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International Journal of Project Management 32 (2014) 861 – 873

International Journal of Project Management

www.elsevier.com/locate/ijproman

Modeling construction time in Spanish building projects

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Received 26 March 2013; received in revised form 10 July 2013; accepted 26 September 2013
Available online 19 October 2013

Abstract

The literature states that project duration is affected by various scope factors. Using 168 building projects carried out in Spain, this paper uses the multiple regression analysis to develop a forecast model that allows estimating project duration of new builds. The proposed model uses project type, gross floor area (GFA), the cost/GFA relationship and number of floors as predictor variables. The research identified the logarithmic form of construction speed as the most appropriate response variable. GFA has greater influence than cost on project duration but both factors are necessary to achieve a forecast model with the highest accuracy. We developed an analysis to verify the stability of forecasted values and showed how a model with high values of fit and accuracy may display an anomalous behavior in the forecasted values. The sensitivity of the proposed forecast model was also analyzed versus the variability of construction costs.

Keywords: Forecasting; Time; Building projects; Construction speed; Construction cost; Regression analysis

1. Introduction

Time, cost and scope are project success factors, and they are commonly mentioned by many practitioners and researchers (Ahsan and Gunawan, 2010). In particular, predicting the required time to carry out the construction of a building has been of great interest for most professionals in the construction industry, since it has traditionally been identified as a key success factor in a construction project (Chan and Kumaraswamy, 1999). But despite the many advances made in the discipline of project management, in general, over the past decades construction projects have obtained poor performance regarding their planned duration (Chan and Kumaraswamy, 2002; Ng et al., 2001). Predicting construction duration accurately at the early stages is of vital importance for a successful project (Dursun and Stoy, 2011a).

Delays are a common problem in the construction industry (Doloi et al., 2012; Meng, 2012), and their magnitude varies considerably from one project to another. They can be caused by different reasons and produce serious economic consequences for the different agents involved in the construction process (Stoy et al., 2007a). From a basic preliminary analysis, the delay of a building project may be due to poor performance motivated by different causes such as failure of contractor, changes in project design or inclement weather (Greenwood and Shaglouf, 1997). But delays can also be caused by initial estimates that are too optimistic about the final duration of works (Ng et al., 2001). In this sense, the existing literature on the topic states that, initially, the construction duration of a building is affected by various factors related to project features. Therefore, it is essential to know these factors, their interrelationship and their influence degree on construction time, to increase the accuracy in the initial estimates (Chan, 1998) and reduce the magnitude of delays.

A lot of research has been developed on factors that may influence construction time. One of the first studies (and the most cited) was carried out by Bromilow et al. (1980) using building projects undertaken in Australia. This research developed a model to estimate construction time using cost as the main variable and considering also client type and the year of

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http://dx.doi.org/10.1016/j.ijproman.2013.09.009

construction. Other studies evaluated this model in Australia (Ireland, 1983; Ng et al., 2001; Walker, 1994) and other countries (Ameyaw et al., 2012; Chan and Kumaraswamy, 1995; Le-Hoai and Lee, 2009; Le-Hoai et al., 2009). Among these studies there are contradictory conclusions regarding the model performance. Ireland (1983) went on to state that the time–cost model is the best to estimate the construction time of a project while Walker (1994) noted that one of the shortcomings of the model is that it does not consider other factors besides cost. As additional variables to construction cost Walker (1994) studied gross floor area (GFA), number of floors, project type and procurement method. In addition to costs, Chan and Kumaraswamy (1995) also recognized that other specific characteristics of a project, such as GFA and number of floors, are factors that significantly influence project duration. Similarly, Love et al. (2005) concluded that in building construction projects GFA and number of floors are key factors to calculate the construction time while cost is a poor predictor. Some variables derived from the main scope factors have also been analyzed in the literature. Chan and Chan (2004) developed a model to estimate the duration for a specific type of housing in Hong Kong that included the derived variable represented by the relationship between GFA and number of floors, or what is the same in most cases, the floor area. In another study Stoy et al. (2007a) found that the cost/GFA ratio, named as "standard", is significant to forecast the construction speed.

