firm automobile service network; complex estimation

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METHOD OF THE BALANCED DEVELOPMENT OF AUTOMOBILE SERVICE NETWORK ON THE BASIS OF COMPLEX INDICATORS SYSTEM

Summary. In article one of ways of improvement of automobile service quality by balanced development of firm service network is described. The analysis algorithm of network subjects work is done. As criterion of an estimation of network activity performance the estimation integrated indicator of all network and estimation complex indicators of its subjects are offered.

МЕТОДИКА ПРИМЕНЕНИЯ КОМПЛЕКСНОЙ СИСТЕМЫ ПОКАЗАТЕЛЕЙ ДЛЯ УПРАВЛЕНИЯ СБАЛАНСИРОВАННЫМ РАЗВИТИЕМ СЕРВИСНОЙ СЕТИ АВТОМОБИЛЕЙ

Аннотация. В статье описан один из способов повышения качества сервисного обслуживания автомобильной техники путем сбалансированного развития сети фирменного сервиса. Приведен алгоритм анализа работы субъектов сети. В качестве критерия оценки эффективности ее деятельности предложены интегральный показатель оценки всей сети и комплексные показатели оценки ее субъектов.

1. INTRODUCTION

In modern conditions of accelerated scientific and technical progress when technics and technologies change by prompt rates, their constructive characteristics become complicated and the number of models and updatings grows, new approaches to management of each life cycle stage of automobile which concerns a category of high technology production are required. One of such approaches is intellectualization of an efficiency estimation process for management of activity of a firm service network (FSN) of automotive industry enterprises and decision-making on network rational development. Absence full and trustworthy information about infringements in automobile work, leading to failure at all stages of its operation, on the one hand does not allow to plan work of the service centers, including terms of spare parts deliveries, with another - complicates processes of construction perfection that reduces automobile reliability, and also conducts to trust loss of a brand at consumers and to decrease manufacturer competitiveness.

Now the companies focused on sale of automobiles without reinforcement by real firm service, will not sustain a competition not only at world level, but also in the country. Only adhering to the strategy focused on maintenance of production working capacity throughout all its life cycle, it is possible to provide steady consumer demand. Since recent time orientation to the client is considered one of obligatory signs of effective management system, in particular this approach is present at the international standard of quality management system ISO [1, 2].

Considerable reserves of increase of firm service system functioning stability, and, hence, and automobile competitiveness, are covered in management perfection. Monitoring of indicators of system functioning and comparison of their current values with similar data of the previous period is one of the methods allowing to estimate a system condition objectively. Decision-making is carried out how values of indicators have changed. Till now a number of researchers attempted to work out an estimation system of an overall performance of firm service system, in particular Yermilov D., Melnik T., Sokolov A., Shmelev A. [3 - 6]. However, the main error of the analysed methods is that they do not consider the main condition of the enterprise competitiveness in modern economy – client orientation. Thus, a priority is reception of long-term profit before short-term benefit, i.e. there is actually a development problem, instead of survivals.

Also as a result of the analysis of the above-stated methods of an assessment of the service enterprise activity it is revealed that all of them take into account limited number of indicators obviously incomplete characterizing all aspects of activity of the FSN` subject. Besides, methods of calculation of indicators are to some extent subjective as are based on the method of expert evaluations on which results aren't always objective.

Taking into account the aforesaid, nowadays a problem of working out of new management methods and algorithms of automobile firm service management and finding strategy of its development gets a special urgency. Developed techniques should consider heterogeneity of network subjects, and also variability of parameters of its functioning. Besides it, predicting expansion of the manufacturer presence in the market and finding strategy of the network development, it is necessary to consider major of activity parameters – client orientation.

2. COMPLEX ESTIMATION SYSTEM

Among set of existing management methods of object by achievement of a "global" strategic target it is possible to allocate Balanced Scorecard (BSC) widespread in the West, but still seldom used in Russia which have offered David Norton and Robert Kaplan [7] on the basis of the American companies researches, with use of the concept tableau de bord developed in the thirties in France and have developed a number of authors [8]. At the heart of this methodology the system approach to an estimation of performance and enterprise operation lays. BSC is a system of the interconnected targets, critical factors of success and key performance indicators. For reception of such system the so-called cause-and-effect diagramme is under construction. It includes the following elements: the enterprise general strategy, perspectives, targets and performance indicators. Thus to each target of BSC there corresponds the set of the targets which achievement is estimated by means of key performance indicators [9, 10]. For the formulated global strategic target «Increase of automotive industry enterprises FSN subject performance» cause-and-effect diagram looks like in fig 1.

