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MODEL OF ASSORTMENT OPTIMIZATION AND INVENTORY MANAGEMENT IN ENTERPRISE

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Abstract. *The actual problems of work in the sphere of organization of supply and sale are considered, the existing developments in the sphere of modeling and optimization of commercial activity of the wholesale trading enterprises are analyzed. The necessity of a comprehensive approach to improving the commercial activities of wholesalers is substantiated. The composition of the solutions included in the integrated approach is determined by the sole purpose, practical possibilities of its implementation and implementation at the wholesale enterprises and is based on the analysis of actual problems of the industry as a whole, interdependence in the work of departments, development of a single optimization criterion. The effectiveness of the integrated approach is based on the fact that for the sake of maximum result it is important not to isolate the development of individual operations, but to improve the entire purchasing system of the wholesale enterprise as a whole. The scientific and methodological approach of carrying out the integrated ABC-XYZ analysis of a range of a trading enterprise by its combination with R/S analysis, which acts as a criterion for the effectiveness of the XYZ analysis and an indicator of the possibility of forecasting the dynamics of sales of individual product groups, has been improved. XYZ analysis, based on the calculation of the coefficient of variation, when there are deterministic factors such as seasonality, cyclicality or trend in a series of determinants, shows erroneous results. Therefore, it is suggested to use R/S analysis to evaluate the quality of the XYZ analysis and to pre-process the data. This will allow us to draw more adequate conclusions about the possibility of forecasting the dynamics of sales of certain product groups in the future.*

Keywords: *inventory, ABC-XYZ analysis, R/S analysis, seasonal component, turnover.*

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Introduction

Increasing competition in many sectors of the economy is creating new demands on all market agents. In addition, wholesalers are no exception. The achievement of sustainable competitiveness by a wholesale trading organization is

determined by its ability to effectively use its competitive potential. The competitive potential of a trading organization integrates a set of such important characteristics as the availability of modern technology, equipment, qualified personnel, the necessary inventory, financial and innovation resources, the degree of organization of the trading process, the level of optimization and automation of business processes of the trading organization, etc. At the same time, it is worth noting the importance of the influence of external factors on the level of competitiveness of a trading company, whose degree of influence is significantly different. However, if externalities can only be limited by their objectivity, internal factors are of great interest to business executives who, in the face of increasing competition, are constantly on the lookout for new, commercially sound management tools and leverage tools their competitiveness. In these circumstances, the issue of modeling and optimization of business processes related to the commercial activities of wholesale trading enterprises is at the forefront. This is due to the fact that modeling as a method of research of complex socio-economic systems opens the management of wholesale trade enterprises the way to find answers to many questions in the sphere of their management and represents an effective means of forecasting their dynamics in the future. Therefore, a model description of the patterns that emerge at each stage of the decision-making process, as well as the relationships between them, is an important prerequisite for further analysis of the enterprise as a whole and effective management of it.

The purpose of the work is to develop a comprehensive approach to improving and optimizing the commercial activities of wholesale businesses, in order to reduce the costs associated with its implementation. To accomplish this goal, the following tasks were formulated and solved: to determine the place of commercial activity in the economy of wholesale trading enterprises and to identify the reserves of cost reductions arising in the course of its implementation; substantiate the need to apply economic and mathematical modeling to improve and optimize the commercial activity of wholesale trading enterprises, to systematize the existing methods and to clarify their main features; to improve the scientific and methodological approach of product range optimization on the basis of integrated ABC-R/S-XYZ analysis.

Literature Review

One of the main ways to optimize supply is to manage the purchasing activities of trading companies, including managing the product mix and inventory. Increasing interest in the assortment policy of commercial enterprises is due to the pursuit of two goals: the need to improve the efficiency of internal resources and adapt to new conditions. Assortment policy of a trading enterprise is the development of a separate strategy for managing different product categories, groups of goods in order to optimally spend resources allocated to manage them. It is this need that confronts the researchers with the task of reasonably distributing the commodity range of a trading enterprise into certain clusters, homogeneous in certain features.

Traditionally, in the scientific literature, such methods of optimization of the product range as ABC and XYZ analyzes are used to solve this problem, which can be applied both independently and in combination.

