

# THE SEARCH FOR MODERN METHODS FOR THE STATISTICAL QUALITY CONTROL OF SERVICES

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**Abstract.** *The countries with developed market economies have vast experience in using the statistical methods in running business. In this respect, the use of Six Sigma techniques and tools to control the output (service) quality is worthwhile. This technique, if introduced in Georgia, can be much beneficial for the businessmen. Different-profile companies use different statistical methods for the output (service) quality control. However, it is the Six Sigma techniques that yield the most pragmatic outputs. This tool enables the different-tier managers to rely not only on their intuition in making managerial decisions but also on the quantitative data obtained through the introduction of  $6\sigma$  to their companies. The measures to search for the modern methods of introduction and better use of the  $6\sigma$  concept seek to improve the output (production) quality of different sites of a corporation, while also meeting the changing demands of customer markets and shareholders. In the search of such measures, the authors of the present article attempted to examine the effect of the  $6\sigma$  set beyond the limits of a corporation and, by considering the public opinion about the corporation, conduct the statistical control of the output (service) offered by the corporation to its clients. The pilot study, accomplished with this purpose by the authors of the article, together with their students, gave quite interesting results.*

**Keywords:** *output (service) quality control,  $6\sigma$  (Six Sigma), sampling observation, managerial decision.*

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## Introduction

The control of output (service) quality by using the statistical methods is not a novelty. The quality control of large consignments of a company production is possible by using the indices of sampling observation and variation analysis. This idea of quality control was pioneered by academician M.V. Ostrogradky in 1846. Dr. Schuhart, an American scientist, has made a significant contribution to the given kind of studies, as well as Dr. Edwards Deming and Josef Juran, Phillip Crosby, A.V. Feigenbaum, Kaoru Ishikawa, Genichi Taguchi and others.

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In the 1980s, thorough, quality-based management was very popular. In addition, the most important programs in this field were considered for the Malcolm Baldrige National Quality Award for US organizations and international ISO 9000 Certification process. (Anderson, Swenney 2012). In this field, particularly pragmatic is the use of the statistical method – the Six Sigma.

Pete Pande thinks that the use of the Six Sigma method will significantly improve the quality of the production in terms of the existing or reduced level of prime cost (Pete Pande, Larry Holpp 2005).

A. Boldirev considers the quality management assessment indicators for transport organizations (Boldirev 2009); T.V. Maleeva describes the issues related to improving the passenger transportation service at agglomerations (Maleeva 2012), while I. Rebrin relates the problems of production quality management through a historical perspective (Rebrin 2004).

Presently, the statistical control methods of production quality are used less in post-Soviet countries, including Georgia. Statistical corporations have an incomplete view of the benefits of using the abovementioned methods and, particularly, the Six Sigma method in respect of the final outcomes (gaining profit). The goal of the present study is to consider the experience gained within the given field in the countries with market economy, which is mostly done not only through the description of the procedures realized at the companies, but also from the outside, by using the forms of quality control in a consumer's view. In order to conduct the pilot study of the given issue, we chose the field of bus passenger transportation of Tbilisi Transport Company. We have set the following tasks to achieve the present goal:

- To demonstrate the production (service) statistical control methods in a conceptual-methodological respect for in terms of market relations and plan economy.
- To demonstrate how relevant the quality of passenger transportation service by city transport is based on the existing information sources and experimental selective statistical studies.
- To consider a possible use of the Six Sigma method for production (service) control with the aim to improve the passenger service quality within the scope of a sustainable, urban city transport strategy.

The methodology of the study is the comparison of old and new methods of statistical control of production (service) quality, conducted to arrive at the correct managerial decisions. Following the methods of the study, a selective, statistical pilot study will be conducted by using the traditional methods of descriptive and analytical statistics.