As the top perspective «Leadership in the market» in which cut financial results of the enterprise activity are considered is allocated. With other things being equal high financial results can be reached by increase tariffs and production prices, or by expansion of client base. Whereas the first method is "extensive" the results received by means of it cannot with the sufficient basis enter into group of the indicators increasing competitive potential of the enterprise. More correct from the point of view of competitiveness growth is the second way - expansion and preservation of client base.

It is known that to involve new client much more expensively than to keep already available ones therefore it is necessary to treat them as a true loyal client. Hence operating satisfaction it is possible to operate costs counting on the client, reducing them, and by that increasing financial indicators of activity [11]. Therefore as following on priority the perspective "Clients" has been allocated.

According to competitiveness definition, it increases the possibility at the expense of increase of clients degree of satisfaction and reduction of their expenses. As it has been specified above competitiveness of the enterprise directly depends on clients loyalty as a component of high client loyalty it is possible to allocate high degree of clients satisfaction at low expenses.

Degree of client satisfaction and their loyalty are in nonlinear dependence according to which for the enterprise it is favorable to achieve high degree of satisfaction instead of to be content with an average level as only the expenses directed on achievement of high degree of client satisfaction bring appreciable return in the form of loyal clients [12].

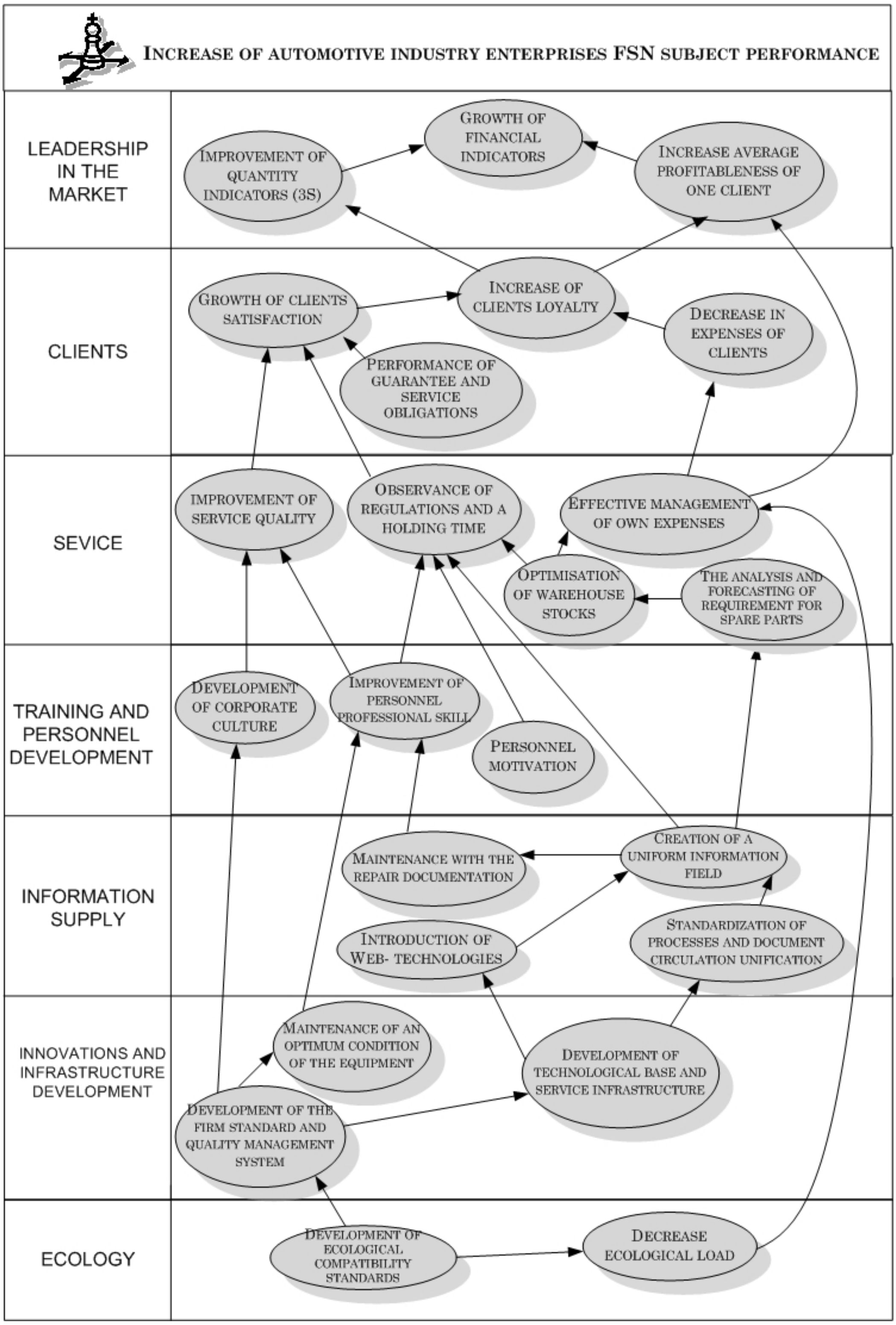

Fig. 1. Cause-and-effect diagram of FSN subject
Рис. 1. Стратегическая карта целей субъекта сети фирменного сервиса

Table 1

Performance indicators of FSN subject activity

Perspective	Target name	Performance indicator name	Indicator type	Infliuence character
2. Clients	4. Increase of clients loyalty	Share of market segment	Estimated	1
		Percent of new clients for the period (single, constant)	Estimated	1
		Index of clients adherence (quantity of the consumers preferring products of the given company / total of consumers of all given products)	Estimated	1
		Preservation of client base (percent of the left clients according to maintenance periodicity)	Estimated	2
