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Simulation Model for Stock of Building Materials Developed with Crystal Ball Software Use

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Abstract. The article presents a simulation model of the inventory with two variables developed using the Crystal Ball software. This model is designed for the purpose of optimization of logistics processes related to the organization of supply and storage of construction materials used in the production process. The result of the model, we get information about what reserve should be basic to the whole process took place without interference. Not always, however, it is possible to create initial stock of this size. Using the Crystal Ball software, it can be obtained information, what is the probability to avoid downtime for different levels of initial reserves. The model is based on the classical model developed by Jaworski Professor of the Warsaw University of Technology. In the new model two variables will be considered. The first variable is the amount of depreciation. In the classical model it is described discreetly. Based on historical data, determines the probability with which will be observed the consumption plan and the probability of default and excess of norm of consumption of this material. The second variable take into account the amount of planned delivery. In the same way as in the case of the size of the depreciation in the classical model this variable was described discreetly. As before, the author recommends a definition based on historical data probability of compliance with the required value of delivery probability and delivery more or less than planned. In the presented model we also consider the possibility of describing random variables using other than the discrete graphics and the empirical probabilities. This procedure allows for the approximation of modelling methods for people who do not have the appropriate set of historical data and would like to use it to minimize the risk of organizational problems. The article shows what results are achieved through the use of the software Crystal Ball, and how they can be used in the organization of the construction investment process.

1. Introduction

The article will present a comparison of two simulation model for supply chain of construction material. Stock of building material management is very important for success of every construction project. If there is no problem with material availability no one will spent a minute to deal with this problem, but if from some reason there is lack of material it become huge problem, because it causes delays [6]. In literature we can find a lot of example why we should work in this area of project management. First of all, we can read about supply chain management [7] which authors model can be part of. Second also important thing is that in twenty first century construction should be sustainable so supply chain also [2]. It is impossible to forget about cost that are create by supply chain management [9], with good policies we can make some savings [5]. Another interesting thing is to look for stock of building material as a part of building information model system [3], [10]. As it was mentioned before, two simulation model will be presented, First classic and then second build with Crystal Ball use. Authors tried to show how we can collect important information, that might help with whole process.

2. Classical simulation model for supply chain with three parameters

The algorithm shown below is a simplification of the algorithm we can find in Jaworski book [4], but it shows a general idea. Authors divided algorithm for three parts. First is data input. In simulation model with three parameters we input information about material consumption, delivery terms and volume of delivery. Data should come from previous experiences [8]. Then green block is responsible for simulation. It is not aim of this article to explain how simulation module works. Simulation is popular technique an also well known. Last block, the red one, shows what information can we obtain as a result of model use. Information we got are, increase, decrease or stay on initial stock. There is no information about confidence level, because in this model it is assumed that it is almost hundred percent sure. But we should always remember that in simulation we can't be hundred percent sure. Sometimes also cost of that "hundred percent sureness" will be too big or even impossible to achieve.

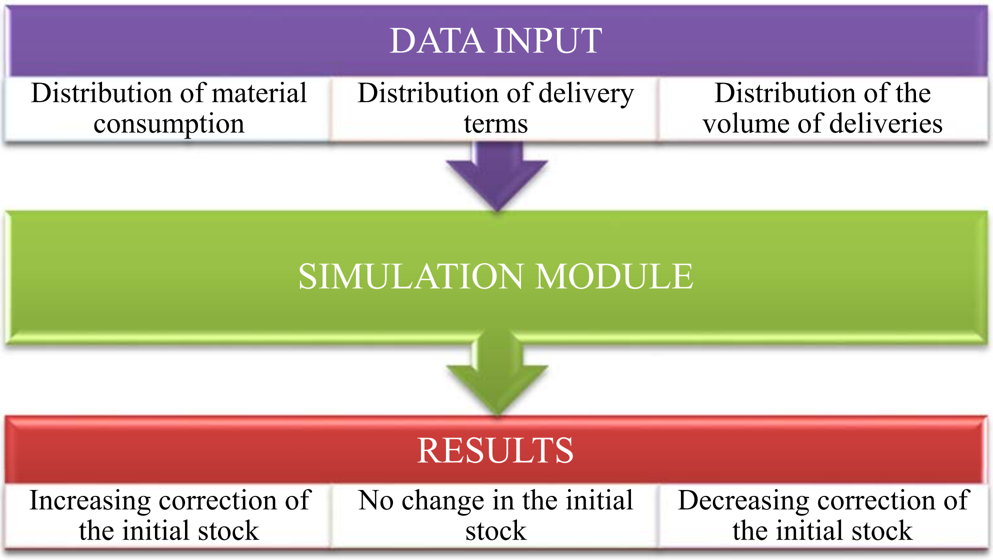

Figure 1. A classic model developed by professor Jaworski [4]

