deadline control procedures of the company, referring to the months of the project monitoring.
Table 3 – Results of the control procedures and of the model’s application.

During the study period there were no postponements of the final deadline of the project. This was, to a big extent, the result of the contractor’s good project management.

The higher registered variation – of -36.6 days – corresponds to a 12.2% reduction of the project’s duration. According to the model, this deadline deviation is associated to a cost deviation of approximately -76,000 €. This figure corresponds to a decrease of the construction site costs of around 10% and a decrease of the overall costs of approximately 2.5%.

Considering the characteristics of the followed project, it is possible to conclude that in more lengthy and expensive projects in which the construction site demands a higher quantity of resources, these percentages may represent severe deviations and may cause serious damages.

This research paper also allows concluding that the fact that the project does not present any duration deviations does not imply that it will not present a cost variation. This happens because there is no directly proportional relationship between deadline deviation and costs deviation – this can be confirmed by the results of Table 3.

7 – Conclusions

As far as the goals established in the beginning of this research are concerned, it is possible to conclude that they were entirely fulfilled.

The proposed model was successfully developed in Microsoft Excel. Even though its use is limited to the followed project, the methodology here described may be applied to other projects.

The reliability of the model corresponds to the reliability of the documents in its basis, as well as to the accuracy of the data supplied during the company’s deadlines control. This model may be used during the execution stage of the project, allowing for the analysis of the resources that, in a given moment, most contribute to its costs deviation and, as such, to establish measures to minimize those consequences. The model may also be used in a proactive way, through the simulation of different scenarios.

The application of the model established that there is no directly proportional relationship between the term deviation of the project and its costs deviation. Furthermore, it was possible to conclude that the existence of delays may represent significant costs deviations, especially in major projects.

About the surveys, it must be said that the sampling, besides being small, did not comprise all of the involved parties. Having only been performed to representatives of the contractor, this constitutes a sampling with results of the interest of SDC and reveals the opinion the contractor has about the remaining parties.

The set of recommendations was also successfully accomplished and it allows drawing the attention to several aspects that must be taken into account during the study and execution stages of a project. The main conclusion to draw from its development is that
all of the parties must register a behavioral change, as to promote a good communication and a healthy relationship between them. Complementarily, each of the parties must ensure measurements that facilitate their own activity.

References