Although Bromilow et al. (1980) and other researchers have shown that time has usually been the most appropriate dependent variable to be analyzed, some models have used the construction speed as an alternative dependent variable (Love et al., 2005; Stoy et al., 2007a,b). In this connection, there is a debate over whether it is possible to obtain better forecasting models using the duration as the dependent variable or if it is more appropriate to consider the construction speed (Stoy et al., 2007b). Different ways to define the construction speed have been presented in the literature. Stoy et al. (2007a) defined it as GFA executed in a month while Love et al. (2005) described the construction speed as the required time to perform a unit of GFA. Other researchers, as Nahapiet and Nahapiet (1985), used the concept of GFA per week. Ireland (1986) also evaluated the construction speed but as GFA per 8 h of working day. As we can see, the construction speed is generally defined as units per time and, consequently, the Love et al. definition is a non-standard definition.

Additionally, some investigations have compared the performance obtained on projects from different countries (Dursun and Stoy, 2011b; Xiao and Proverbs, 2002) and their results reveal the existence of differences in construction speed according to the physical location in which a project is developed. Thus, project time performance is context-specific (Le-Hoai et al., 2013).

To our best knowledge, research has not been conducted in Spain, either to identify factors which influence construction time or to propose models for estimating the duration of building construction projects. Therefore, within the Spanish context of the building sector, the main aim of this study is to develop a forecast model to estimate the construction time of new builds. The research focuses on the project construction phase, understood as the stage where the physical form of a project is created in compliance with design specifications (Chan and Kumaraswamy, 1997). In this study it is understood that this phase covers the period of time from the beginning of works until all planned construction activities are completed. To achieve the aim of the study, a statistical analysis was carried out using real data belonging to a set of building projects in Spain. The project scope factors represented by cost and GFA are analyzed in a special way, since they are used the most to develop predictive models (Greenwood and Shaglouf, 1997), as the one proposed in this study. Furthermore, we take into consideration that construction costs tend to be sensitive to commercial effects (Forsythe et al., 2010) and also that the final cost of works usually differs from the costs estimated before starting the work (Love et al., 2005). This difficulty to establish the actual cost of construction process could impair the ability of a model to predict the final duration when cost is used as a predictive variable. Nevertheless, it is necessary to emphasize that the possible shortcoming, which shows the cost variable, might be overcome by using the existing ratio between the actual cost and the estimated cost. There is evidence that this ratio may be lognormal (e.g., see Lipke et al., 2009).

2. Research methodology

2.1. Data set and variables

The project collection analyzed in this study belongs to a database that contains more than 300 projects with different uses, locations and sizes. It is a collection of Spanish construction projects classified in different constructive typologies. All projects were developed between the late 1980s and early 2000s. The research focused on new builds, such that projects relating to industrial buildings and rehabilitation were discarded for the analysis. Special sports facilities (swimming pools, soccer fields, etc.) and other singular constructions (bullrings, churches, etc.) were also excluded. We selected 168 projects as valid for the proposed study and they were classified into 7 subgroups according to their nature and scope (see Table 1).

From the discussion presented in the Introduction section it can be deduced that there is no consensus in the literature on what factors influence most significantly on the construction time. Some of the proposed variables cannot be measured objectively and, therefore, they can be hard to introduce into a prediction model (Forsythe et al., 2010). According to the available data, we selected a quantitative variable that represents the total cost of construction and two groups of quantitative variables related to GFA and number of floors (maximum number of floors excluding the roof). But sometimes it is necessary to use derived variables because some of the significant variables might not be a single entity and they appear as a ratio (Chan and Kumaraswamy, 1999). Similar studies to that proposed have also used these kinds of variables (Chan and Chan, 2004; Dursun and Stoy, 2011b; Stoy et al., 2007a), and they have obtained good results with their use. For this reason in this study two new variables were derived: (i) total GFA/total number of floors, and (ii) total cost of construction/total GFA. All independent variables used in the regression analysis are shown in Table 2.

Considering that there is no general agreement in the literature about which is the most appropriate dependent variable to predict