## Conceptual-Methodological and Practical Aspects of the Issue

In the conceptual-methodological respect, the output (service) quality control system, in terms of market relations, is somewhat different from the one functioning in terms of the plan economy. We remember the five-year quality plans, such appeals as “Let us work without any failing enterprises!” and the like. Unlike market economy, such initiatives were hierarchical, directed “from top to bottom” and, in some cases, did not really yield the best outcomes in respect of high output (service) quality. In terms of market economy, an enterprise can freely choose the kind and volume of the production (services). Its goal is to gain good profit and, unless its product is of high-quality, it fails to occupy its niche on the market and the profits are slow as a result. Besides, there are differences in the types and methods of product quality control.

Over time, the countries with developed market economies have acquired considerable experience in using the statistical methods in business. At this point, let us consider the question of improved quality control of the output and services by using  $6\sigma$ .

In statistics, the Greek letter  $\sigma$  (sigma) is known as the square value of deviation (square deviation) from a nominal (mean, rated) value of basic indicators. Right from the outset, we should point out one thing – which is, by the way, stated in textbook publications considering these issues – the less the variability of the given indicator, the better it is for the customer.

In the theory and practice of statistics,  $\sigma$  (sigma) is used in many ways. It is used to identify the statistical regularities of product demand and supply. For example [2], when selling women’s gowns, one can consider that a lesser percentage of women wear small-sized gowns. As the woman’s weight ( $X$ ) increases, the women’s percentage ratio ( $f$ ) also increases gradually (Kbiladze, Metreveli 2015). Size  $S$  is taken as the smallest size of adult clothing and is followed by sizes  $M$ ,  $L$ ,  $XL$ ,  $2XL$  and  $3XL$ . So, with women’s weight increase, the following regularity can be seen: the least percentage of women wear the smallest size of clothes. As the women’s weight increases, the demand for  $L$  and  $XL$  sizes increases, too, and, probably, most women wear these sizes. With a further increase of women’s weight, the demand for  $2XL$  and  $3XL$  clothes falls. Let us show this concept graphically.

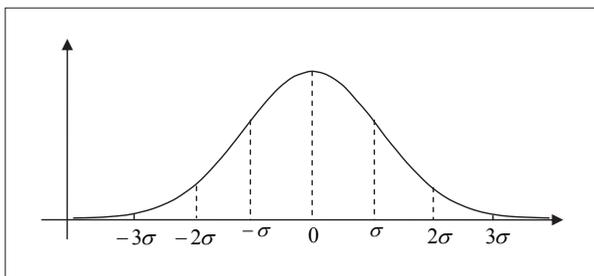


FIGURE No. 1. Variation of Square Deviation ( $\sigma$ ) in relation to sizes of women clothes

TABLE No. 1. Sigma level and quality [3]

Sigma level	Defect per million
6	3.4
5	233
4	6 210
3	66 807
2	308 537
1	690 000

Source: Pete Pande, Larry Holpp 2005.

The application of  $\sigma$  (sigma) as the load of a variation indicator for the output and service quality control is even wider. For instance [3], Jack Welch, the Director General of the world-famous company General Electric, says that the  $6\sigma$  statistical set brought his company the economy of 2 billion USD in 1997. (Pete Pande, Larry Holpp 2005) Similar success was reached by other famous companies, too, including MOTOROLA.

The dissipation of the given indicators when using  $6\sigma$  (Six Sigma) falls within the half of the admissible space (field, area etc.). In such terms, the probability of defective production or services is low and is limited to some units per million only (See Table No. 1).

Working with level 99.9997% will lead to no defects at all. As the present material shows, working with Six Sigma virtually excludes the defective production per million.

The output quality control system was subject to a certain evolution. Six historical stages can be identified in the study of this phenomenon in the corporations: individual quality control, quality control at different departments, quality acceptance control, statistical quality control, complex quality control and quality assurance (ISO 9000). (Bokenova 2005)

Now, the question is: how can we economize on money and meet the cliental demands simultaneously in terms of reduced costs of output?

