MODEL FOR PROPOSED CONSTRUCTION TIME FOR TRANSPORTATION FACILITIES

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1. Introduction

Determining a sustainable construction time is one of the most demanding tasks of managing the building projects. When defining the mutual relationship, all the building participants almost exclusively focus on the cost of construction while the matter of the duration is unjustifiedly neglected. Therefore the deadline is often overschedule or changed and sometimes even a matter of dispute among the parties to a contract because the overrunning deadline often results in cost increase which has to be covered by a participant of the building process.

Numerous researches conducted both world wide and in Croatia, point out the frequency and the damaging effect of being overschedule with the start date of the project finalization [1, 2, 4, 5, 12]. The research conducted by the World Bank or the Standish Group [1, 2] show that the proportions of the overrun are large and frequent. The research conducted in Croatia [3, 4] shows that about 2/3 of the building projects have significant or large overrun of the initially planned time. The similar results have been obtained in Slovenia [5] as well as in other countries of the broader region. The correlation between the planned and the effectuated fits into the assessment of the Standish group study which says that only about 1/3 encounters no serious problems in realization of the planned goals of the project in which process 2/3 of the projects do encounter them, so that the researches declared time to be the „killing factor“ [2]. It is crystal-clear that the deadline problems transfer to relations among the participants of the project and, eventually, to the financial part of doing business.

2. Development of „time-cost“ model and its application on building projects

Our research [4] analyzes different world research studies about construction time whose aim is to find an appropriate prognostic model for planning the sustainable construction deadline in the earliest phases of the project. By the end of the 1960s, the researches were focusing on the development of a numerical model which would enable a quick and real estimate or verification of construction time without applying detailed planning techniques.

From the number of researches the model developed by Bromilow stands out. In this model the project time is related to money in the exponential relation $T = KC^B$, K and B being constants [6,7]. K is a constant representing the number of working days required for the completion of unit value work. This paper defines as a unit value work the value of 1.000.000,00 kunas (Croatian currency – exchange rate 1 USD is ca 4,6 kunas). This model is logical and simple and has later been used in many additional researches [4, 8, 9, 10].

3. Research of „time-cost“ model in Croatia

The first researches related to development and application of „time-cost" model in Croatia were conducted from 2002 till 2004 on the civil engineering structures and building construction structures built from 1992 till 2003 [4]. This research was conducted on 107 structures sorted out into four categories: 41 state and local roads, 27 highway sections, 25 road structures (overpasses, tunnels, bridges, etc.) and 14 building construction structures (office buildings, residential buildings...). The constants K and B were determined and the „time-cost" model was defined for each category. A comparative analysis with the corresponding world results was also performed. The testing and rejecting of the null hypothesis confirmed the applicability of this model for the structures in Croatia. From 2005 till 2007 the second research on new projects was conducted and its goal was to check the influence of time.

3.1 Gathering of data, size and structure of the samples

In this research all the relevant data about structures, their contract and real prices and construction time were gathered through questionaires sent to investors and contractors. Particular missing data were filled in after interviewing persons in charge of the projects. This paper shows part of the research results related to state roads and highway bonds (hereafter roads). The sample for roads comprises 27 road sections which were built in the past ten years. Due to a longer construction time, the price correction was made on the basis of price increase index obtained from the Central Bureau of Statistics. [11].

3.2 „Time-cost" model algorithm

The Bromilow model $T = KC^B$ was used in the research and the constants K and B were being determined for specific market conditions in Croatia. The defining of the „time-cost“ model follows subsequent steps:

1) Price correction using price increase index in relation to the monitored period and exibition of prices in corresponding currency.
2) Calculation of price and time natural logarithms – $\ln C_C$, $\ln T_C$, $\ln C_E$, $\ln T_E$, where Cc and Tc are contract values and C_E and T_E are effectuated values.
3) Verification of linear dependance between the variables price – time:

a) by visual appraisal of „x – y“ graph
b) by quantifying the intensity of correlation using the regression coefficient R

4) Conducting of regression analysis and establishing the equation of assessor's straight line
5) Testing of the null hypothesis: H_0:β_1=0
6) Determinig the confidence interval for slope and intercept
7) Calculating the residual and determination coefficient
8) Verification of the results using residual by drawing and appraisal of „y – e“ graph, that is by appraising the variable value y according to the corresponding residual.

