Analysis of risks in the modelling of material consumption trends in the production process

Alena Breznická[1] Ľudmila Timárová[2] Beáta Kopiláková[3]

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Faculty of Special Technology, Alexander Dubček University of Trenčín,
Ku kyselke 469, 911 06, Trenčín, Slovakia[1,2,3]
alena.breznicka@tnuni.sk
ludmila.timarova@tnuni.sk
beata.kopilakova@tnuni.sk

Abstract

Quantitative risk analysis approaches in today's technologically advanced age represent a suitable process for mathematical investigation, revealing the context of the origin and existence of risks and their possible effects on ensuring reliability. Today, manufacturing, and industrial companies, with the growing pressure of globalization, must deal with vast amounts of data that evaluate various processes in maintenance management, warehouse and inventory management, or quality evaluation processes. One way to ensure objective collection, analysis and evaluation of robust data is to use Bootstrapping principles and modules. Many companies use these tools and are now becoming available to a wider range of users. Bootstrap principles, with which it is possible to enter the calculation of robust estimates, e.g., standard errors and confidence intervals based on the bootstrap method is therefore suitable for estimating statistics such as mean, median, correlation coefficient or regression coefficients. In this article, we will take a closer look at what bootstrapping is, show you how to enter the calculation of bootstrap estimates, and what types of output are then displayed. Logistic forecasting of spare parts with sporadic consumption are difficult because of problems associated with obtaining data inscrutable demand, which is usually characterized by long periods of zero demand. The presented contribution presents the possibilities of using the method, which is the starting point for the stochastic forecast of future consumption. Based on this method, we can determine the minimum order stock level. The results of the simulations are also presented in graphical outputs

Keywords: bootstrap, simulation, inventory management

1. Introduction

The method used makes it possible to modify the investigated data set. It will generate a number of usable and simulated samples. Based on this principle, the method makes it possible to determine standard errors, perform hypothesis testing for numerous types of statistics, and construct confidence intervals. Empirical values about sporadic consumption may contain random zero values. As a result, variable results can be affected to determine the desired quantity. Due to imponderability of input data naturally random distribution of variable / consumption / do not correspond to standard theoretical probability distributions. Suitable alternative is non-parametric method using past data of sporadic consumption known as bootstrapping [1]. We include it in the simulation statistical methods - MC, which are based on stochastic prediction of future consumption from data of past consumption. Matlab software can also be considered a suitable simulation tool, with which we can determine the prediction of individual indicators and we can thus prevent losses.

The used method analyzes the system based on the assessment of data with random consumption data, from which the simulation processes the experimental function PDF, CDF allocation, random variable / consumption / useful for determining the modeling parameters of surface management of supplies. The probability of a phenomenon or observed event that is equal to or less than a given value is defined by a function that has the character of a cumulative distribution. In technical terminology, abbreviated CDF. The inverse value of the CDF is defined as a function of the percentage value and gives a discrete result that is less than or equal to the probability of the phenomenon.

- PDF: Probability Density Function, returns the probability of a given continuous outcome.
- CDF: Cumulative Distribution Function, returns the probability of a value less than or equal to a given outcome.

Bootstrapping software products are now offered as software products of companies dealing with information technology, consulting in the areas of demand forecasting, inventory planning and optimization, for example Smart Software [2]. The method used is one of the possible application methods. It offers possibilities for simulating what states might occur if repeating data sets from a base file were followed. The principle then is that repeated random selections from the available data. Such selections of a random nature can have a small-er dimension than the dimension of the available data and therefore can be created without repetition or with repetition. The random sampling forecast is based on long-term, statistical monitoring of consumption, which may not be representative. They are therefore universal and suitable for use in many areas.

This article presents the possibilities of use and the basics of bootstrapping. The paper offers an example using real data to create confidence intervals. With suitable process prediction and programming tools with knowledge of bootstrapping principles, it is possible to use the possibilities of simulation modeling in processes that are demanding, and we can create a simulated model. We can then use the simulation together with the application in practice.