The  $6\sigma$  concept has three major goals: client satisfaction, acceleration of the production cycle and reduction of deficient goods. And yet, what does it mean to work under the Six Sigma? In case of expedient business management, it is understood to be a total denial of deficient products and services. This goal is hard to achieve by using the statistical methods only; instead, a corporation is needed to decide and introduce this project to its company. The corporation employees must work in the mode ensuring that the production process considers the permanently (swiftly) changing demands on the market, the demand pool being constantly studied and accented and the company shareholders being always content. These goals can be achieved by means of regular trainings of the company professionals to enable them to handle the ongoing challenges in the branch. The introduction of the Six Sigma method to the company needs a traditional development of such methods as project management, which consider planning, budgeting, drafting diagrams and collective management.

After highlighting the theoretical and practical issues of  $6\sigma$  (Six Sigma), set at lectures and seminars, the authors of the present article had an idea to complete a pilot statistical sampling study to evaluate the quality of the customer service rendered to Tbilisi bus passengers.

In order to accomplish the pilot study, a study design was developed; buses on different routes were selected as the observation object and the students traveling by bus between their homes and the higher institutions were taken as units of observation.

Prior to the accomplishment of the pilot study, we tried to study the operation of public transport in Tbilisi, presented by a transport company. It offers the transportation of passengers with subway, bus and cableway lines. The owner of the full holding of shares is the capital authority. The subway of Tbilisi has been in operation since 1966. In the first years of the state gaining independence, the subway operated non-stop and every day, being the principal means to transport passengers. Per the statistics, the number of passengers transported by Tbilisi subway as of March 31, 2017 is 365 182, and that of the passengers transported by bus is 408 831. (Tbilisi City Hall 2017)

At present, there are 2064 bus stops in Tbilisi. There are e-counters installed at the bus stops showing the real time of bus arrivals. The buses are equipped with automated pay boxes. The main fleet of the city mostly has “Bogdan”-type buses with their mean age of 10 years. These vehicles use diesel fuel, which has negative impact on the ecology of the city. Aiming at improving the passenger service and ecology, the City Hall of Tbilisi has decided to purchase 200 new, modern buses. The first consignment of the new buses has already been delivered and is being exploited.

The number of passengers transported by city transport and subway is exceeded by the number of passengers transported by private minibuses. The minibus fleet is mainly represented by more than 2000 8-metre-long minibuses with over 1700 minibuses running en route on a daily basis. The socially vulnerable part of the population and most military veterans are given reduced-fares, except for taxi vehicles. The minibuses are a major competitor of city buses and subway, first of all due to their ability to transfer their passengers to the desirable location owing to the great number of routes they have.

## **Pilot Study and Results**

The goal of the study was to determine the quality of the bus passengers in the capital of the country by considering the respondents' (students') opinion. The study design envisaged the following:

- 1) Study of the actual service quality by answering the following questions by the respondents:
  - If they needed more than two vehicles to get to the destination.
  - If they needed two or more trials to get on the bus.
  - If they had to keep standing when traveling on the bus.
- 2) Improvement of the bus passenger service quality by answering the following questions by the respondents:
  - If additional vehicles were needed in rush hours.
  - If the vehicle fleet needed modernization.
  - If the electrical vehicle was to be re-introduced.

The answers to the first set of the statistical questionnaire helped identify the defects in the bus service, in particular, 100 passengers needed more than 2 vehicles to get to the destination, 120 passengers could get on the bus after two or more trials and 300 passengers had to keep standing on the bus because of the lack of seats. The level of  $\sigma$  (sigma) can be obtained by dividing the number of the interviewed students dissatisfied with the bus trips on the total number of the transferred students (5000), multiplied by the number of defects. The result is the value of DPO (Defects per Opportunity) of 0.036. This value is the number of defective service. The results of the study are equivalent to 36.000 defects per million transferred passengers (DPMO – Defects Per Million Opportunities), which, in accordance with the table above, is near 3.25.