   If the dots on the graph do not have a significant arrangement
   or pattern but are randomly scattered about, then it is a case of
   random mistakes.
9) If the model is assessed as acceptable based on the previous one, the assessments for slope and intercept indicators and the maximal and minimal values from the confidence interval are adopted.

10)The values of constants K_C, B_C, K_E and B_R are calculated by including the assessed values of slope and intercept indicators, so that the following stands:

$$\ln K = \beta_0$$

$$K = e^{\beta_0}$$

$$B = \beta_1$$

3.3 Processing of gathered data

The gathered data for each of the two chosen groups were processed by applying statistics software. Money values are expressed in billions of Croatian kunas (1 Euro = 7,5 kunas) and the construction time (T) is expressed in days.

Figure 1. shows the „ln C_C-ln T_C„ graph, that is, the graph of relation between contract prices and duration of road projects. The visual assessment of the graph enables the possibility of approximation of the straight line, which is only a preliminary verification. The possibility of linear approximation also confrims the correlation coefficient value $R = 0{,}79$. Determination coefficient as a measure of model applicability is $R^2 = 0{,}63$, while the adjusted coefficient is $AR^2 = 0{,}61$.

Figure 2. shows the graph „ln C_E-ln T_E“ , that is, the functional dependence of „price – time“ for effectuated values of road projects. In this case $R = 0{,}71$, $R^2 = 0{,}50$ and adjusted determination coefficient is $AR^2 = 0{,}48$.

The obtained coefficient values allow the usage of linear regression. Verification of the null hypothesis by F-test and level of significance $\alpha = 0{,}05$ was performed. By its rejection, the linear dependance of the variables T and C as well as the applicability of the „time-cost“ model were confirmed. [12]