	5. Performance of guarantee and service obligations	Quantity of claims	Estimated	1
		Quantity of kinds of rendered services	Projected	1
		Quantity of the concluded turnkey contracts with service firms	Projected	1
		Quantity of automobiles on a guarantee	Estimated	1
	6. Increase of clientssatisfaction	Index of client satisfaction	Estimated	1
		Quantity of clients complaints on service	Estimated	2
	7. Decrease in expenses of clients	Average losses of clients because of expectation in queue and automobile idle time	Estimated	2
		The general expenses for service	Estimated	2
3. Service	8. Improvement of service quality	Between-repairs run of an automobile and units	Estimated	1
		Share of repeated references of clients because of flaw	Estimated	2
	9. Observance of service time specification	Speed of reaction to the arrived demand	Estimated	2
		Average time of repair	Estimated	2
		Efficiency of a production cycle	Estimated	1
	10. Efficient control own expenses	Cost of idle times for the service firm	Estimated	2
		Share of warehouse illiquid asset	Estimated	2
		Cost of the paid penalties for untimely service	Estimated	2
		Specific transport expenses on spareparts	Estimated	2
	11. The analysis and requirement forecasting in spareparts	Automobile idle time because of absence spareparts	Estimated	2
		Quality of the made demand (percent of acknowledgement of the demand by stores list)	Projected	1
		Percent of spareparts satisfaction directly from a warehouse	Estimated	1
	12. Optimisation of warehouse stocks	Expenses for supplying of a warehouse stock	Estimated	2
		Stock turnover rate	Estimated	1

The above degree of client satisfaction of service quality then he will appeal for support in the service centre more willingly. Besides, one satisfied client would result behind itself two more on the average. However, potential financial benefits are shown in long-term prospect. On the contrary, consequences of clients dissatisfaction are shown much faster and can be very heavy. One disappointed client can tell about the problems, which have arisen with him on the average to 35 more potential clients of the company, and this secondary effect is capable to affect the future volumes of rendered services negatively.

The basic performance indicators connected with each of the specified target "Clients" and "Service" can be the indicators resulted in table 1.

On the basis of the performance indicators allocated by BSC complex system of FSN estimation has been developed (Fig. 2).

