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## The methodology of carrying out empirical research on the cumulative effect of the factors generating construction delays

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### Abstract

The aim of this article is to present the model of carrying on empirical research of the cumulative effect of the factors generating delays on the construction site. The paper describes the successive stages of the proceedings, the process of implementing the model, the problems that emerged during the research and the directions for further research work. Moreover, it was developed graphical model structure decision, which shows the successive stages of research

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*Keywords:* Empirical research; decision model; construction delays

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### 1. Introduction

For several years, there is a trend in Poland to orient researches to meet the needs arising from the industry. The beginning of this trend can be conventionally considered in 2007, when there was appointed " Program Operacyjny Innowacyjny Gospodarka 2007-2013" [3,9]. The project met with a very positive reception, and has contributed to the development of many innovative solutions and their implementations. Moreover, the benefits achieved through the undertaken cooperation, argued for a continuation of this type of project. They have been reflected in the next program– „Inteligentny Rozwój 2014-2020”. One of the industries that receives many benefits from this project is undoubtedly civil engineering.

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The main problems, which the Polish construction sector has to overcome, are delays of works [1,5,6,7,8]. The purpose of this article is to present a methodology that will make possible thoroughly study the presented problem.

## 2. Difficulties in obtaining data

Construction companies are very willing to share so-called best practices. There may be mentioned the procedures relating to security, acceptance of works and control of quality of construction elements. This information is easily available, usually in the form of brochures attached on the websites of individual companies. It is much more difficult to get so-called adverse information. There may be mentioned the conflicts with other participants in the investment process, accidents on construction sites or construction delays. The author, during his research work focuses on the last-mentioned problem - missing the deadlines of building works.

It should be noted that the adverse information require confidentiality, because they can greatly harm the image of the company. Moreover, the deterioration of the image will almost certainly have a negative impact on the financial result of the company. However, the adverse data is the most valuable, because they let researchers to develop tools that are helpful in the critical points of the entire project.

The author has partnered with a number of companies that are general contractors due to recommendations received from his Alma Mater, as well as many organizations and associations. Two of the most important associations are Polish Construction Employers' Association and Polish Association of Construction Managers. It is worth to be noted, that there constantly appear new partners from industry, which join the project.

## 3. Plan of the developed methodology

On the day of writing an article, a research project is not funded by any external entities. True, it limits the pace and scope of work carried out, but this also gives one very important advantage - independence. Typical projects after obtaining adequate funding, in Polish conditions, very often have to hold rigidly previously accepted project frameworks. This is, unfortunately, incorrect behavior because the essence of research consists in the fact that, depending on the results obtained, it is recommended to correct the next actions. It allows for complete customization of the research to the needs of obtaining specific solutions. This is particularly important if the project involves a large number of partners and each of them has its own contribution to the assumptions of the project. Of course, it should be looked for an appropriate compromise that allows all partners to achieve most of the benefits initially planned.

Figures 1, 2 and 3 show the decision-making model, which presents the methodology of research.

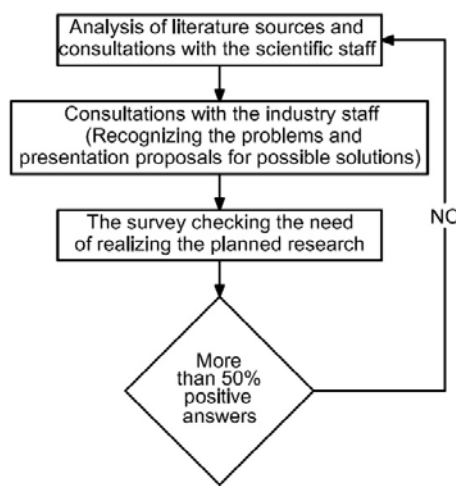


Fig. 1. The structure of decision model - Part 1 of 3. [own elaboration]

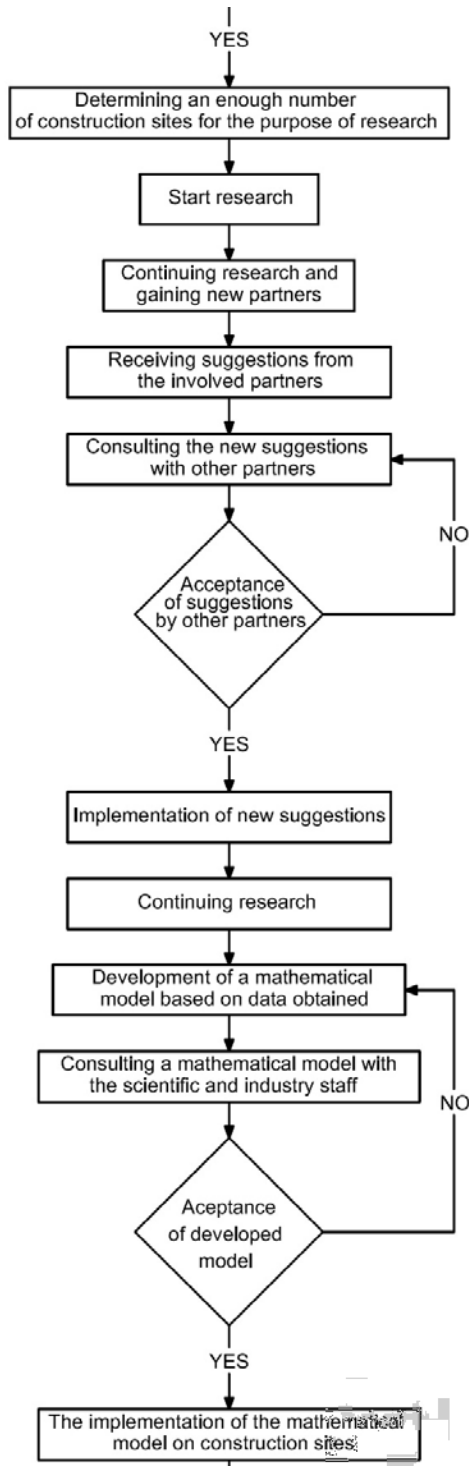


Fig. 2. The structure of decision model - Part 2 of 3. [own elaboration]