As mentioned above, the research also envisaged the study of the students' opinion regarding the improvement of the city vehicle service in what can be calculated by using the integrated statistical value (Formula 1), proposed by Professor Bikenti Gabidzashvili (Gabidzashvili, Kbiladze 2010):

$$K = \frac{\sum K_i}{n}, \quad (1)$$

where  $K$  is the integrated coefficient of the attractiveness of the business environment,  $K_1$  is the sub-index of  $i^{th}$  factor and  $n$  is the number of factors.

The sub-index can be calculated with the following formula 2:

$$K_i = \frac{x_i - x_{\min}}{x_{\max} - x_{\min}}. \quad (2)$$

During the abovementioned study, the following question with several possible answers was given to the respondents: “Which measures do you think are necessary in improving municipal transportation?”

The following answers were available:

- 1) Providing additional vehicles during the rush hours;
- 2) Modernizing the vehicle fleet;
- 3) Adding electrical vehicles.

When analyzing the study results, some separate sub-indexes must be calculated. As the results of the study suggested, 147 respondents were for providing additional vehicles during the rush hours, 97 respondents were for the modernization of the vehicle fleet and 109 respondents thought the provision of electrical transport as the best means to improve urban transportation.

Consequently, the sub-index of the first factor will be  $K_1 = \frac{147 - 97}{147 - 97} = 1$ ; that of the second factor will be  $K_2 = \frac{97 - 97}{147 - 97} = 0$ , and that of the third factor will be  $K_3 = \frac{109 - 97}{147 - 97} = 0,24$ . As a result, the integrated value will be  $K = \frac{1 + 0 + 0,24}{3} = 0,41$

meaning that 41% of the respondents think that some changes would be necessary to improve urban transportation.

Thus, the use of the Six Sigma statistical set by the businessmen of Georgia to examine the output (service) quality control can be much beneficial. Consequently, the introduction of this method in different fields in Georgia is urgent as well.

## **Conclusion**

At present, a sustainable urban transport strategy of Tbilisi is developed under the support of the government of Georgia and Tbilisi City Hall. The strategy envisages the improvement of the passenger transportation service and focuses on the ecologically pure, efficient, innovative, safe and financially sustainable transport service. The strategy is divided into three phases (Jean Manuel Giely 2015): the short-term phase (2015-2017); the mean-term phase (2018-2021) and the long-term phase (2021-2030). This strategic document envisages a fundamental reorganization of the operation of the city vehicle transport.

In the first phase, it is planned to reconstruct the network of buses and minibuses (under the technical support of the Asian Development Bank and financed by Tbilisi City Hall).

In the second phase, the process of restructuring the bus and minibus network will continue with the aim to improve passenger service, and the renovation of the bus fleet will continue.

In the third phase, it will be examined whether the multimodal transport model is renewed. The restructuring of the bus network will continue and the process will be evaluated.

The pilot study revealed that the application of the statistical control methods and the Six Sigma tool in the first instance, both in a traditional manner, immediately at the corporations and beyond the corporations through the interviews of the population to gain the real picture, may contribute much to the improvement of the output (service) quality. The benefit of the study accomplished by using this method is evidenced by the results of special studies accomplished by the National Statistics Office of Georgia to reveal the shadow economy, in particular:

- The declared indicators of beauty salons were 6 times lower than real indicators;
- The indicators declared by restaurants were reduced by 3.7 times in comparison to the real indicators obtained by the research;
- The actual volume of sold fuel was 3.1 times higher in comparison to the presented official indicators;
- The actual volume of construction produce was more than 2 times higher as compared to the officially declared indicators;
- The actual indicator of bread baking was more than 3 times higher than the declared indicators (Kbiladze, Metreveli 2016).

We think that the study described in the present paper will help the relevant bodies to control the degree of accomplishment of the measures envisaged by the sustainable urban transport strategy of Tbilisi.

The residents using the city transport of Tbilisi were interviewed by using the Six Sigma tool. This method revealed that 41% of the study respondents were dissatisfied with the present conditions of urban transportation. The authors of the article consider that the use of the Six Sigma method for the statistical output (service) quality control will be particularly efficient when the results of similar accomplished studies, both within and beyond the corporations, will be the same or nearly the same.

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