And many authors lean in favor of a compatible analysis (Aktunc, E. A., Basaran, M., Ari, G., Irican, M., & Gungor, S. (2019)).

The basic idea behind ABC analysis is to take a differentiated approach to managing the various assets that result from the unequal division of cluster entities under Pareto law, which states that 20% of the causes are responsible for 80% of the consequences. ABC analysis has been successfully used to improve the various areas of activity of commercial enterprises. The objects of analysis may be the product range, suppliers, buyers, competitors and more. In this paper, we investigate precisely the use of ABC analysis to optimize the range of trading enterprises, which is based on the idea that different goods have different degrees of importance for the enterprise and can be divided into three groups - A, B and C - that make up the structure of the indicator efficiency (e.g., enterprise revenue) of 80, 15, and 5%, respectively. However, it is worth noting that this proportion is conditional, and this ratio may vary. Thus, in Dastych, T.K.D. (2018) it is proposed to distinguish clusters as follows: group A - objects whose share in cumulative total is 50% of total turnover; group B and C - from 50% to 80% and from 80% to 100% of the total turnover, respectively. In each case, the boundaries of clusters for the population should be justified separately, for which you can use the double-tangent method or the polygon method.

Methodology

The entities that form the three groups have different degrees of importance to the enterprise and therefore require different management styles for their inventory.

Group A combines the "most important" objects that bring the best result (profit, income) to the enterprise, despite the fact that they occupy a very small share in the overall range. Stocks of this group must always be full in order to avoid shortages and supply disruptions.

Group B is a 'medium-sized' entity that can be developed into Class A in the long run. As Group B is a lower priority commodity, inventory levels should be lower than Group A commodities.

Group C - these are "problem" objects, which take up excess resources (take up space in the warehouse, freeze working capital, require additional human, financial, transportation costs).

Therefore, the absence at the right moment of Group C goods in the warehouse does not significantly affect the overall turnover of the enterprise. However, this does not mean that such goods should not be presented in the product range.

The exclusion of this group from the product range of the enterprise can lead to a decrease in the overall result, since the whole set of goods will again be redistributed into three groups according to the chosen proportion, for example 80-15-5%. This product group informs the analyst of the existence of an imbalance in the range and requires him to analyze more carefully the reasons for this result. If these

reasons cannot be eliminated, the product is removed from the range.

Thus, the main task of ABC analysis is not to divide a set of goods into groups as an end in itself, but to separate groups that require different styles of inventory management.

The above shows that ABC analysis cannot be called a panacea for inventory management, but rather the initial and simplest stage of optimization. It ranks goods by priority, but that alone does not bring significant savings. The fact is that, according to Pareto law, about 80% of income comes from Group A goods, which stocks should always be in stock. Therefore, only the 20% that accounts for Group B and C products are in the savings reserve. Even if you reduce the inventory by these two groups twice (which can lead to a significant and long-term deficit), the overall level of inventory maintenance costs will decrease only by 10%. In addition, ABC analysis does not take into account uneven demand, such as seasonal fluctuations or surges in demand. The importance of considering these parameters lies in the following. Considering that the main reserve for reducing inventory costs is the reduction of insurance stock, which largely depends on the degree of predictability of sales volumes and time, the level of predictability of demand is almost the main criterion for the division of goods into groups. The higher the level of demand forecasting, the less insurance reserves you need to have, and vice versa. Therefore, there is a need for a more thorough analysis of the product range of the enterprise using other methods that take into account the uneven demand.

One of the methods that is recommended in the scientific literature to identify the stability of the market and the ability to predict it is XYZ analysis, which can be both standalone and continue ABC analysis.

The content of XYZ analysis is to differentiate objects into groups based on the level of demand for them.

The objects are divided into groups according to the following scale:

- group X - goods whose variation coefficient does not exceed 10%, is characterized by stable sales volumes, slight fluctuations in demand and high forecast accuracy;

- group Y - goods, the coefficient of variation of which is in the range of 10-25%, are characterized by some fluctuations in demand and average ability to forecast sales;

- group Z - products with a coefficient of variation exceeding 25%, characterized by subpar sales and low predictability of demand for them.