The tables below present simple example of classic model use. The example will be use in new model also, so we can show a comparison of this two models. First three tables show empiric distributions of used parameters. In classic model it was assumed that data become from past experience in realization of building works. If we have such data it might be better than typical distribution like e.g. Poisson distribution, if we don't have such data we have serious problem to work with. The table shows that in twenty percent of cases workers will have efficiency on level of 80 percent's that was assumed. In twenty-five they will have ninety percent, in forty percent they will have assumed hundred percent. Only in fifteen percent cases they will have efficiency coefficient above one. In ten percent of cases they will have hundred and tem percent and in five percent hundred and twenty. In authors opinion distribution with such characteristic describes construction conditions in Poland [2], also the same with two others distributions shown below.

Table 1. Distribution of material consumption

x	f(x)	F(x)	X
- 0.2	20	20	0.8
- 0.1	25	45	0.9
0	40	85	1.0
0.1	10	95	1.1
0.2	5	100	1.2

To be clear is good to notify in this point that in described example it was assumed that delivery should be in every 5 day for 25 five day of construction. Last column shows after how many days delivery will come.

Table 2. Distribution of delivery terms

y	g(y)	G(y)	Y
- 2	5	5	3
- 1	5	10	4
0	75	85	5
1	10	95	6
2	5	100	7

Last presented distribution deals with volume of deliveries. Also is described by empiric discrete distribution.

Table 3. Distribution of volume of deliveries (in unitary terms)

z	h(z)	H(z)	Z
- 0.1	10	10	0.9
0	80	90	1.0
0.1	10	100	1.1

Table 4. Simulation in classical model

Draw number	Delivery term	Volume of delivery	Material consumption	Stock of material	Corrected stock
				5	7.2
60	5				
83			1.0	4	6.2
06			0.8	3.2	5.4
35			0.9	2.3	4.5
72			1.0	1.3	3.5
23			0.9	0.4	2.6
46		5		5.4	7.6
00	3				
56			1.0	4.4	6.6
51			1.0	3.4	5.6
22			0.9	2.5	4.7

If we have all input data collected, it can be started simulation. For this paper simulation will be shown in the table. Simulation was done classically by draw number from the compartment of 0 to 99. First drowned number respond for delivery term, next for volume of delivery. Than we draw series of number which response for defining material consumption in the time between delivery. Whole process was shown in table below. Basic assumption of the model is that first delivery comes before we start material consumption. Above table show only a part of simulation, we can see that in some moment lack of material has level of 2.2 unit. As a result, there was a correction of assumed level of stock of material from 5 to 7.2.

3. New developed model build with Crystal Ball software use

New developed model was created in MS Excel with Crystal Ball add. Below you can see block scheme of the model. It also was divided into three part. Data input, authors chose only two variables. Simulation module, created in Crystal Ball and result block. From the result we can read more than before. Of course we have information about increasing or decreasing of basic stock, but we have also information of probability of success in every level of material stock.

