USING OF CLUSTER ANALYSIS METHOD AND BCG MATRIX TO PREDICT THE DEVELOPMENT OF THE AUTOMOTIVE INDUSTRY

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Abstract: *The global automotive industry is an important component of the global economy. Data of statistical observations of the development of the automotive industry allow us to conclude that the global industry recovered from the 2008-2009 crises and resumed growth. By the end of 2016, the volume of registered vehicles increased more than two times in comparison to 1996. It is important to predict the development of the automotive industry in different countries. The principles of Boston consulting group matrix were used for forecasting. The cluster analysis method was used for the objectivity of the assessment in the preparation of the Boston consulting group matrix. The distance between the available objects was calculated using Euclidean distance. The indicators used include the dynamics of the growth in the number of registered vehicles and the share of a particular country in the total volume of registered vehicles. Country grouping of car manufacturers made it possible to divide countries into clusters that reflect the position of countries in the global market of vehicles. The assessment showed an objective division of the whole set of countries into four groups, which are characterized by the following features.*

The first group of countries has a large market share, more than 1 per cent, and a growth rate of more than 4 per cent. The leader of this group is China. The increase in the volume of registered vehicles in 2015 compared to 2014 amounted to 10.36 %. This group includes other countries with significant production volumes of cars, such as India, Indonesia, Iran and Turkey. This group in accordance with the BCG matrix can be attributed to the "stars".

The second group "question" includes 92 countries; their main characteristic is quite high growth rates-more than 2 %, the maximum growth rate in the countries of this group - 18 %. Further development of production in these countries will depend on various factors – demand for automotive products; - attractiveness of production for import, etc.

The third group of countries "money bags" consists of 10 countries with a significant market share, more than 1 %, and a significant growth rate of more than 1.3 %. The leader of this group is the USA, whose share in the total registered vehicles is 20.6 %, and the rate of increase is 2.33 percent.

The fourth group of countries - "dogs" - consists of 27 countries. Their main characteristic is the minimal market share and negative or minimal growth rates. The maximum growth rate does not exceed 2 %. The prospects of this group for the production of vehicles are uncertain, as factors affecting the sale of products - demand and cost of production - do not allow for market growth.

The grouping showed the possibility of using the cluster analysis and matrix of the Boston consulting group (BCG) for forecasting in the market of vehicles.

Key words: *Cluster analysis, matrix of the Boston consulting group, vehicles, forecast.*

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1. INTRODUCTION

The world vehicle population in 2016 amounted to 1.32 billion cars and trucks. This figure is almost twice as high as the world fleet of vehicles, which was achieved 20 years ago - in 1996. This year, the fleet of vehicles amounted to 670 million cars and trucks. At the same time, there has been a trend of doubling the fleet of vehicles every 20 years. So in 1976 the total fleet of vehicles was 343 million cars, the total fleet of cars in the world grew by 4.6% compared to the previous year.

Total sales of vehicles in 2017 amounted to 96.04 million vehicles. This indicator grew by 2.7% compared to a record in 2016. Despite the fact that growth in general was stable, in many countries in 2016 there was a certain decline in growth rates, caused by a decrease in the level of consumer confidence. Currently, there is a tendency to encourage governments to sell electric vehicles, but sales growth is hampered by the lack of an infrastructure for charging cars.

The largest role in the global automotive industry is played by countries such as the United States, China and Japan, which have the largest fleet of vehicles in the world. The motorization index is led by countries such as Puerto Rico, the United States and New Zealand.

Characteristics of the Russian and European market.

The Russian automobile vehicle population in terms of vehicle volume is in fourth place after Japan. This characterizes positively the Russian automobile market and its significant potential. It should also be noted the level of automotive industry of the Russian automotive industry (358 cars per 1,000 people). According to this indicator, the Russian car market is on the 51st place. At the same time, there is a significant market growth potential to the level of the US automotive index at the level of 821 cars per 1,000 people. This allows us to conclude that the maximum growth potential of the automotive market can be up to 56.4%, which makes the Russian market one of the most attractive markets in the world.