However, some scholars have highlighted other gradations. For example, in for group X, the range of the coefficient of variation is 0-20%, for Y - 20-50%, and for Z - 50-100%, and Frankeová, M., Farana, R., Formánek , I., & Walek, B. (2018, April) set the following limits: X = 0-50%, Y = 50-100%, Z> 100%. Apparently, there is no consensus on this, because unlike ABC analysis, where the sum of particles is limited to 100%, XYZ analysis has no such limits. Therefore, the choice of the range of the coefficient of variation is an empirical task that must be solved taking into account the specificity of the specific product and enterprise. According to the author, the most rational in this situation is to calculate the coefficients of variation, find their

minimum and maximum values and form accordingly groups of goods.

The XYZ analysis algorithm includes the following steps:

1) identification of the object of analysis;
2) the choice of parameters by which the object will be evaluated;
3) determining the period for which the analysis will be conducted;
4) estimation of the coefficient of variation and division of objects into groups;
5) analysis of the results obtained.

The methods described above have been tested numerous times in various fields of data analysis for their simplicity. Repeated use has revealed their advantages and disadvantages, which are given in Table 1.

Considering the advantages and disadvantages of ABC and XYZ analyzes (Table 1), we can conclude that these methods are complementary.

Table 1. Advantages and disadvantages of ABC and XYZ analyzes

	Advantages	Disadvantages and limitations
ABC analysis	Simplicity Transparency Versatility Automation capability Optimization of resources	The need for data homogeneity Inadequacy in some cases of division of the population exactly into 3 groups The inability to account for the seasonality factor The need for a careful approach to the choice of period, by which is being analyzed Limited applications for complex analysis multidimensional phenomena
XYZ analysis	Simplicity Transparency Mathematical validity Possibility of promotion adequacy of conclusions thanks to regularities of a number (trends, cyclicals, seasonality	The need for data over a long period The likelihood of false conclusions in the case is high small sample The complexity of automation through a large proportion human logic Use in its pure form is only possible in conditions close to the laboratory Unsuitable for businesses that work for orders

While ABC analysis allows us to estimate the contribution of each product to the sales structure, the XYZ analysis assesses the persistence of demand for that product. Therefore, in the scientific literature, it is recommended to carry out a combination of ABC-XYZ - analysis.

In addition to the disadvantages of XYZ analysis, mentioned in Table. 1, there is a significant limitation that can negate the full benefit of such an analysis. It is at the heart of this analysis, and is due to the fact that all conclusions about sales stability and forecasting are based on only one indicator, the coefficient of variation. Although it is a well-known statistic that has a well-founded mathematical apparatus, it is not capable of separating cyclicality, seasonality, trend, or other explanatory changes from random fluctuations in the observed magnitude. In other words, if the sales dynamics of a particular product are characterized by seasonal changes that occur very often, then the coefficient of variation will be unjustifiably high, which will automatically attribute the product to a group of low-predicted ones, although

this may not be true. After all, if a number of sales volumes are characterized by a trend or cyclicality, then it is likely that this will continue to be the case in the future. Therefore, these components (trend, cyclicity and seasonality) can be considered as well predicted components of the series. And the level of predictability of a series is estimated precisely by its random component, which remains after being excluded from a number of such components as seasonality, trend and cyclicality. It is the likelihood of false conclusions about the ability to predict the dynamics of sales in our case, and is a major drawback of XYZ analysis, which often negates all its benefits.

As can be seen, XYZ analysis, like any other statistical method, imposes a number of requirements on the input data. Namely, for its successful use, such preconditions as linearity and taciturnity of time series, subordination to the normal law of distribution, independence of the levels of the series, etc. must be satisfied. At the same time, to say that the series of dynamics describing economic phenomena, including changes in demand for enterprise products, satisfy these prerequisites can not always.

Therefore, to optimize the product range of a trading company, we see two developments. The first variant is suitable for such series, which can be reduced to stationary by certain transformations. It consists of ABC analysis and XYZ analysis with a preliminary seasonal decomposition of time series characterizing the dynamics of sales of various goods, according to the algorithm described below. The second option is relevant for time series that do not obey the normal law of distribution. First, it differs in that XYZ analysis is replaced by another method, which allows drawing conclusions about the stability of sales of a certain product and the possibility of predicting its dynamics, but is not based on the calculation of the coefficient of variation. It is proposed to use R/S analysis as such method.