Bootstrapping is applied Monte Carlo method, where we make no parametric assumptions about the studied set n of data x = (x1, x2,.,xn), from which are randomly generated samples y. Monte Carlo simulation is a well-known simulation method using random sampling. Monte Carlo permutation is a method developed by Dr. The master who used it for testing. The statistical simulation method developed by Smart and Willema in is based on bootstrapping prediction [3]. It is a random selection based on a long consumption history, but may not be representative. If in practice these data are not available for a sufficiently long time, it is possible to use information on the consumption of a stock item for a shorter previous period, usually a month, a year. In a study that was carried out in practice, we assessed selected parameters in 50 monitored periods of data collection. The following figure graphically shows the basic scheme of the frequency of the monitored quantity.

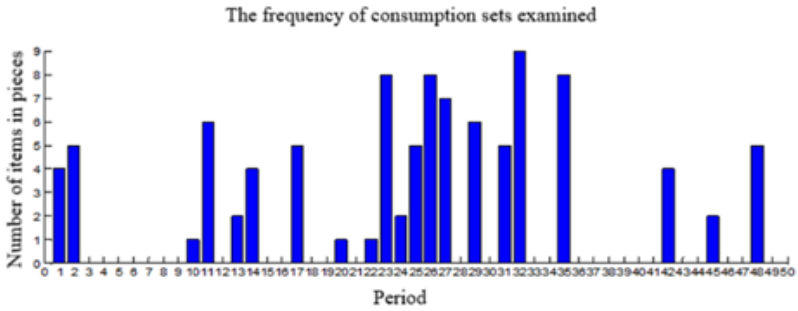

Figure 1: Bar graph of consumption item in 50 monitored period

The input data can be characterized as a set of data from the assessed, monitored consumption. From the given file we can determine the numerical characteristics of consumption. These are expressed deterministically. The given characteristics do not have the stochastic character of the consumption process. As an example, for the items of Fig. 1: min = 0, max = 9, average = 1.9600, default value = 2.8209. Bootstrapping is a statistical method based on repetitive selections from a single data set. This means that in this way it generates a large random selection of data from the input data and thus calculates the specified statistics for each of these selections [4]. The used method provides results about the numerical characteristics of the assessed system and further offers outputs of statistical characteristics, namely histograms and data sampling. Bootstrap random selections y are generated from the examined set several thousand times by se-lection with repetition or replacement of selected data from the examined data set x = (x1, x2, ..., xn, y = (y1, y2, ..., ym) required number of m (n) data The selected numerical values of yi are independent of each other and collected when selecting the Bootstrap with the same probability (even distribution). The monitored samples often have characteristics of differences. Since a recurring selection, some xi data may appear repeatedly or not at all. Appropriate use of the method is to determine future consumption for inventory / delivery time. Based on a random selection of data and a simulated number of selections, we can calculate and compile a histogram of the frequencies of the sum of the consumption of items. This will allow us to determine a signal level that will alert us to an impending shortage of items in stock. We can use the principles of lean maintenance. The following figure shows a histogram of frequencies from a given selection of monitored periods.