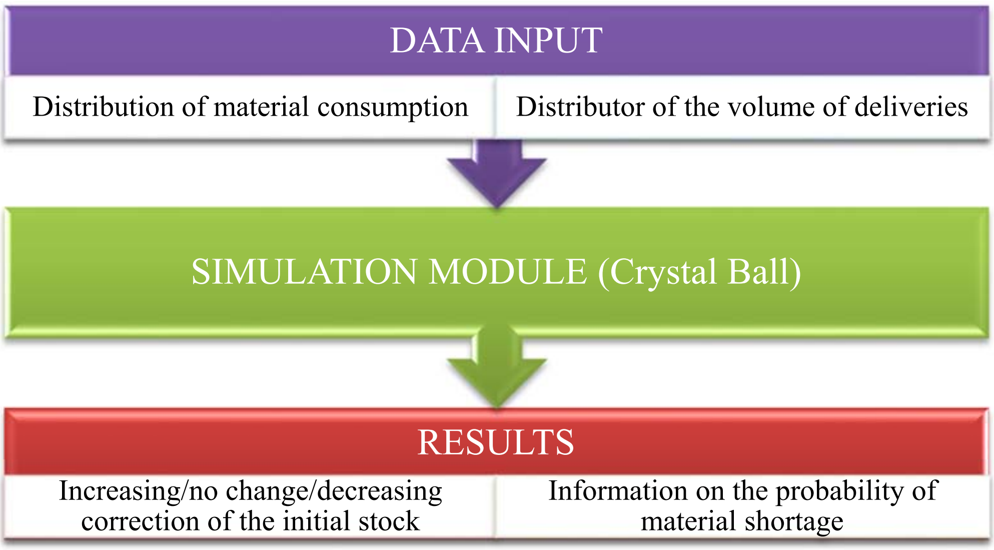

Figure 2. A newly developed model with Crystal Ball software use

Authors decided that distribution of material consumption will be the same as before, empiric and discrete. For delivery volume triangle distribution was chosen.

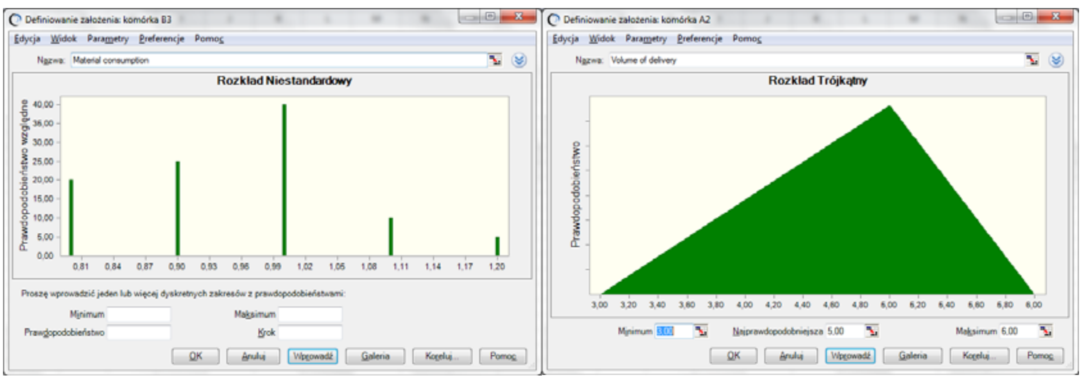

Figure 3. Material consumption distribution and delivery volume distribution window in Crystal Ball

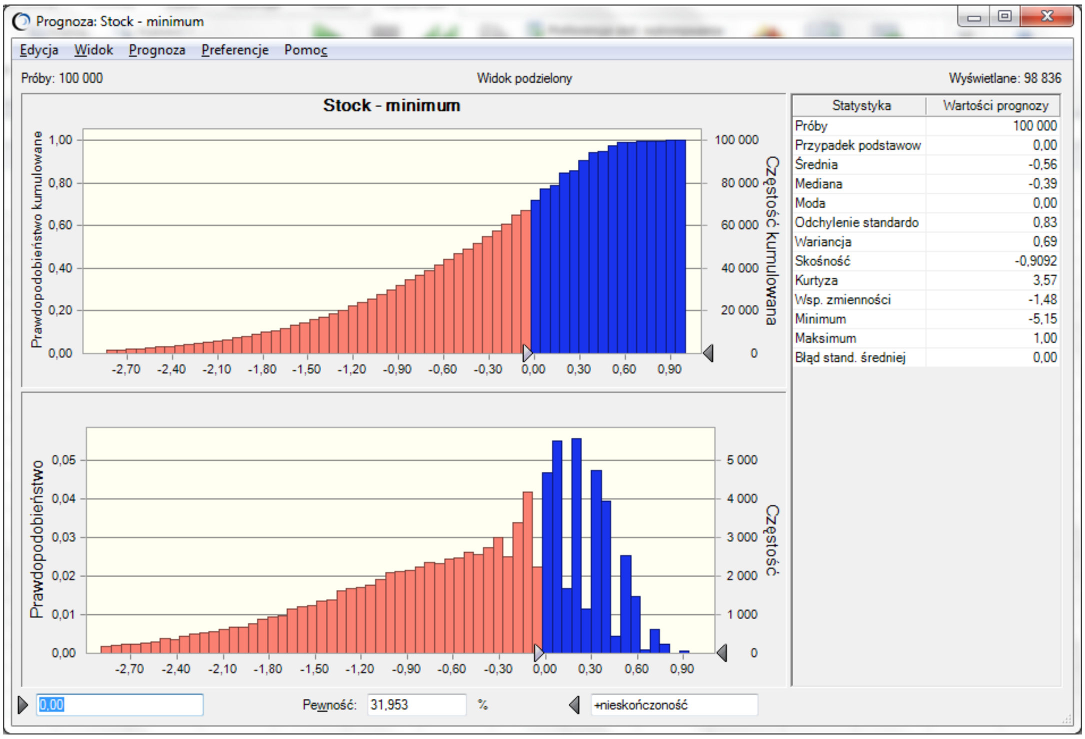

Figure 4. Crystal Ball result window (with basic stock equal 5 unit)