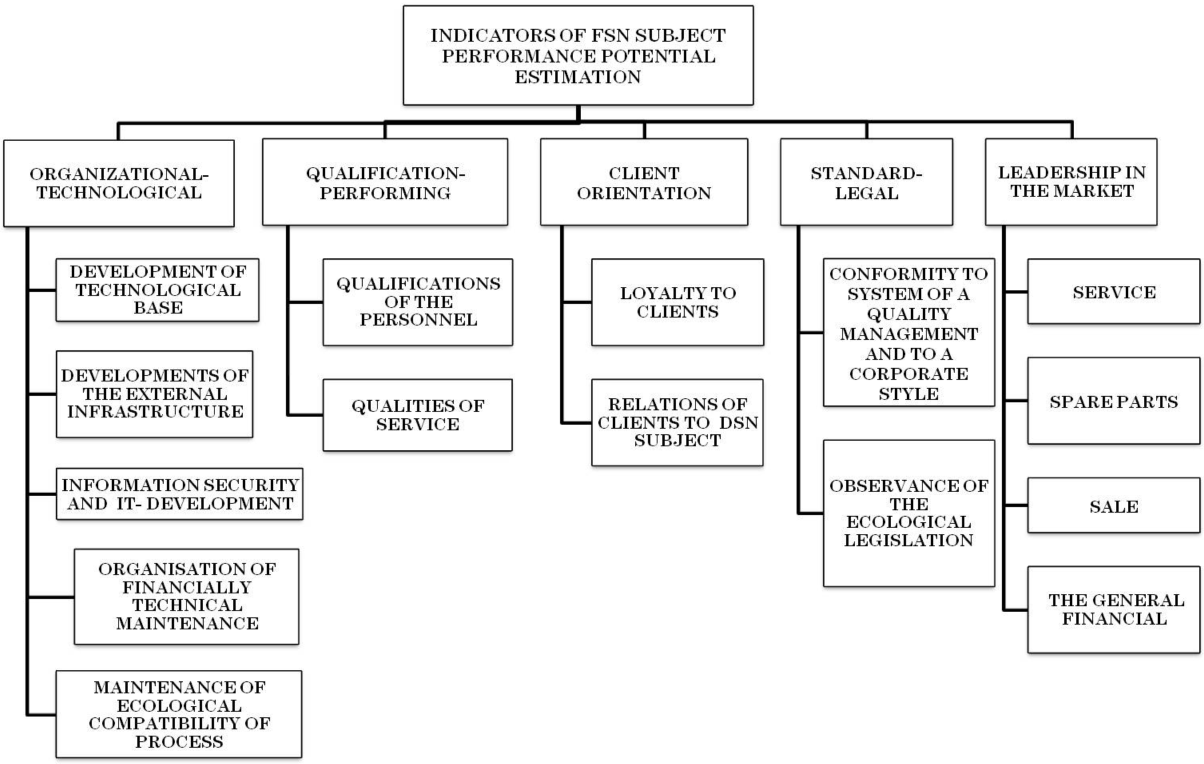

Fig. 2. Complex system of FSN performance indicators
Рис. 2. Комплексная система показателей эффективности СФС

During formation of indicators system it is necessary to consider a format of service enterprises, i.e. a spectrum of rendered services, hierarchy of processes and interrelation of subsystems. There is defined whether it is a "full-formatted" center (sale of automobiles and spare parts, the full list of services), an average (sale of spare parts, current service), or the service centre with the minimum set of services (sale of spare parts, simple service). Whereas FNS subjects differ by kinds of carried out functions it is necessary to spend an estimation of their work results differentially, allocating for each homogeneous group the own list of the factors influencing results of activity, and, hence, the enterprise competitiveness. In this sense differentiation of both indicators, and their values should be made for different types of FSN subjects.

The enterprises of each group differ not only activity directions, number of working posts and their specialisation, but also those minimal requirements to the general indicators which are shown to the service enterprises at their estimation (quantity of the personnel, the minimum areas of a service zone, warehouse, administrative-household premises, parking, the minimum set of the equipment, the special tool and adaptations, the operating-repair documentation).

All allocated indicators of estimation system are divided in two groups: the projected parameters characterising potential of the subject, and target estimated parameters (a column «Indicator type» in tab. 1.