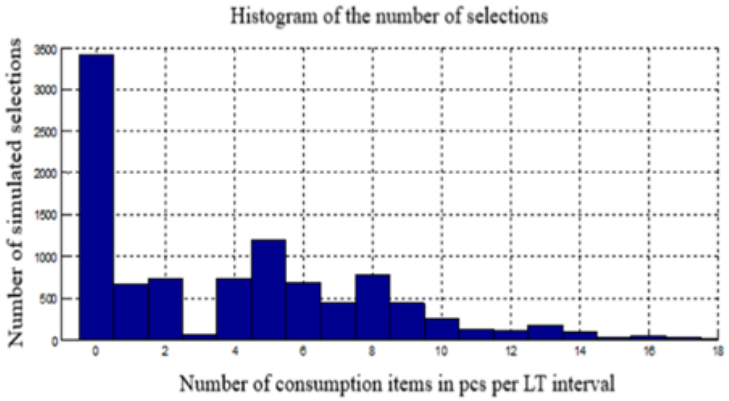

Figure 2: Histogram of sum frequency for 10000 selections

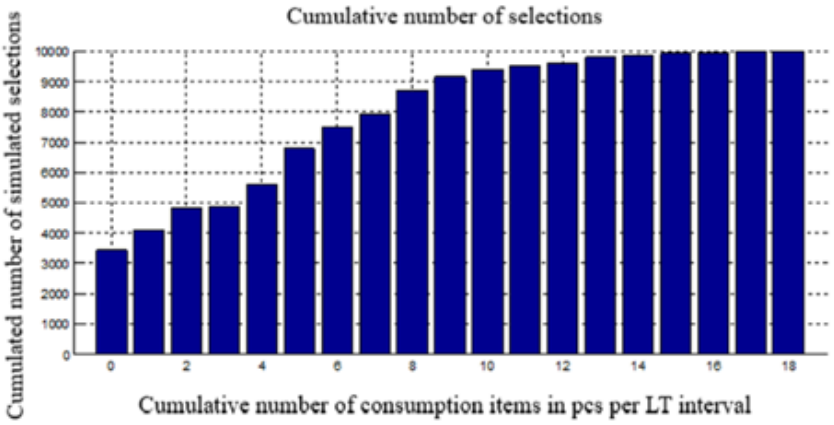

Figure: 3 Histogram of sum frequency for 10000 selections

Statistical data such as average, standard deviation, variance of consumption for lead-time are calculated directly from the data needed to create the histogram, not to generate a derived empirical distribution function. This provides the basic assumptions for the design and representation of the cumulative frequency or probability of future consumption of an item [5].

2. Experiment and simulation model

The presented simulation model was built from available algorithms and MATLAB software commands with the following sequence. MATLAB is a simulation language developed for scientific and technical calculations, modelling, algorithm design, simulation, data analysis and presentation, measurement and processing signals, design of control and communication systems. Therefore, its use for modelling bootstrapping processes is advantageous. The basis is the computational core, which is focused on operations with matrices and is therefore considered the strongest aspect of the MATLAB simulation language with its optimal algorithms. The kernel is extended by a number of extensions (Toolboxes = application libraries), which are intended for solving tasks from almost all areas of technical practice. The process simulation and prediction model is designed from simple MATLAB algorithms and commands with the following sequence, so that it is easily defined and usable as a universal procedure [6]. Initial sample for the determination of the consumption data vector. Determination of the sequence of calculation of numerical characteristics of samples of initial consumption.

Determination of the sequence in compiling the simulation algorithm:

- the model takes data of a random nature from the bootstrapping module options,
- defining the time interval requirement of the model,
- inventory decline and analysis / blue,
- the signal level informs about reaching more states than the order level, insufficient stocks.

Experiments created for the simulation of the given process should have the character of confirmation of the validity of the value of the optimal inventory for the tracked items defined by bootstrapping depending on the delivery date, the chosen probability of providing the item and the total cost of the inventory. The aim of the experiment is to assess the impact of changing the delivery time with different input data: the number of repetitions of the bootstrapping simulation, the number of time periods of the simulation, financial costs for storage, financial costs per warehouse unit of material tracked per day, costs for transportation and delivery of material. Determination of simulation input data. We have selected monitored variables such as the number of selected delivery time periods, the number of bootstrap selections of the quantile required logistic delivery support [7]. Subsequently, using the Matlab simulation tool, we generate matrices of bootstrap indexes of evenly distributed selections. The final steps are to convert the index matrix to the bootstrap selection consumption matrix and the sum of the bootstrap selection values. Graphic and statistical processing of output data are shown in the following figures. Simulation model was created from simple algorithms and MATLAB commands with the following sequence. Given the results of simulation experiments for determining the safety inventory in the likelihood of assuring 0.95 / starred / for periods for 100000 Bootstrap selections.