The scientific and methodological approach of carrying out the integrated ABC-R/S-XYZ-analysis of the range of trading enterprise is obtained by the combination of ABC-XYZ-analysis with R/S-analysis. This approach, unlike the existing ones, uses the results of R/S analysis as a criterion for the effectiveness of XYZ analysis, which allows to determine the feasibility of forecasting the dynamics of sales of product groups.

Based on the findings of the integrated analysis, recommendations can be developed to optimize the product range of the studied enterprise and its inventory management, which will improve the efficiency of trading enterprise as a whole.

Results

The question of modeling of commercial activity of wholesale trading enterprises is considered in the works of many scientists.

In particular, in Ivanov, D., Tsipoulanidis, A., & Schönberger, J. (2019), an algorithm is used to calculate the parameters of a trading enterprise and its counterparties that maximize the profitability of trading operations in the short term. For this purpose, the dynamics of the volume of circulating assets of the enterprise on the basis of differential equations is simulated. In general, this approach provides a

satisfactory result, since, under the known initial conditions, it gives estimates of the required parameters and allows us to predict the amount of working capital for the future. However, there are a number of drawbacks to this approach. First, the assumption of chance and the absence of aftereffects in the processes inherent in the activity of a trading enterprise are taken as a basis. Secondly, the differential equation approach has its limitations, including the complexity, and often the impossibility, of finding a solution on a large number of parameters, which is typical for modeling complex systems like trading enterprises. Third, the consideration of only the dynamics of working capital in modeling the activity of a trading company seems somewhat limited, although in the work it is explained by the short-term model.

The tools of fuzzy logic solve the following problems of modeling the commercial activity of wholesale trading enterprises: the task of finding areas of effective commercial activity, the task of calculating promising product range, the task of forming the relations of advantages in the analysis of commercial offers, the problem of semi-automatic distribution of goods. The models developed by the author of this work suggest that mathematical methods of fuzzy set theory are effective in modeling the commercial activity of wholesale trading enterprises in the context of incomplete and fuzzy information and accompanying any entrepreneurial activity of uncertainty. These methods have a number of disadvantages, in particular such models can only be resolved with a limited amount of data. In addition, the model developed by the author of the search for the optimal price of goods implies the need for information about consumer demand, which in a real situation is quite difficult to obtain, and the coefficient of elasticity is taken constant, which is rarely true. Also, built models lose sight of the possibility of influence of price change of one product on the dynamics of sale of other goods (substitute and complementary goods). Thus, the models proposed by the author have a number of significant limitations that cannot be ignored.

Klodawski, M., Jachimowski, R., Jacyna-Golda, I., & Izdebski, M. (2018) a decision support system is proposed, which contains a set of models for optimizing the commercial activity of a wholesale trading enterprise, in particular such works as: market research of the market; selection of perspective assortment for each client of the wholesale enterprise; sales analysis and demand forecasting; optimization of trade and purchasing activity; evaluation of the financial condition of the wholesale enterprise; evaluation of the efficiency of the developed system.

It is noteworthy that a comprehensive approach to modeling the business activity of a wholesale enterprise is noteworthy, but the method of selecting a prospective assortment for each customer of a wholesale enterprise using the toolkit of intersection of fuzzy sets completely repeats the approach given in Kumar, N., & Soni, R. (2017) does not allow to claim scientific novelty. To optimize trading and purchasing activity, the author developed a dynamic linear programming model that takes into account a large number of factors. However, it is based on the assumption of the linearity of economic processes, which oversimplifies the real situation and, in some cases, leads to entirely false conclusions. In addition, the model developed is complex to deal with on specific data. The author gives an example of its realization

in the case of two suppliers of a wholesale enterprise, which, in turn, produce products of two types and two consumers - retail trade enterprises. Obviously, in a real situation, we are talking about a much larger number of both counterparties and types of products. With many variables, this model will become indistinguishable.