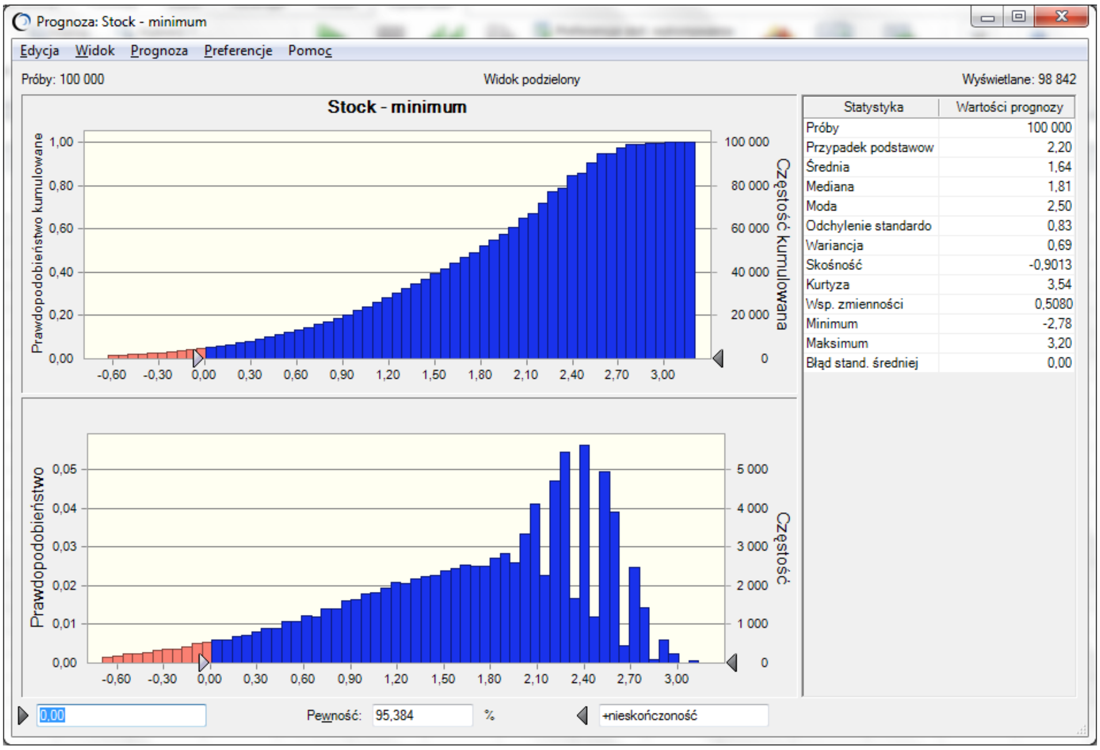

Figure 5. Crystal Ball result window (with basic stock equal 7.2 unit)

The result of the Crystal Ball software shows two charts, Graphs of probabilities cumulated probability. Figure 4 is a chart, provided that the initial inventory is equal to 5 units. In this case, the probability that there is no material equal 32 percent. Figure 5 shows the simulation results within stock at the initial level of 7.2 units. In this case, the probability of success was more than 95 percent. Every time the modelling was undertaken in the amount of one hundred thousand experiments. Such calculations do not take a lot of time. With the purpose of further analysis calculation with 6.1unit of initial stock level was done. The probability of success was nearly 76 percent. If we would be interested in the probability of the absence of material below 20 percent adequate initial stock should be 6.2 units.

4. Conclusions

Two supply chain models were presented. First one was classic model with three variables. Second one was built with Crystal Ball software use. First model is good but information given are rather poor. Second one need specialized software but we've got a lot information an if we have few minute to check some option we can find answer for two important question. First, what is probability of success with assumed basic level of material in stock. And second one, if I'm interested in probability of success e.g. 80 percent how big should be level of basic stock. Answer for this two question can be really helpful in construction organization process. Additional plus for second model is that we can also use classic, well known probability distribution, not only empiric ones. We can advise this methodology for construction supply chain managers.

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