Projected parameters influence structure of processes and subsystems of subjects, they are defined as resources which are used in work, and conditions in which service enterprises activity is carried out.

Design parameters influence structure of processes and subsystems of subjects, they are defined as resources which are used in work, and conditions in which service enterprises activities are carried out.

Estimated parameters for the "full-formatted" service centers and service stations also should differ and reflect activity results on sales of automobiles and spare parts (goods turnover on spare parts and the sold automobiles) and on service (volume of the rendered services in service kinds, degree of clients satisfaction of service quality, percent of posts loading).

For an estimation of functioning performance of both individual service enterprises and FSN as a whole it it is necessary to have initial values of projected parameters of each of them, and also the statistical information characterising parameters of their functioning during the different periods. Accordingly, for each typical service enterprise the maximum values of its work estimated indicators corresponding to put in pawn projected capacities (profitability, costs per one client etc.) are defined.

As performance of each of FSN subject is characterised by degree of achievement of limiting values of each of projected entrance parameter irrespective of a format, for comparison of complex indicators of subjects functioning in each group it is more logical to use relative individual performance indicators. Therefore at the first stage the relative indicators characterising degrees of achievement of the maximum values of these parameters are calculated, that will be accepted as individual performance indicators.

Thus, each FSN subject will be characterised by set of indicators $\{i_f\}$ $f=1, F$ comprehensively and adequately reflecting its competitive potential. As set $\{i_f\}$ the indicators listed in table 1 act. Thus, considering that the initial set of indicators $\{i_f\}$ has various physical sense and influence character on a total estimation of FSN subject competitiveness, their separation into groups (a column «Influence character » in table 1) has been executed:

1 – the indicators, which increase leads to growth of the general FSN subject performance estimation $i_f^{(+)}$, $f = \left(\overline{1, l}\right)$ (for example growth of personnel qualification positively influences level of subject performance);

2 – the indicators, which reduction leads to growth of the general FSN subject performance estimation $i_f^{(-)}$, $f = \left(\overline{l+1, F}\right)$, (an increase in customer waiting time in queue, on the contrary, reduces performance).

To result influence character of indicators on a total estimation to uniform direction, values of indicators of the second group should be transformed under the formula:

$$\tilde{i}^{(-)} = \frac{1}{i^{(-)}}, f = (\overline{l+1, F}) \qquad (1)$$

Then growth of general indicator value will be reached by growth of values of separate indicators entering into it.

Then FSN subjects are sorted on homogeneous «the same format» groups for which indicators of efficiency and use of production potentialities are analyzed. Comparison of subjects among themselves in limits of the same format groups, definition of the best practice of production potentialities use and revealing among the general set the enterprises-leaders and the enterprises-outsiders is made. The FSN subject will be effective if the current value of the projected parameters can not achieve higher values of estimated parameters, and projected parameters have been established at the level of maximum values.

At the enterprises where capacities are involved in full degree, the attention to the question on achievement of an optimum management maximum is brought. For the enterprises which have not settled the production potentialities, the reasons of low efficiency of functioning are established, the entrance parameters which have not reached the maximum value and adjustment of which will allow to organize activity more rationally are allocated, the plan of measures on optimization of processes is developed. After that the analyst estimates, what improvements planned actions will bring to each FSN subject and all system as a whole. The developed actions are brought to the notice of subjects for the subsequent performance (Fig. 3).

