Hierarchical Models of Causality in Research of Satisfaction of Customers' Satisfaction with Educational Services

Irina Pavlovna Lebedeva

Perm State National Research University, Perm, Russia

Abstract: In the article the author proposes an approach to causality study, which based on the study of the hierarchy of factorial interaction, aimed to reach a particular aim of the social system functioning. Based on the hierarchy, a method of the statistical analysis of non-experimental data is developed to reveal latent factors and to build mathematical models of their interaction. To model the latent structures the factorial analysis in combination with the regression analysis is proposed. The proposed approach has been implemented in investigation of customers' satisfaction with educational services provided by higher education institutions.

Key words: Causality ⋅ Social system ⋅ Mathematical modelling ⋅ Educational service ⋅ Customers' satisfaction ⋅ Higher education institution

INTRODUCTION

For any investigation identification of causative relations, caused by multiple random and non-random factors, is significant. A level of complexity and indeterminacy of their interaction in social systems questions the possibility both to reveal such relations and register all existing factors that determine them [1]. In practice, however, it is necessary to realise the causative relations to control functioning and development of a social system. Then, it is reasonable to search for specific factors that interact to reach the particular aim. The selection of a particular system according to the noted aim may determine the use of the system analysis in causality investigation as a perspective method. In particular, to determine the direction of the factors interaction it is possible to consider causative relations in the aspect of the hierarchy of the main system structure. The task is complicated, first of all, when the aim is registered as a set of criteria. The task can be divided into subtasks that are solved by specific methods. Secondly, factors are often latent, that is why the experiment is either impossible or pointless. Therefore, non-experimental factors are to be used. In this case the main method of

revealing causative relations is the factorial analysis. Thirdly, objectively existing indeterminacy of the social system functioning may be aggravated due to the use of inappropriate methods of the causality analysis.

While causative relations are indeterminate and multivalent, it is necessary to reveal their scientific and practical value that is determined mostly by the possibility to take into consideration the fluctuations of the resulting parameter based on the fairly objective data of the factor interaction. In particular conditions of a social system functioning such quantitative assessment can be used as a prerequisite for further predicting and controlling the system. However, formalisation of social phenomena, related to the obtained assessment, results in the loss of their qualitative content [2]. Therefore, a reasonable combination of qualitative and quantitative assessments in causality investigation is provided by means of the analysis of the hierarchy of causative relations. In this case the relations that correlate with a higher level of the hierarchy will also function as factors. According to the noted hierarchy the method of the quantitative analysis of the social system is developed that includes mathematical modelling of factor relations, regarding the stochastic character of social phenomena [3].

Corresponding Author: Lebedeva, Perm State National Research University, 15, Bukireva, Perm, 614990, Russia.

This method covers a case of non-experimental data use and consists of the following stages:

- Working out a set of criteria as resulting parameters, according to which the degree of a reached aim is assessed.
- Concretisation of the criteria as a system of indicators, which give a quite profound view of the subject of investigation according to a chosen theory and development of the ways of their measuring.
- Forming the hierarchy of the main structure of the system according to the identified criteria.
- Search of latent factors, correlating to each level of the hierarchy and analysis of their structure.
- Determining the direction of interaction between the factors and their causal relations.
- Modeling relations between the factors and the resulting parameter.

A more efficient justification of causative relations can be made due to the combined use of the system analysis, content conceptions and statistical methods (correlation, factorial and regression analyses, etc.), regarding the time parameter while calculating the factor and resulting parameters [4,5,6]. However, the question whether the revealed relations are true is still unsolved. Therefore, the key procedure in investigation of causative relations is verification of the model and assessment of its value for solving a certain practical task. If the causative relations, that are revealed and registered quantitatively, improve the process of task solving, then it is logical to consider them as variant of the model of such relations. Such relations are "soft" by nature because they reflect only general trends of interaction of specific factors, related to a certain social phenomenon.