Characterizing the Russian automotive industry, it should be noted that after the rapid recovery that was observed at the beginning of the current millennium in Russia, the growth of the automotive market in 2012 slowed down, and in 2013 its stagnation started, which was caused by worsening macroeconomic indicators, which in turn caused decrease in sales of vehicles across Russia. By the end of 2017, sales of vehicles in Russia amounted to about 1.7 million units. At the same time, the volume of sales of vehicles did not exceed the volume of production of vehicles reached in the amount of 1.8 million units.

At the end of 2017, sales volumes declined, while at the end of 2016 this indicator fell to the minimum values reached for the period from 2005-2017, as well as other indicators that characterize the Russian actual gross domestic product, presumably reaching the bottom. It should be noted a positive trend in the growth of the share of domestic brands against the background of a decline in the share of imported cars.

It should be noted that the fact that sales of vehicles around the world increased and amounted to 96.8 million units cars in 2017. The total fleet of vehicles increased by 4.6% in 2016, which indicates a positive trend in the development of the industry for the production of vehicles.

Forecasts in 2016 showed that a possible recovery of the market will begin in 2017. The current change in the sales of Russian cars shows that the forecasts made have found practical

confirmation. Thus, the Russian automotive market shows a positive trend in the growth of sales of vehicles. In accordance with these blowouts, the sales of vehicles are expected to increase to a value of two million vehicles per year and the continuation of this growth in the future.

Assessing the state of the Russian automobile industry as a whole, we can draw the following conclusions. A significant reduction in car sales due to the crisis does not reduce the long-term potential of the Russian automotive market, which is quite high due to the low level of ownership of vehicles and the considerable age of the vehicles in operation.

Among the factors that will determine the pace of recovery of the Russian automotive market, include the price of oil, the ruble rate, the interest rates for credit resources, government support measures and their effectiveness, as well as work to reduce the "cost of operating and owning a car" indicator.

It should be noted that, according to the value of financial resources, the Russian economy lags far behind the developed countries. At the same time, the lowering of the Bank of Russia's key rate, the growth of the business of captive banks owned by automakers, and the gradual recovery of the Russian consumer market will ultimately contribute to the growth of the share of car sales on credit, increasing the growth of the consumer market.

The growth trend of the Russian automotive market corresponds to the growth trend of the European market, which in 2017 continued to grow and reached a relative index of 3.6% and an absolute value of 20.82 million units. Despite positive market growth in previous years, European countries did not achieve sales of 22 million vehicles per year, which was reached before the previous recession. Among the European countries should be allocated to the UK, which achieved a market growth rate of 5.3%, Germany, with a growth rate of 2.7%, and France, which showed growth of 5.1%.

Characteristics of the US and North American market.

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North America is one of the most significant regions for the global automotive industry. Nevertheless, following the results of 2017, this region became the only one in which there was a drop in sales of cars by 1.4%. At the same time, the absolute value of the sales indicator as a result of the decrease reached 21.2 million units of vehicles.

One of the reasons for the decrease in the decline in sales in the US, which was 1.8% compared with the same period in 2016. At the same time, in 2016, the US share in the increase in vehicle volumes worldwide in 2016 was 2.4%. At the same time, the growth rate of vehicles in the US in 2016 was higher than the average value of this indicator for the previous decade, which was 1.2%. It should be noted that in the US, about 4% of the world's population owns a fleet of vehicles, whose share in the total world volume is 21%. The total number of vehicles registered in the US is 271 million pcs. If we talk about relative indicators, then the ratio between the number of people and the volume of vehicles in the US is 1.2 people per vehicle. For this indicator, countries such as Austria (1.4 people per vehicle), New Zealand (1.2 persons / per vehicle) and Luxembourg (1.4

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people / per vehicle) are approaching the United States. Thus, the United States is one of the most important global markets for cars, although it should be noted that its potential for future growth is not very significant.