In particular, demand-forecasting models have been developed to optimize inventory and receipts from the collection of commercial arrears in deferred payment products, as well as models for organizing the sales system, including optimization of the transport department. The auto-regression method and the integrated moving average Box-Jenkins method were chosen as the prediction method. In order to optimize the work of the transport department, it is proposed to automate the route mapping with the help of mapping technologies and satellite navigation systems. This approach is more up-to-date and relevant than, for example, the Lukinskiy, V., & Lukinskiy, V. (2017) linear programming method for optimizing traffic flows.

It is worth noting that considerable attention is paid to the optimization of inventory management (Nguyen, T. (2019)) in the modeling of commercial activity of wholesale trading enterprises. An analysis of the literature indicates that the most common method of optimizing inventory management is the symbiosis of ABC analysis and XYZ analysis. This trend was started in Permatasari, M., Ridwan, A., & Santosa, B. (2017). The authors of these sources emphasize the effectiveness of combining ABC and XYZ analysis to evaluate the contribution of each product group to the sales structure and to detect sales fluctuations. However, XYZ analysis provides adequate results only in case studies. If the time series have a seasonal component, then the XYZ analysis will show a large deviation, which means a low probability of correct forecasting of the trend for the future, although it is known that the detection of seasonality coefficients increases the chance of adequate forecasting of the dynamics of the time series. Therefore, more advanced methods, such as fractal analysis, should be used in addition to ABC-XYZ analysis. This will allow you to fully evaluate the entire range of the enterprise and find the levers to manage each product group individually.

In Walek, B. (2018, May), based on the theory of active systems, economical and mathematical models of inventory management of hierarchical trading enterprises have been developed, taking into account the uncertainty and asymmetry of the awareness of individual units of the trading network.

Particularly noteworthy is the work of Stojanović, M., & Regodić, D. (2017), which not only developed a functional and structural model of the wholesale inventory management system, but also offered an information system for optimizing its logistics activities.

The analysis of scientific works, which describes the modeling of commercial activity of wholesale trading enterprises, allows to conclude that the authors have considered various aspects of it. However, insufficient attention has been paid to optimizing the transportation function while transport costs constitute the most promising reserve for reducing the unproductive turnover of wholesale trading enterprises. In addition, most of the models developed in this field are static in nature and cannot adapt quickly to changing conditions. Therefore, we consider it expedient

for the modern level of development of wholesale trade organizations to use an approach to modeling the commercial activity of such enterprises, which in a complex would solve these tasks, in particular, would allow to optimize transport flows, assortment and inventory management system, as well as to forecast the dynamics of sales on the basis of a simulation model describing the consumer market.

Thus, the analysis of the history of origin and features of the application of existing methods of economic and mathematical modeling allowed us to draw the following conclusions. A distinguishing feature of the current stage of economic development is its mathematization. It manifests itself in the replacement of the object under study with a model, with further study of its properties and extrapolation of the conclusions to the object. For a long time, linear models of economic systems development prevailed in science. They were simple enough to understand, formalizable and mathematically solvable. However, further research and the discovery of new features in the development of complex socio-economic systems has led to the understanding that linear models well explain the behavior of only simple, closed, equilibrium systems over a short time interval, which is essentially a partial case of nonlinearity. And, starting from the end of the twentieth century, a new approach to the analysis of economic systems begins, taking into account their nonlinearity, nonequilibrium, openness, multivariance, self-organization, processes of bi- and polyfurcation, called "economic synergetics". It treats non-linearity and instability as a source of diversity and complexity of economic dynamics, rather than noise and random disturbances, as the traditional economy does.

The inefficiency of linear forecasting methods was once again proved by the unprecedented financial and economic crisis of 2008, which seriously raised the question of the ability of science to adequately describe complex socio-economic processes and anticipate their development. The emergence of new trends in the development of economic systems, of course, necessitates the change of methods of their description, which are being improved, complicated, taking into account more and more nuances, but most importantly, they are beginning to be based on a qualitatively new principle of nonlinearity. In such circumstances, the most appropriate realities are economic cybernetics and metaheuristic methods.

The efficiency of the entire logistics chain of a trading company depends largely on the features of its product range and inventory management system. This leads to the urgency of optimizing the product range, which requires the development of a separate management strategy for different groups of goods in order to minimize inventory, and therefore the most economical use of resources allocated to manage them.