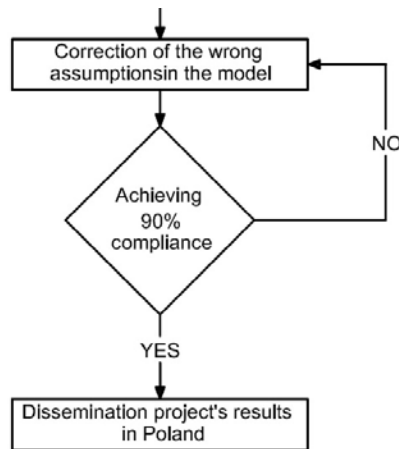


Fig. 3. The structure of decision model - Part 3 of 3. [own elaboration]

Studies have been started from a profound analysis of the available literature sources, both national and foreign. Then the obtained information has been confronted with the realities on construction sites. In this way it was selected group of factors generating delays on construction sites [5]. The next step was to verify the initial assumptions. It was decided to realize the survey. The survey involved more than 750 engineers. More than half of those surveyed answered that it is good or very good idea to carry out the research. It was sufficient to confirm the desirability of further works [6]. In case of failure, it would be needed to redevelop the assumptions of the project and verify them again.

When the accuracy of the initial assumptions of the research is verified, it should be determined the number of construction sites that will participate in the project. The right sample size can be determined by using the program *Statistica*. Below is presented a general scheme of action in determining the sample size [10].

1. Determination of the null hypothesis and the alternative hypothesis.
2. Choice significance test.
3. Selection of the expected differentiation size.
4. Selection of the expected dispersion size.
5. Determining the level of significance ( $\alpha$ ).
6. Determining the test power ( $\beta$ ).
7. Estimate the required sample size.

After determining the sample size, should be taken very complicated organizing issue to obtain a enough amount of industrial partners. General contractors more often see real benefits from the cooperation with scientific research institutes. It creates favorable conditions for the creation of specific scientific and industrial consortia, whose cooperation is aimed at achieving mutual benefits. There are ready to implement solutions for industry partners and interesting areas for research and reflection for science partners.

When the required number of construction sites will join the project, the research should begin. Of course, it is acceptable and even recommended to continue gaining of new industrial partners to increase the sample size. Moreover, it is very possible that there will be discovered new aspects related to the studied issue during the research. Because of them it will be often needed to correct the accepted initial assumptions. It is important that from the beginning the project was provided as large as possible freedom of interference in the initial assumptions. In order to achieve high project flexibility, it should be very carefully created for example the rules of project funding. This action will protect the project from a situation in which correction assumptions of the project (intended to serve, for example, increasing the usefulness of the product) will cause loss part or all of the funds obtained.

When it was reached the established amount of data, it should be proceeded to develop a mathematical model. The most popular parts of mathematics for solving such problems is fuzzy logic [4] and artificial neural networks [2]. The final decision on the applied mathematical tools will be taken only after extensive consultations with

industry and science. The proposals of final products that may be developed based on the obtained data and using previously mentioned methods will be presented to interested partners.

Finally, after all the previous actions, it will be possible to proceed with the implementation of the developed model. Implementation will be carried out on the construction sites belonging to previously involved industrial partners. Wrongly estimated factors concerning the impact of the cumulative effect of the factors generating the delay on construction sites should be systematically changed. The implementation process will continue until the 90% efficiency of the developed model. Then it will be possible to develop a commercial program. The consortium, of course, will have free, unlimited access, but external entities will have to buy the appropriate licenses.

#### 4. Verification of the developed model

The structure of decision making model has a strong foundation in the literature and expert opinion. However, like any structure built on the basis of the available knowledge base requires verification. Verification of the model research runs from October, 2015. In this time the following issues has been successfully completed:

1. Determining the initial project assumptions [5].
2. Determination of the final products of the project [5].
3. Verification of the initial assumptions by the survey [6].
4. Start collecting data from construction sites.
5. Correction impractical assumptions at the beginning of the project (the need to correct arose already during the research).
6. Joining new partners from industry (increasing the size of the sample).

At the moment there are being developed the following topics: determining a sufficient sample size, automatization of data collecting and the creating construction of a mathematical model. It is worth to be noted that the faculty and industrial staff are satisfied with the current process of researches. It is a confirmation of the proper construction of the model of implementing empirical research and confirmation of further work according to the accepted decision-making structure.

#### 5. Summary and conclusions

Currently research should primarily meet the needs coming from industry. It is important, that research should be executed in the framework of consortia consisting of scientific institutes and partners from industry. The presented methodology for carrying out empirical research is the organizational pillar, which will let for developing a model which will be useful for process of estimating the cumulative effect of the factors generating the delay on construction sites.

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