Despite the decline in car sales in the US, other NAFTA countries show positive dynamics. So the increase in vehicle sales in Mexico was 4.6%, in Canada, sales increased by 4.7%, the first time reaching 2 million units of vehicles per year.

Characteristics of the market of Southeast Asia and China.

As for South-East Asia, in general, this region shows significant growth. Also this region is of great importance for the modern world automotive industry. The greatest influence on the market of southeast Asia is provided by China, which ranks second among the countries that produce cars in terms of the fleet in operation. After an impressive sales growth of 14.4% in the national car market in 2016, the growth in sales in 2017 did not become so impressive and amounted to 3%. The volume of sales of vehicles amounted to 28.88 million units vehicles compared with 28 million units in 2016. At the same time sales of SUVs (SUVs) increased, and cars and crossovers (CUV) decreased. The reason for this is that the Chinese government has set strict environmental standards to improve the environmental situation, the use of which implies the disposal of several million physically and morally obsolete cars per year. Given this in 2016, there was a significant growth potential of the Chinese market. So basically Chinese

car buyers are forced to buy new cars. At the same time, the choice of cars offered in the Chinese market is quite large - the buyer is offered more than 500 models available in the market in a wide price range. This program operated in 2016, so a significant number of probable purchases in 2017 were carried out over the past year, which caused cooling in the Chinese market. It should be noted that China's share in the total volume of vehicles is growing rapidly enough in 2016 (increased from 12.8% in 2016 to 194 million cars and trucks). It should be noted that by the number of vehicles, China has not yet reached the US indicator. Nevertheless, the growth rates of registered vehicles in China are striking. For six years the growth rate of the fleet amounted to 100 million units vehicles per year. In 2016, sales of vehicles amounted to 28 million unit's vehicle, which in absolute terms corresponds to the fleet of vehicles in China in 2004. At the same time, China has significant potential for growth. The indicator of the provision of vehicles is 7.1 inhabitants per vehicle, which shows China's lag behind the developed countries.

Government stimulation of sales of cars on alternative fuel made China one of the main operators of these cars after Norway. The growth in sales volumes by the end of 2017 was 53%. The increase in sales of cars on alternative fuel was affected by measures to discourage sales of cars on traditional fuel, based on high payments for vehicle registration. At the same time, registration of a vehicle using alternative energy sources is free of charge.

Another largest manufacturer and operator of vehicles - Japan increased sales by the end of 2017 by 5.3%. In absolute terms, sales volume amounted to 5, 23 million units of vehicles per year. The volume of vehicles registered in Japan amounted to 76 million units. Compared to 2015, this indicator grew by 0.4%. In terms of registered vehicles, Japan ranks third after China, which surpassed Japan in 2010. The level of motorization in Japan is quite high - 1.7 people per vehicle. However, such negative factors as population aging and low birth rate can impede the growth of the fleet of vehicles regardless of the economic situation in the country, as well as a certain phase of the economic cycle.

Sales of vehicles in India grew by 9.5%. The absolute indicator, which characterizes the sales of vehicles, was 4.06 million units of vehicles in 2017. At the same time, the relative growth rates for the results of 2016 amounted to 7.1%. It should be noted that tax reform is currently underway in India, which in the long term will ensure economic growth, but at the first stages of its implementation may have negative consequences for the development of the economy. Nevertheless, sales of new vehicles in India have reached a new record of 4 million vehicles per year.

The level of motorization in India is quite low - 28.8 people per vehicle. At the same time, the total fleet of vehicles in India is 46 million pieces, which roughly corresponds to the fleet of vehicles in Germany, whose population is 16 times smaller. The dynamics of the park's change shows that the total volume of vehicles in India is growing by an average of 11% over a ten-year period. For comparison, the average growth rate of a car park in Germany is 1.2%. One of the few countries in South-East Asia that showed a decline was South Korea, where sales fell by 1.8% to 1.79 million vehicles a year. A possible reason for this is the preparation of the country for the Winter Olympic Games.