Traditionally, in the scientific literature, such methods of optimizing the product range as ABC and XYZ analyzes are used to solve this problem, which can be applied both independently and in combination.

However, the XYZ analysis has a significant feature: if the sales dynamics of a particular product are characterized by seasonal changes that occur very often, then the coefficient of variation will be unjustifiably high, which will automatically attribute the product to a group of low-predicted ones, although this may not be true.

Therefore, to address this shortcoming, a methodology for integrated ABC-R/S-XYZ analysis has been developed, which differs from the existing combined ABC-XYZ analysis in that it is supplemented by R/S analysis as a criterion for the effectiveness of the XYZ analysis and the opportunity indicator forecasting the dynamics of sales of product groups.

Table 2. Results of ABC analysis on turnover (calculated by the author on the basis of enterprise reporting data)

Product group	Group turnover (pcs)	Turnover ratio	Cumulative ratio	ABC Analysis Group
Group 1	4117026	31,76%	31,76%	A
Group 2	254261	19,655	51,41%	
Group 3	243261	18,83%	70,23%	B
Group 4	79976	6,18%	76,41%	
Group 5	78270	6,05%	82,46%	
Group 6	67497	5,22%	87,68%	
Group 7	67111	5,19%	92,86%	C
Group 8	36007	2,78%	95,64%	
Group 9	24163	1,87%	97,51%	
Group 10	19343	1,49%	99,01%	
Group 11	12871	0,99%	100,00%	
Total for the period	1293786			

Table 3. ABC profit analysis results (calculated by author based on company reporting)

Product group	Gross profit (UAH)	Profit ratio	Cumulative ratio	ABC Analysis Group
Group 1	1607043,74	24,03%	24,03%	A
Group 2	1544774,42	21,77%	45,79%	
Group 3	768881,32	11,50%	57,29%	B
Group 4	720398,80	10,77%	68,06%	
Group 5	628638,26	9,40%	77,46%	
Group 6	598363,2	8,95%	86,40%	
Group 7	290365,51	4,34%	90,74%	C
Group 8	254011,65	3,80%	94,54%	
Group 9	151818,64	2,27%	96,81%	
Group 10	140214,71	2,10%	98,91%	
Group 11	72991,60	1,09%	100,00%	
Total for the period	6688501,85			

The results of ABC analysis of turnover and profit make it possible to form a consolidated matrix (Table 4).

Table 4. Results of two-dimensional ABC analysis of turnover and profit (built by the author)

ABC analysis of turnover	A	Groups: 1,2	-	-
	B	-	Groups: 3,5,6	Group 4
	C	-	Group 8	Groups: 1,9,10,11
		A	B	C
	ABC Profit Analysis			

From the Table 2 shows that two commodity groups have the largest share in the turnover, namely 51.41%. They form group A.

Product groups that have entered Group B occupy the middle position in terms of turnover for the enterprise and under effective marketing and pricing policies can be developed to class A.

The rest of the product groups (group C) are not selling as well as expected. The reasons may be inadequate price, too narrow range within the group, etc.

According to the algorithm of ABC analysis, the proportion of each product group in the total turnover and profit for the period was calculated, then the product groups were sorted by descending of these particles, after which their cumulative shares were calculated and the groups A, B and C were divided using the double tangent method. For the ABC analysis of turnover they amounted to 60-30-10%, and the profit - 46-41-13%. The results of ABC analyzes of turnover and profit are given in Table 2 and Table 3.

Group AA is formed by groups 1-2. These two groups of products are unambiguous leaders in the product range of the enterprise and require constant and careful accounting and control, as well as analysis of the competitive environment and forecasting demand, to form an adequate stock insurance situation and to prevent inventory shortages.

Group 4 (group BC) bring more turnover to the enterprise than profit, possibly due to a small margin.

Group8 is an outsider in terms of turnover, but provides an average profit for the enterprise. The situation may be altered by the better layout, promotion or expansion of the product line in this product group.

Group BB is formed from commodity groups that are “stable middlemen”. They require routine control and accounting. Last but not least.