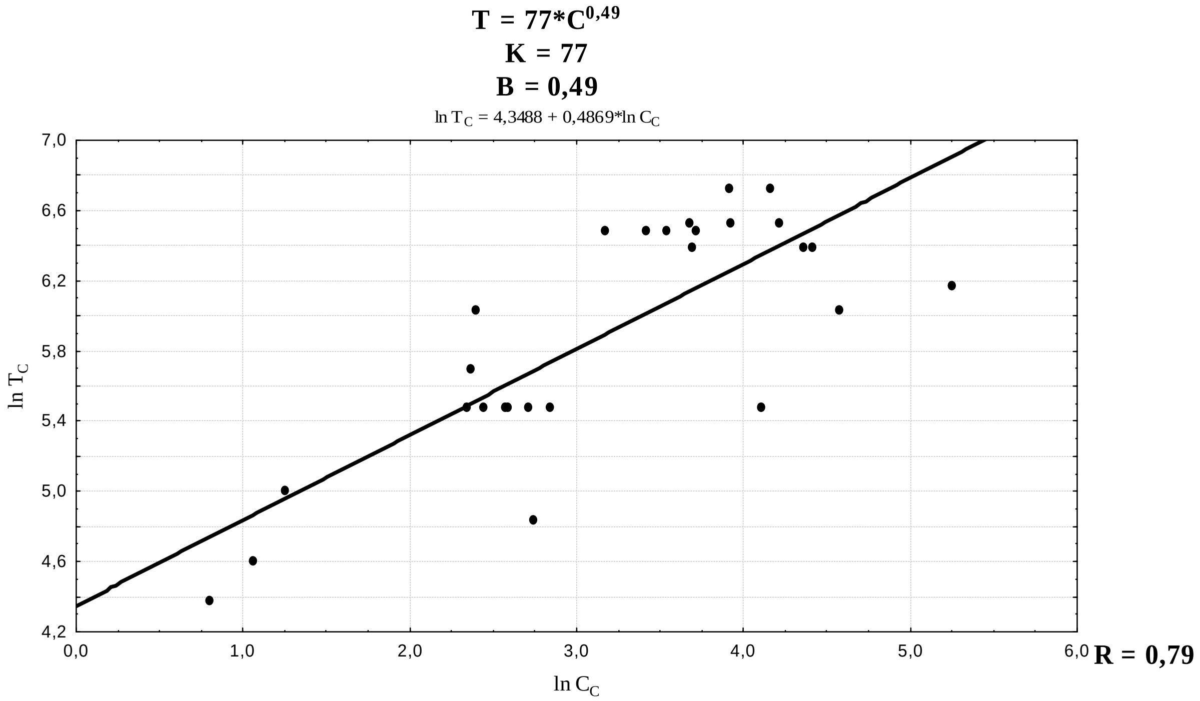

Figure 1. Graph "ln C_C-lnT_C" for roads of higher importance (highways and expressways)

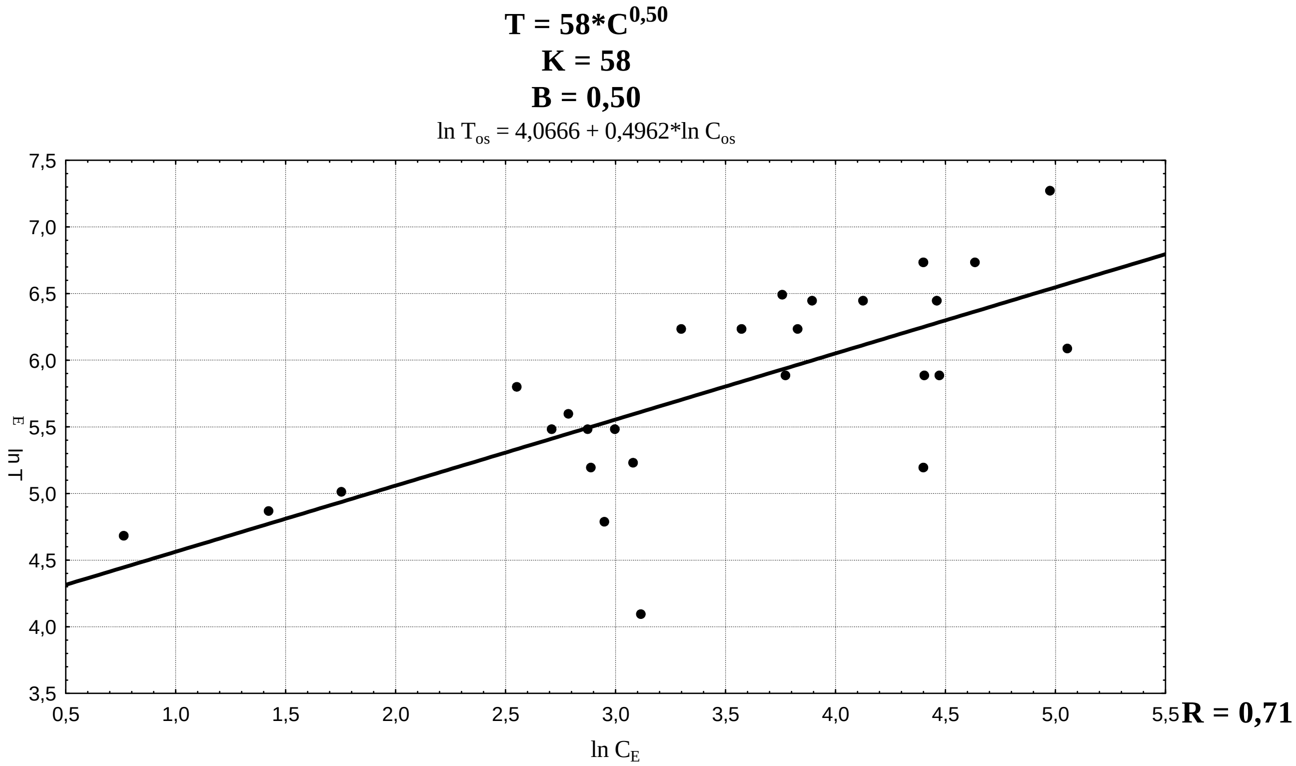

Figure 2. Graph "ln C_E-lnT_E" for highways and express ways

3.4 Survey and analysis of obtained results

„Time-cost“ relation for effectuated values of road construction time is:

$$T = 58 * C^{0,50}$$

At the same time, the planned values from the construction contract show a somewhat different relation:

$$T = 77 * C^{0,49}$$

The difference in value of the constant K shows that a longer estimated contract time was anticipated for work completion of money value unit which in this case is 1.000.000,00 kunas so that it could be said that the construction is being done somewhat faster than planned. When the subjects are highways this appearance is really present in practice. Yet, previous research [8] has shown that the state roads trend is exactly the opposite, which explains the indicator of the total overrun of road construction time.

If the sample is corrected in a way that the extreme samples are excluded from it, then the relation for the contract values is:

$$T = 67 * C^{0,54}$$

While the relation for the effectuated values is:

$$T = 66 * C^{0,45}$$

It can be seen that approximately same values of the constant K were obtained both for the fixed and the effectuated values, while the constant B at effectuated values is somewhat lower than at fixed values, that is, the obtained value points out the lesser influence of project complexity to the construction time.

While the research was being conducted it was established that the relation T/T_C (sustainable by calculations and contract construction time) according to the contract price C—can be successfully approximated by a straight line with a very high determination coefficient $R^2 = 0,82$ as it is shown in Figure 4. The straight line shows a tendency of increase sustainable in relation to the fixed time with increase of the price of the structure.

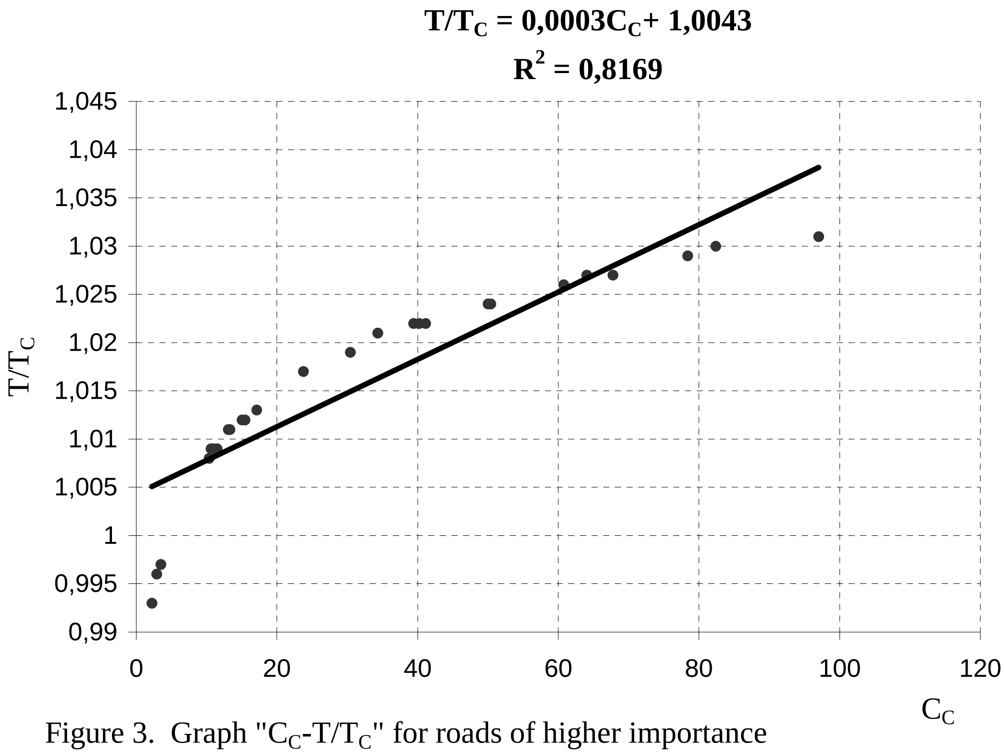

Figure 3. Graph "C_C-T/T_C" for roads of higher importance

Verification of regression model hypothesis was performed by checking the diagram of residuals vs. predicted values. The conducted verifications of linear dependence, null hypothesis and residuals justify the application of the "time-cost" model for analyzing the category of structures in Croatia.