Among the Southeast Asian countries should also highlight the increase in sales of cars in countries such as the Philippines and Thailand, sales growth of which amounted to 15.7% and 13.4% respectively.

Description of the market of South America.

Most countries in South America, like India, have a small amount of vehicles per inhabitant of the country. This predetermines the future potential growth of sales in these countries. For example, in Brazil, which has the largest fleet of cars in the amount of 43 million vehicles, the vehicle security indicator is 4.9 people per vehicle. Despite the fact that in 2016 the countries of South America in terms of total sales showed a 10-year low, in 2017 the automotive market grew by 12.7%. In the case of the country, the sales of cars in Brazil grew by 9.2% and reached 2.24 million vehicles a year. Thus, Brazil was able to reverse the situation in which the growth of the fleet of vehicles in 2016 was less than one percent (+ 0.8%), and returned to the "shock" growth rate, which averaged 6.1% per year. One of the reasons for this is a reduction in interest rates, which allowed for growth against the backdrop of deferred sales in previous years. The leaders of growth among the countries of South America were Argentina and Chile in 2017, which achieved growth in relative terms of 27 and 17.9 percent, respectively. The absolute values of sales in Argentina were 0.89 million units and 0.37 million units of vehicles. It should be noted that the rapid growth of the automotive market continues from last year. So in Chile, which registered only 5 million vehicles, in 2016 there was a significant increase in the fleet of vehicles, which in relative terms was 15.4%. Despite the growth in sales of vehicles in general in South America in a number of countries, there is a significant drop in sales. So car sales in Venezuela almost stopped as a result of the economic crisis, and in Colombia in relative terms they decreased by 6.1%.

The aim of such a group is to identify, on the basis of the grouping, generalized groups of countries with similar characteristics. Such a grouping will allow not only to more accurately characterize the characteristics of a particular group, but also to form a forecast for the change in the state of the country and its transition from one group to another.

2. METHODS

Our studies [2], [3] have shown that for such a grouping it is advisable to use a matrix proposed by the Boston consulting group. The scheme for using the matrix of the Boston consulting group is quite simple: on the horizontal axis X, the market share of the economic entity is deferred, and the horizontal indicator Y reflects the indicator "growth rate of market share."

The received groups of economic subjects can be divided into four conditional groups of stars, cash bags, questions, dogs. This matrix can also be transformed for the purposes of assessing countries in terms of the degree of development in them of the production of vehicles and other indicators. Given the lack of an open access to complete data on the number of registered vehicles by country in 2016, the data of the World Organization of Automobile Manufacturers (OICA) [4] for 2015 are used for analysis. The existing matrix of the Boston consulting group will be changed as follows: the X axis will be used to reflect the data on the country's share in the global volume of vehicle registration, along the Y-axis; we will reflect the data on the growth rates of the share of each producer country.

The resulting groups will be characterized as follows: "star" - a group of countries with high growth rates, while occupying a significant share in the volume of registered vehicles. The "money bag" is a group of countries that occupy a significant market share and at the same time the market growth rates are insignificant. To the "dogs" group we will refer countries with a small market share and low growth rates of the market. "Question mark" is a group of countries whose market share is insignificant, but the growth rates, which are quite high. To improve the

objectivity of the assessment in the process of preparing the matrix of the Boston Consulting Group, we apply methodological approaches known as cluster analysis, which is a method for grouping the obtained multidimensional observations and objects by calculating the distances between the objects obtained with further redistribution of observational groups (clusters and taxa). To determine the distances between existing objects, the formula for the Euclidean distance is calculated by the formula (1):

$$r_w(y_i, y_j) = \sqrt{(y_i^{1,2,\dots,n} - y_j^{1,2,\dots,n})^2} \; , \qquad (1)$$

where $y_i^{1,2,\dots,n}$ and $y_j^{1,2,\dots,n}$ are the actual parameters of the parameters showing the position of the objects y_i and y_j. The groups will be selected using the "nearest neighbor" method, as well as to increase the information content and accuracy of the classification of indicators that assess the state of the automotive industry of a specific country.