Group SS are commodity groups that do not make a significant contribution to the enterprise, both in terms of turnover and profit. Before deciding to remove them from the range, it is necessary to carefully analyze the reasons for this situation. Mechanically excluding them from the product range can lead to an overall decrease in results, as all product groups will then be redistributed according to the ratio of 60-30-10% or 46-41-13%.

The next stage was the XYZ analysis of demand for the products of the studied enterprise. Data from May 2014 to October 2018, inclusive, were used. An extension of time is needed to investigate more closely the dynamics of sales.

The results of the analysis show that if you use the conventional scale (group X = 0-10%, Y = 10-25%, Z> 25%), then no product group falls into group X. This means that all the product groups listed enterprises are characterized by medium and strong fluctuations in demand, which makes forecasting for these groups inappropriate. However, this situation is ambiguous and may be related to the impact of seasonality or trend. In this case, the variation of the data will be large, as evidenced by the high values of the coefficient of variation, as in our case. Therefore,

to test the hypothesis of the influence of seasonal factors, a seasonal decomposition of time series was performed using the classical method of seasonality indices.

A comparison of the results of the XYZ analysis before and after the removal of the seasonal component is given in Table 5 and Table 6.

Table 5. Results of the XYZ analysis to eliminate the seasonal component (calculated by the author on the basis of enterprise reporting data)

Product group	Coefficient of variation, %	XYZ Analysis Group
Group 1	10,10%	Y
Group 2	11,23%	Y
Group 3	14,99%	Y
Group 4	16,70%	Y
Group 5	21,85%	Y
Group 6	22,54%	Y
Group 7	25,98%	Z
Group 8	21,14%	Z
Group 9	28,18%	Z
Group 10	32,25%	Z
Group 11	33,09	Z

Table 6. Results of XYZ analysis after seasonal component elimination (calculated by the author on the basis of enterprise reporting data)

Product group	Coefficient of variation, %	XYZ Analysis Group
Group 1	6,50%	X
Group 2	6,70%	X
Group 3	8,64%	X
Group 4	9,47%	X
Group 5	11,24%	Y
Group 6	17,05%	Y
Group 7	19,73%	Y
Group 8	19,91%	Y
Group 9	21,22%	Y
Group 10	24,01%	Y
Group 11	29,39%	Z

As you can see, after the seasonal decomposition of time series, the situation has changed dramatically. Removing the seasonal component, which is deterministic, we obtained a number of random fluctuations, which were estimated by XYZ analysis.

The coefficients of variation across all product groups decreased significantly. This suggests that our hypothesis about the influence of seasonal factors was correct. If we did not eliminate the seasonal component, we would have made false conclusions about the possibility of forecasting demand for commodity groups, which would lead to wrong actions in the field of inventory management.

The next step was R / S analysis to identify the memory in the rows that reflect the dynamics of product group sales. Today, R/S analysis is the most common method of studying fractal properties of time series. His method is to calculate the Hearst coefficient, the obtained values of which are interpreted as follows:

→ When H = 0.5, the time series are stochastic ("white noise");
→ When 0.5 <H <1, the time series is characterized by persistence, that is, the property of long-term memory ("black noise");
→ When 0 <H <0.5, the time series is characterized by anti-persistence, i.e. the time series changes faster than in the case of a random process ("pink noise").

The calculated values of the Hearst coefficient are given in Table 7.

Table 7. Results of R/S analysis (calculated by the author based on enterprise reporting data)

Product group	Hearst coefficient
Group 1	0,716
Group 2	0,728
Group 3	0,654
Group 4	0,677
Group 5	0,679
Group 6	0,618
Group 7	0,687
Group 8	0,613
Group 9	0,689
Group 10	0,604
Group 11	0,555

Table 7 shows that for all commodity groups, except for biscuit, the value of the Hearst coefficient is greater than 0.5. This indicates that the dynamics of such groups are characterized by persistence (i.e., sustainability), that is, long-term memory. This means that if sales were increasing in the past, then it is likely to continue. At the same time, the higher the Hearst coefficient, the more correlated the values are. The Hearst factor has the highest values in the first two product groups (cookies, crackers and caramel, iris, jelly sweets), which, according to XYZ analysis, are well-predicted.