3.5 Relation proposal for calculating the sustainable construction time

Based upon the previously displayed analysis of roads, the following relation for calculating construction time in Croatia is proposed:

$$T = 66 * C^{0,45}$$

The proposed values can be used for predicting construction time in the early project phases under regular circumstances without extreme influences.

4. Model application for early anticipation of sustainable construction time

The obtained relations between construction time and money from article 3 are average figures which can be effectuated under average circumstances. They can be used for duration planning in the early project phases when initial cost estimates are known or as basis for contracting business when frame price is also known. It makes sense to additionally correct the obtained figures when finally determining the sustainable contraction time. Our longtime research [3] has clearly confirmed the pattern of some phenomena exclusively related to the way of effectuating the project.

The three following factors which can significantly change the planned deadline stand out from the analysis of the forty potential internal or exteernal factors:

- Proportion of project changes during its carrying out
- Project management quality
- More significant problems with finances

The roads are regionally constructed as public projects in more than 90% of cases and influence on planning and sustaining the deadline depends on interest and influence of the governing policy about the specific project. If the policy is interested in the project, the deadline can be planned as if the project were private.

When all the above mentioned insights are applied to building construction structures with supposition that the duration interval T has particular limiting values T [60, 700] in days which refer to most projects, the formula for determining construction time for highways and express ways runs as follows:

$$T = k_{ch} * k_{pm} * k_{f} * (K * C^{B})$$

the k_{ch}, k_{pm} and k_{f} being correction coefficients for change influence, project management and financial problems. Our initial research on coefficients shows following proposed figures:

Table 1. Correction coefficients

Changes	large	medium	small
	1,50	1,25	1,00
Project management	excellent	average	poor
	0,80	1,00	1,20
Financial problems	grave	moderate	no
	1,35	1,05	1,00

All those coefficients were obtained through preliminary research and are of rough value. The continuation of research requires their exacter values and correlations as well as the possible influence of other factors. However, it can be established already at present that the extreme negative influence can double the construction time which was calculated through relation from the article 3 while the construction time can be reduced by 1/3 if under positive influence. This is a significant message to the investors which should be taken into consideration when determining the deadline.

6. Discussion about results and conclusions

The conducted research shows that it is possible to determine the methodology for calculating construction time. This methodology can be used in the early phases of the project and help in determining sustainable deadlines when closing the contract. This provides both the investor and the contractor with a credible basis for final negotiations and determination of fixed time. The analysis of the obtained results offers following conclusions:

1. For constructing roads of higher importance a 15-22% larger amount of time is negotiated, with a maximum deviation range from the average of 0428 to 1,884 and a standard deviation of 0,401. This actually reflects the policy interest and influence on expediting the work completion on public project of their special interest.
2. When compared to the corresponding results from abroad, the values K and B which were obtained by this research are larger. That indicates to a possible low productivity which could be result of more poorly organized work or an out-of-date technology.

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SUMMARY

The paper deals with the applicability of the «time-cost» model for calculating the sustainable construction time for transportation facilities. In this model the time is expressed as a function of money in the project, while the specific constants K and B need to be determined. These constants depend on economic characteristics of the country or a larger area and therefore had to be separately calculated for a region with similar economic characteristics. The modeling of the constants was performed for the roads. The obtained results have been analyzed and compared to the corresponding results from abroad.

Key words: construction time, „time-cost“ model, constants K and B, highways, expressways

Poštovani,

Dostavljam vam članak pod nazivom **MODEL FOR PROPOSED CONSTRUCTION TIME FOR TRANSPORTATION FACILITIES** u nadi da će zadovoljiti kriterije objave u časopisu Suvremeni promet.

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