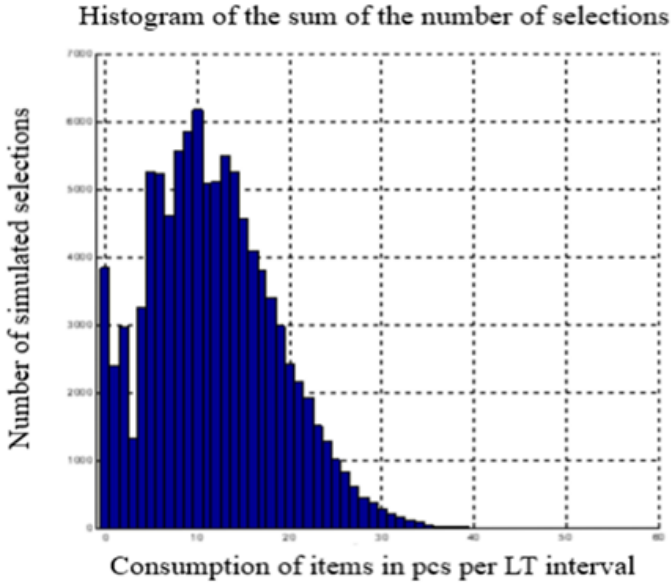

Figure 4: Result of simulation bootstrap experiments

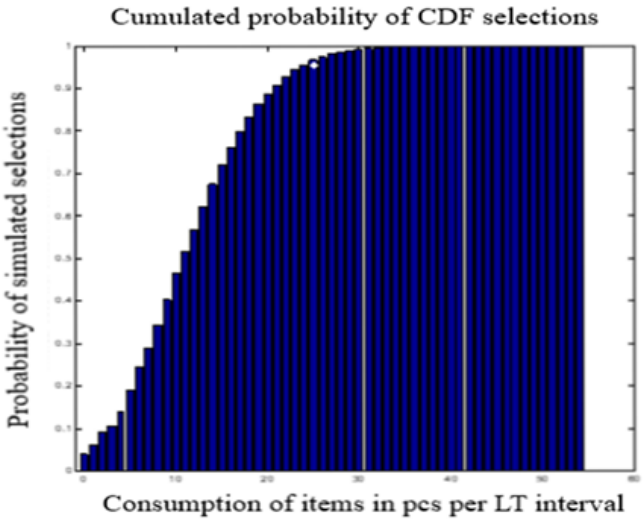

Figure 5: Result of simulation bootstrap experiments

The empirical CDF is interesting, but also as the fundamental component of a statistical approach called the bootstrap [8]. The use of the empirical CDF curve gives us a picture of the statistical sample. The cumulative distribution function of the fair value of the random variable X is a given function $F_x(x) = P(X \leq x)$.If we made a simulation experiment with hundreds of thousands of selections of item consumption data for 50 monitored periods, we would see that sums of selections according to index of item oscillate approximately at the level of 2000, which confirms that selections are made with uniform distribution probability.

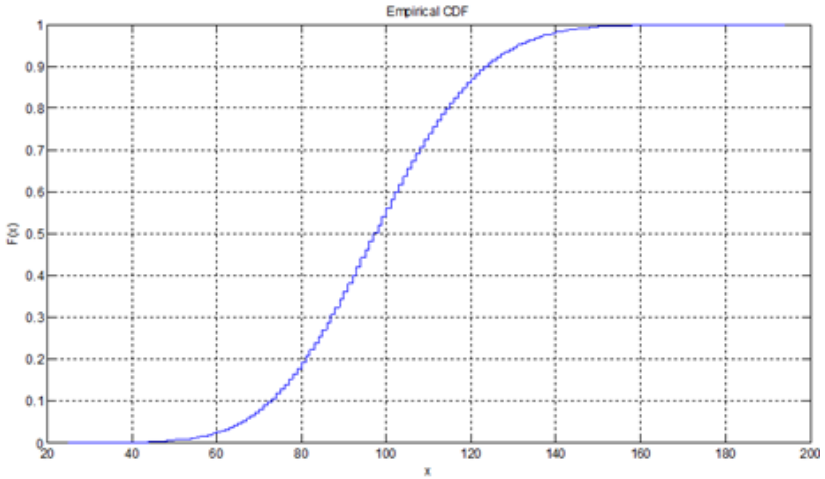

Figure 6: Simulation of sum of 100000 whole initial sample selections

The presented analysis and model combines the simulation algorithm of the supply process based on the principle of simulation with a variable time step.