Similarly, the R/S analysis shows the conformity of product groups, the dynamics of which can be predicted, but worse than in the previous case (the Hearst coefficient of about 0.6), with the group Y by XYZ analysis.

Table 8. The results of the combined ABC-XYZ analysis of the product range DAREX-ENERGO LLC (created by the author)

ABC analysis of turnover	A	X	Group 1	-	-
		Y	Group 2	-	-
		Z	-	-	-
	B	X	-	Group 3	Group 4
		Y	-	Group 5	-
		Z	-	Group 6	-
	C	X	-	-	Group 7
		Y	-	Group 8	Groups 9,10,11
		Z	-	-	-
			A	B	C
	ABC Profit Analysis				

Only commodity group chocolate has a Hearst ratio of about 0.5, which indicates the random nature of the series and the inability to adequately predict its dynamics. XYZ analysis similarly singled out chocolate in the low-predicted group.

Therefore, the results of the R/S analysis and the XYZ analysis after the removal of the seasonal component are completely identical, which proves the feasibility of preliminary transformations of the input data before conducting the XYZ analysis, in particular seasonal decomposition.

The results of ABC (commodity turnover and profit) and XYZ analysis can be conveniently presented as a matrix of combined ABC-XYZ analysis (Table 8).

Based on the results obtained, recommendations were developed for inventory management of the studied enterprise.

AAH, AAY, VVH and VYY groups are offered to keep records of disposal of goods on a daily basis and to maintain stable stocks taking into account the projected amount of consumption in the future and insurance stock, since even the smallest deficit of these groups of goods can undermine the efficiency of the enterprise. At the same time, we must strive to avoid excesses, because the demand for these product groups is stable and well predicted.

Group BB3 with high turnover and profitability has a low sales forecast. This may encourage management to try to ensure that all the goods in this group are in stock by creating excess inventory. However, it can cause an increase in the average inventory of the enterprise, which will lead to higher costs and freezing of funds in the form of inventories. Therefore, the products of this group should analyze the current ordering system. Part of the goods makes sense to use a system of orders with a constant volume of orders. For the second part of the goods, it is advisable to provide a higher frequency of deliveries and increase the frequency of control.

Group CBY, as mentioned above, brings in an average profit for the enterprise, but lags behind. Therefore, it is worth expanding the product range within the group, change the layout and hold promotions. For stocks, it is necessary to switch to a system with a constant amount or volume of orders and to form an insurance stock, based on the financial capacity of the enterprise.

Group BCX is probably undervalued because it sells well, but does not bring the company the desired profit. This group proposes to increase prices and change packaging and packaging. With regard to inventory management, it is recommended that you switch to a regular periodic ordering system and reduce your inventory. The expediency of being present in the assortment of commodity groups forming the SS group should be carefully reviewed. They have a low sales volume and do not bring significant profit to the enterprise.

Therefore, it is worth carrying out various promotions to stimulate demand. As the dynamics of sales of commodity groups can be successfully predicted, it is recommended for CCX and CCY groups to maintain the insurance stock at the existing level or to apply a system of orders with constant periodicity.

Conclusion

Thus, the advanced methodology of integrated ABC-R / S-XYZ-analysis of the range of trading enterprise differs from the existing combined ABC-XYZ-analysis in that it is supplemented by R/S-analysis as a criterion for the efficiency of XYZ-analysis and the indicator of the possibility of forecasting the dynamics of sales of goods groups. It is also suggested to pre-process the data before conducting the XYZ analysis to eliminate the influence of deterministic factors such as seasonality, cyclicality or trend. This transformation of data significantly improves the outcome of the XYZ analysis and allows us to draw more adequate conclusions, which reduces the risks of making incorrect management decisions in the area of assortment policy and inventory management of trade enterprises.

Based on the implementation of integrated ABC-XYZ-analysis of the range of trading enterprise, which allows to structure the product range of the enterprise into groups, taking into account their contribution to the turnover and profit of the enterprise, as well as the possibility of forecasting their demand in future periods, recommendations on optimization of the product range of the studied enterprise and managing its inventory, which will increase the efficiency of the wholesale trading enterprise as a whole.

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