Consider an example of how such method can be developed and implemented in investigation of customers' satisfaction with educational services provided by higher education institutions.

The Structure of Factors Determining Customers' Satisfaction with Educational Services Provided by Higher Education Institutions: Customers' satisfaction with an educational service, being one of the important criteria of education quality, which is considered to be a control point of higher professional education institution activity [7-10]. The final stage of education in higher institution is characterised by a more intensive interaction of outer and inner factors that reflect students' general satisfaction with a training programme. These factors are rather specific since they are related to certain educational, social and economic conditions determining the limits of their conceptual interpretation. Therefore, the ways of revealing of causative relations by statistical methods and mathematical modelling are of great theoretical significance. Taking into consideration the aim and dynamics of functioning of the social system, the factors of satisfaction with a training programme will be considered as dependent variables, while those of satisfaction with a certain educational service (particular discipline) will be considered as independent variables. Consider the case when a sample includes higher education institutions that provide different fields of education and different training programmes, which allows to explore general and specific ways of factors interaction.

However the factors themselves can be specifically structured within the applied theory of measuring customers' satisfaction. One of the theories is related to the verification theory, in which customers' satisfaction is considered as a result of comparison of customer's expectations (or a level of demand) and his/her perception of actually performed services. Then, a customer assesses the service performance and its value according to certain criteria. In this case satisfaction factors can include either satisfaction with the service performance or its value, or both.

Correspondence of the factor structure and real conditions depends, first of all, on how completely the factors reflect characteristics of the service, which can be hierarchically ordered. The service characteristics were formulated and analysed separately for the blocks «conditions», «process», «result». These characteristics are considered as observable and measurable variables that form linear combinations of latent factors.

Regression Analysis of Latent Factors of Satisfaction with Educational Services: Measuring of the characteristics of satisfaction with an educational service is provided through the development of special anonymous questionnaires, where the corresponding indicators are averaged for each student group. The assessment of satisfaction with a certain educational service was based on 40 indicators and satisfaction with a training programme in general-30 indicators. Further, the noted indicators were used to form the noted characteristics (corresponding indices of satisfaction including both the assessment and the value of educational service performance). The correlation analysis of these characteristics proves the necessity of the

factorial analysis performance. Thus, one common factor was formulated (principal component analysis, «weight» 73,3 %) from the whole sample; the factor includes all noted variables with high negative loadings. It is called «Deficiency of general satisfaction with a training programme».

Consider the factorial analysis results for characteristics of particular educational services at the final stage of studying in higher institution. The variables «Service cost» and «Service image» are excluded from the factorial analysis because they do not have valuable correlation with other variables. Two general factors are formulated. The first factor («weight» 65,2%) is characterised with high positive loads from all the variables except «Programme content is interesting» and «Presentation of programme content is comprehensible». The second factor («weight» 25,6%) has valuable positive loads from these two variables. The first factor is called «Satisfaction with the process and result of educational service performance», while the second factor is called «Satisfaction with the content of an educational programme». The revealed factors explain the structure of relations between educational service characteristics. In this case the most important is a set of procedural characteristics of educational service performance and its result, then-comprehensibility and attractiveness of the educational service.

The regression analysis resulted in the following regression equation:

$$F = -0,47 * F_2 \quad N = 40; R=0,47; p<0,05 \tag{1},$$

where F is «Deficiency of general satisfaction with a training programme»;
F_2 is «Satisfaction with the content of an educational programme».

The analysis did not allow to build adequate non-linear regression models. The present one-factor linear model shows that, if satisfaction with attractiveness and comprehensibility of the educational programme content increases by 1 point, deficiency of general satisfaction decreases by 0,47 point.

In this case it is sensible to perform the differentiated regression analysis, in which particular characteristics of satisfaction with a training programme act as dependent variables.