We can characterize the parameters of the model:

- Lead Time, the number of time units from sending the order to the delivery of the item.
- Stock order level – Reorder Level is set as an optimal level with regard to delivery time and security probability.
- Probability of provision – The level of service provided. Demand during implementation will not exceed supply with a specified probability.
- Safety Stock – Safety Stock. Inventory created due to fluctuating demand and/or lead time to protect against item shortages.
- Determining the stock level - the level is defined as the optimal level depending on the delivery time. The optimal order level is modelled by bootstrapping selection with the demand forecast requirement during the supplier's lead time rounded to the nearest higher order quantity. Fig. 7. at the time when the stock ordering level is reached, the software will generate an order request to the supplier marked with a red star.

The descriptive approach allows tracking the level of the order as well as the time to draw the offer to replenish the stock with the requirements for the specified level of logistics security.
Protection against item shortages is implemented through insurance stocks, which are dimensioned due to unstable demand. The safety stock is not necessary if we define the optimal stock using the bootstrapping definition of the optimal stock. Curves in graphic form then evaluate the current state of supplies of materials to warehouses.

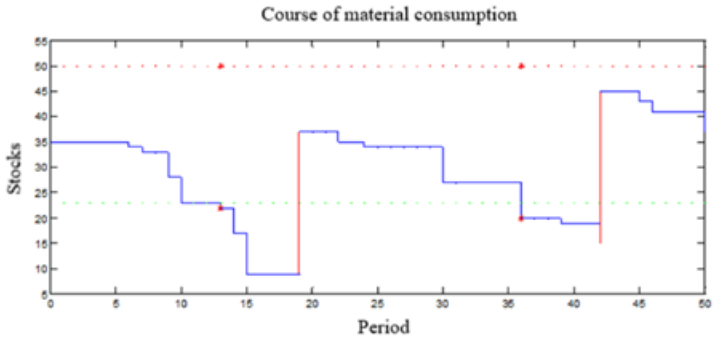

Figure 7: Development of simulation experiment with level inventory management

3. Results

The above approach allows to set the ordering level ordering and the time of issue of requirement to resupply according to determined level of logistic support [9]. At the point of intersection with ordering level information system generates an order to the supplier. Ordered quantity is determined by bootstrap forecasts of consumption during the delivery period of the supplier and rounded to the next higher order quantity. Level management and course of simulation through the simulation model for its use is shown in Fig.7. The initial inventory is current consumption is gradually reduced to the optimum level of inventory (bottom green signal level).

The model allows to change the levels of input values / number of simulation periods, the level of probability of logistic support, initial inventory, the level of ordering /. The logic of model is useful for setting up automatic level management of inventory for items with sporadic consumption. The signal level set by bootstrap method ensures maintenance of required logistics service. From the presented simulation of the processes, we can determine that the increased demand for logistical support of the optimal level of supply can cause an increase in the level of the optimal stock level and also an increase in costs. Interestingly, procurement costs are about the same, shipping costs are going down and storage costs are going up. Simulation experiments are intended to demonstrate the validity of determining the optimal inventory of an item determined by bootstrapping, depending on the lead time of the order, the selected probability of securing the item and the total cost of inventory. The presented model makes it possible to change the levels of input values / number of simulation periods, required level of probability of logistics security, initial stock level, order level/. The logic of the model can be used to set up automatic stock level control in the case of items with sporadic consumption

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