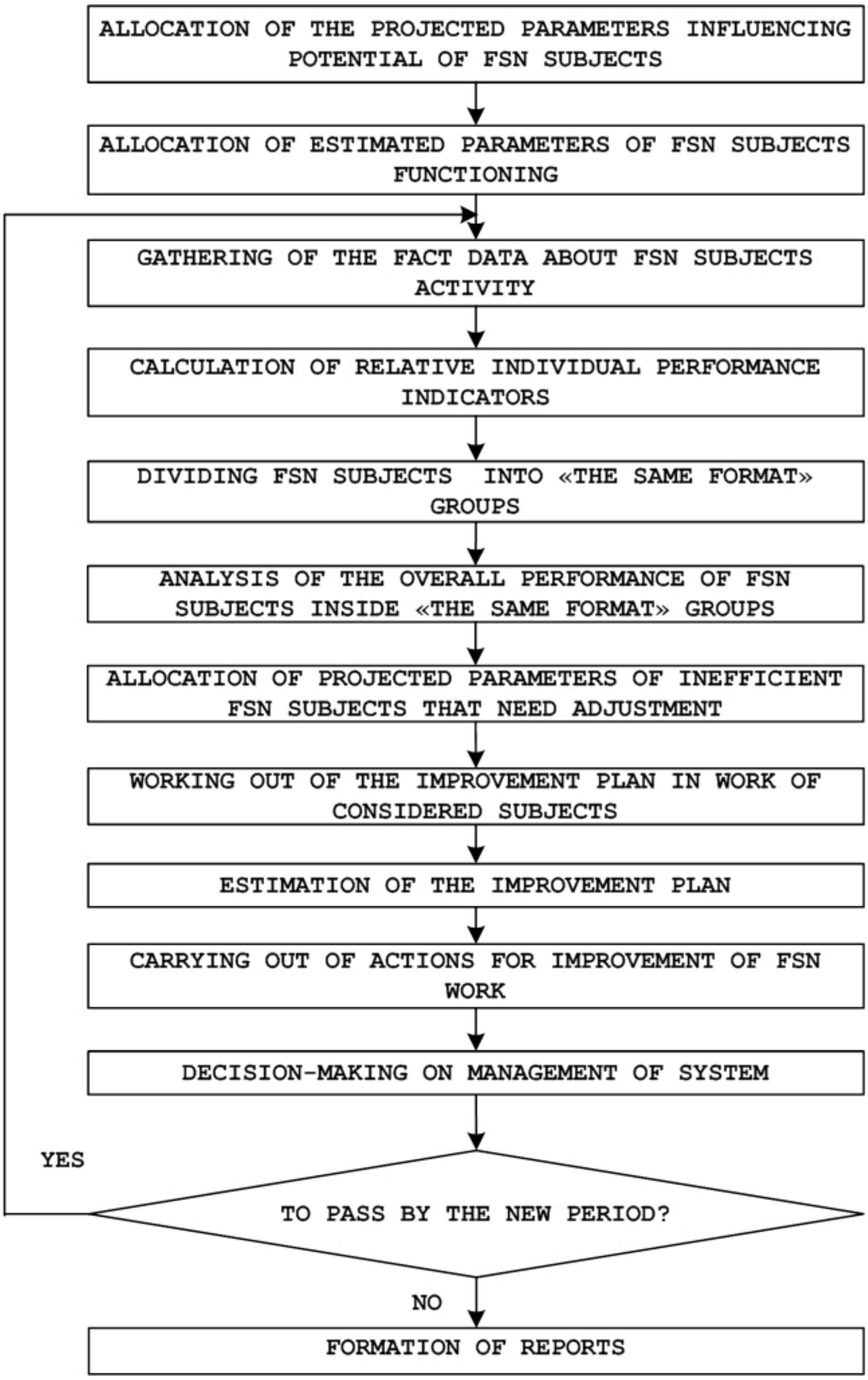

Fig. 3. Analysis algorithm of FSN subjects work
Рис. 3. Алгоритм проведения анализа работы субъектов СФС

3. ALLOCATION OF TYPICAL CLASSES OF FSN SUBJECTS

For classification of FSN subjects it is offered to use statistical cluster analysis and neural networks: for evident definition of classes quantity - a hierarchical agglomerative method with construction classification tree; for check of correctness of splitting - a method of *k*-averages and the Kohonen neural network based on training without the teacher [13].

Cluster analysis allows to classify set of all measured samples of FSN subjects activity: $X_1, X_2, ..., X_S$, each of which has a set of classification attributes $\tilde{O}_p = \{x_{p1}, x_{p2} ... x_{pf}\}, \; p = \overline{1, S}$.

Before procedure of separation of FSN subjects on classes, initial data should be normalised. The sense of normalization consists in reduction of numerical values of the chosen variables to uniform scale. The new normalised values of variables are calculated under the formula:

$$x_{inorm} = \frac{x_i - \bar{x}}{\sigma}, \sigma = \sqrt{\frac{\sum_i (x_i - \bar{x})^2}{n-1}} \tag{2}$$

where: $x_{i\text{norm}}$ – a normalized value, x_i – an initial value, $\bar{x}$ – an average value, σ – standard deviation, *i* – quantity of array elements.