The other models can be as well assumed, especially if the initial set of educational service characteristics changes. Practical value of the built models, their compliance with real educational conditions, makes new ways for improvement of the educational

process, regarding the revealed interrelations. It was found out that if sample conditions change, the value of equation coefficients slightly changes, but a type of dependence remains the same. Therefore, these interrelations can be considered as general trends of interaction between the factors, which are related to different subsystems in the system of satisfaction indicators.

The question arises: «How will the noted interrelations change if assessment is considered as the only factor of satisfaction with service performance or its value?». The statistical analysis of both indicators of the service performance and its value allowed to deduce a common factor. In both cases this factor is characterised by high positive loadings for all the variables except «Service image» and «Service cost» that relate to objective characteristics of the service and explains over 60% of total variability. In the first case the factor (E) is called «Satisfaction with subjective characteristics of service performance», in the second case (I)-«Value of subjective characteristics of the service». The service was assessed after its performance that is why it is logical that satisfaction with the service performance influenced considerably the assessment of the service value. Following this variant of causative relations we have built the following regression equations:

$$I = 0,55*E \quad R=0,55; p<0,001; N=342. \tag{2}$$

$$I= 0,61*E+0,22*E^2-0,22 \quad R=0,63; p<0,001; N=342. \tag{3}$$

Both equations are adequate according to the Fisher's ratio test and the equation coefficients are valuable according to Student's t-test ratio. We can choose the equation that makes experimental data «smoother» (remainder is less). Still, both of them are important. The first equation can show direct proportionality relations between the factors, while the second equation allows to measure the value of factor E =-1,39, by which the minimum value of factor I =-0,64 is reached. Therefore both models can be used in practice to improve the intentional formation of customers' attitude to various characteristics of the service.

If we analyse the graph we can suppose that adequacy of a linear equation is determined by a combination of several samples having different averages. This means that it is reasonable to build such models in each of these samples. It was found that in some samples a linear model is appropriate, while in other samples-a quadratic model is appropriate, i.e. change of conditions leads to change of the type of dependence. In this case

we should question whether it is reasonable to use common models (built for a combined sample). In previous models (where primary variables were indices of satisfaction) the structure of equations is more stable and undependable on the sample specificity. Therefore, we can obviously trace the limits of causative relations, which difference is determined by the character of the analysed variables. It can be supposed that integration of characteristics of the service performance and its value will help build more common models of causative relations, while the differentiation provides building of various local models that are more stable. Regarding this condition, it is necessary to use both equations (2) and (3) to show causative relations in a combined sample as general hypothetic «soft» constructions. In case the conditions (sample specificity) are concretised, these models are also concretised and turn into more «rigid» ones. Note that at the stage of formation of a general set of primary parameters it is impossible to consider all causes. However, building of adequate models, which reflect almost all primary parameters and their qualitative interpretation prove that all essential factors are considered.

CONCLUSIONS

- In the study of causative relations a reasonable combination of qualitative and quantitative methods may depend on the hierarchical structure of the subject in question. The hierarchical order of the subject can be used to hierarchically arrange and explain causative relations, in particular due to a complex use of statistical methods.
- The schemes of the complex statistical data analysis vary, as every next stage of the analysis is determined by stability of causative relations at the previous stage and adequacy of qualitative interpretation of mathematical models built.
- The use of regression equations as an analytic form of the causative relation presentation is aspect-oriented, as it requires a higher level of formalisation of the investigation subject. Analysing the system of these equations or their diversity for particular conditions of indexes measuring, we can considerably improve the qualitative analysis of the subject in question, which is necessary to explain the factor interaction.
- Mathematical modelling of customers' satisfaction with educational services has a great potential, on condition that each stage of the statistical analysis of the services as non-experimental data

includes grounding of causative relations in the aspect of the hierarchy of the interaction between the studied factors.

- General directions of the factor interaction, presented as regression equations (built with the account for the structure of customer's satisfaction and the specificity of their sampling), make ways for a further improvement of efficiency of the service performance and appropriate influence on customers' preferences.

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