The first step was done on a tree-based clustering and is under construction horizontal or vertical dendrogram - the graphon which distances between objects and clusters are defined at their consecutive association.

As the metric it was used Euclidean distance. As algorithm of classification Ward's method is chosen which based on the assumption that on the first step each class consists of one element. The advantage of this method consists that it Works well with a small amount of elements and is aimed at selection of clusters with approximately the same quantity of elements.

For acknowledgement of correctness separation of ***S*** measured samples of FSN subjects activity on ***k*** classes each of which is characterised by ***F*** attributes classification by a method of k-averages is spent. In the beginning of this method classification procedure the quantity of classes defined according to an agglomerative method is set. Further during iterative process clusters centers are calculated and objects are moved from one class to another until one of conditions will be executed: clusters centres are stabilised, i.e. value of quality criterion will not cease to improve or the number of iterations does not become equal to the specified maximum iteration number [14]. In our case, for initial separation ***S*** measured samples of FSN subjects activity on ***k*** classes at first it is necessary to sort distances between all samples and then as the initial clusters centres to choose observations at constant intervals.

After carrying out cluster analysis average values of each indicator for every cluster is paid off to estimate how much clusters differ from each other. The values of the F-statistic calculated for each attribute are the indicator that the selected attributes are well discriminated clusters. Those attributes on which for all clusters zero hypothesis ***H₀*** has proved to be true: $\sigma_{dw}^2 = \sigma_{db}^2$ (σ_{dw}^2 - the deviation within clusters, σ_{db}^2 - the deviation between clusters), i.e. $F_p \langle F_{\hat{e}\eth}$, $F_p = \frac{\sigma_{db}^2}{\sigma_{dw}^2}$, can be considered insignificant and to be excluded as classification attributes.

4. CONSTRUCTING NEURAL NETWORK CLASSIFIER, FINDING THE COMPLEX PERFORMANCE INDICATOR OF NETWORK SUBJECT

To determine the origin of the re-measured FSN subject sample to one of the known classes the method of constructing neural network classifier used, it was assumed that by means of a classification technique all set of cases has already been divided into ***k*** classes.

The Kohonen neural network, which has two layers: the input and output was chosen. At the input layer are fed sequentially ***S*** vectors of classification attributes $X_p = \{x_{p1}, x_{p2} ... x_{pf}\},\ p = \overline{1,S}$. Associated with each output neuron set of weights ***W*** connecting it with each entry. For example, k-th output neuron has a weight $\boldsymbol{w_{1k}, w_{2k}, ..., w_{fk}}$ component weight vector $\boldsymbol{W_k}$. They are connected through an input layer with inputs $\boldsymbol{x_1, x_2, ..., x_f}$ components of the vector values of the training sample ***X*** (Fig. 4). The output $\boldsymbol{N_j}$ of each neuron is a sum of weighted values of the input signal vector. This can be expressed as follows [15]:

$$N_j = w_{1j}x_1 + w_{2j}x_2 + ... + w_{fj}x_f,\ j = \overline{1,k} \qquad (3)$$

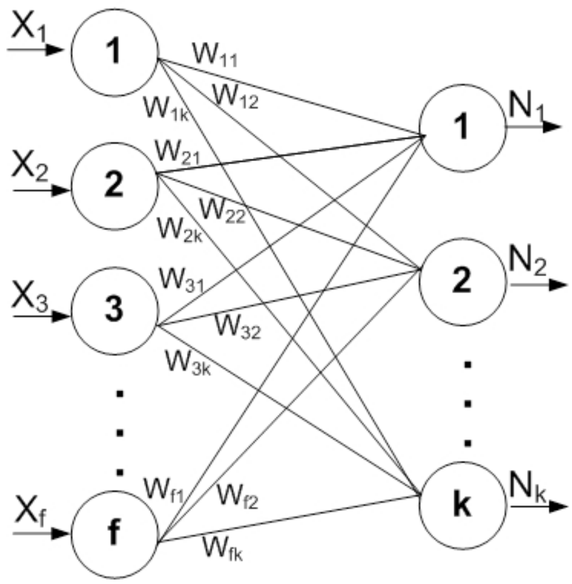

Fig. 4. Kohonen neural network
Рис. 4. Нейронная сеть Кохонена

After the network is trained, it can be used as a neural network classifier (as the weighting of membership functions used Kohonen network weight matrix ***W***), which can be used to classify new samples of data to one of the previously defined classes.

Once the inputs of the trained network is fed vector ***X*** of classifications attribute, output vector ***N*** = ***XW*** is calculated. The new sample belongs to the *j*-th output layer neuron (and hence, to the j-th class), in which the value of the activation function $\boldsymbol{N_j}$ is maximum. If on a network input to submit a data set that is not similar to any of the known samples the network will not be able to take it to one of the previously identified classes and thus reveal his "originality", that means the appearance of subject of FSN new type and necessity of allocation of a new class.

For calculation the complex performance indicator of FSN subject construction a neural network separately for design and performance indicators is spent, i.e. the inputs are fed, respectively, the vectors of projected parameters values $X_{pr} = \{x_{pr1}, x_{pr2} ... x_{prF_{pr}}\},\ pr = \overline{1,S_{pr}}$, and estimated parameters values $X_{oc} = \{x_{oc1}, x_{oc2} ... x_{ocF_{oc}}\},\ oc = \overline{1,S_{oc}}$. Further weights are found and activation functions are computed Ypr and Yoc. The complex indicator is the ratio of the activation functions of the two networks $\frac{Y_{oc}}{Y_{pr}}$.

5. CALCULATION OF ESTIMATION INTEGRATED INDICATOR OF PERFORMANCE MANAGEMENT OF FIRM SERVICE NETWORK

After calculation of performance indicators of each subject the performance management estimation indicator of all FSN as a whole is finding, monitoring its dynamics it is possible to draw a conclusion on character of FSN development (decline, stability, development), then appropriate strategic plans are developed.

$$I_{FSN} = \sum_{t=1}^{T} \frac{\sum_{i=1}^{m^t} I_t^i \cdot S_{pt}^i}{\sum_{i=1}^{m^t} S_{pt}^i} \cdot q_t \quad (4)$$

where:

T – the number of hierarchical levels in FSN; m_t – quantity of subjects of t-level hierarchy;

I_t^i – performance indicators of i-subject in t-level; $S_{\partial t}^i$ – input weighting coefficient of performance indicators of i-subject t-entity level in the average level for all t-level (automobile park attached to the subject);

$q_t = \dfrac{2 \cdot (T - t + 1)}{T \cdot (T + 1)}$ – input weightiness coefficient of average value of t-level`s performance indicator in integrated performance indicator of all FSN;

t – place of FSN hierarchy level at ranging.

For the above-described structure of FSN which consists of three levels the formula takes the form:

$$I_{FSN} = \frac{\sum_{i=1}^{m} I_{1L}^i \cdot S_{p1\mathrm{L}}^{\mathrm{i}}}{\sum_{i=1}^{m} S_{p1L}^{\mathrm{i}}} \cdot q_{1L} + \frac{\sum_{j=1}^{n} I_{2L}^j \cdot S_{p2\mathrm{L}}^{\mathrm{j}}}{\sum_{j=1}^{n} S_{p2L}^{\mathrm{j}}} \cdot q_{2L} + \frac{\sum_{k=1}^{u} I_{3L}^k \cdot S_{p3L}^{\mathrm{k}}}{\sum_{k=1}^{u} S_{p3L}^{\mathrm{k}}} \cdot q_{3L} \quad (5)$$

6. CONCLUSION

The offered method of a complex estimation of an automotive industry service network activity on the basis of BSC allows to raise efficiency of development both all network and its subjects through resources redistribution in a network and construction of development strategy taking into account potential of each subject. At strategy construction the potential of each enterprise and also degree of achievement of projected parameters is considered. By monitoring dynamics of integrated and complex indicators the analyst is able to provide the parameters that need adjustment and to develop science-based solutions to improve the functioning of the firm service system.

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