As indicators we will use indicators that characterize the country from the point of view of development of the dynamics of growth in the number of registered vehicles and the share of a particular country in the total volume of registered vehicles.

3. RESULTS

The carried out grouping of countries - car manufacturers allowed to get a clear breakdown of countries into clusters, allowing revealing the positions of countries in the world market of vehicles.

The carried out grouping of countries - car manufacturers allowed to get a clear breakdown of countries into clusters, allowing revealing the positions of countries in the world market of vehicles.

The first group of countries - "stars" is characterized by a significant market share, more than 1% and growth rates of more than 4%. The first group includes countries such as China, India, Turkey, Indonesia, Iran, Malaysia, Thailand, Mexico, and South Korea. The leader of this group is China. The increase in the volume of registered vehicles in 2015 compared with 2014 was 10.36%. This group is characterized by high growth rates, while it occupies a relatively large market share. It should be noted that the countries of this group are quite large car manufacturers. So the volume of production of vehicles by China according to the International Organization of Automobile Manufacturers (OICA) was 28,118,794 vehicles in 2016. According to this indicator, China is the leader of the world automotive industry. Other manufacturers are also quite large car manufacturers. For example, India produced 4,488,965 units in 2016 vehicles per year. The volume of production of cars by other countries amounted to at least 1 million units vehicles per year; such countries include Indonesia, Iran, Turkey, etc. This group is characterized by a rather large volume of domestic demand for automotive products. This makes the country's data attractive for the development of production of vehicles in the territory of the country. Concerning the forecast of development of the automobile market, and manufacture in the given countries it is possible to draw the following conclusion: these countries will be leaders on sales and manufacture of vehicles. In the future, their positions will increase significantly. Concerning such countries as India, Turkey, Indonesia, Iran, Malaysia, Thailand, Mexico, it can be assumed that the motor vehicle market has significantly accelerated, due to the relatively low level of automatization of these countries. With the growth of the market and the associated slowdown in the growth rates of sales and production, the

countries of this group will move to the third group of "money bag" with a change in basic characteristics.

The second group of countries is a "question mark", it unites 92 countries. Among these countries, including: Egypt, Panama, Georgia, Syria, Uruguay, Pakistan, Iraq, Albania, Mozambique, Vietnam, and Austria. The main characteristic of these countries is the following: quite high growth rates - more than 2%, the maximum growth rate for the countries of this group of Belize with a growth rate of 18%. At the same time, the market share of these countries is insignificant. Given this, the countries in this group have sufficient development potential, especially given that the level of motorization in most of these countries is very low. However, most of these countries have a significant population, for example, Egypt and Iraq. Further development of production and sales of cars in these countries is in question and will depend on various factors: - demand for motor vehicles; - the attractiveness of production for imports, etc. An important factor ensuring the development of the automotive industry and the automotive market for most countries will be the development of the economy and the growth of incomes of the population. As the country develops, these groups will fall into the group of 1 "stars" or in group 4 "dogs" with a change in the corresponding characteristics.

The third group of countries consists of 10 countries, including: Poland, Great Britain, Argentina, USA, Brazil, Australia, Russia, Germany, Spain, Canada, and Japan. This group is characterized by a significant market share (over 1%), as well as significant growth rates (more than 1.3%). The leader of this group is the United States whose share in the total volume of registered vehicles is 20.6%, and the growth rate is 2.33%. It should be noted that factors affecting sales in these countries are moderately positive, which provides an increase in sales in these countries. These countries also include Russia, with a share in the total world registration volume of 4% and a growth rate of vehicle volumes of 1.67%. At the same time, growth in vehicle registration is taking place against the background of the financial crisis in Russia. This suggests that Russia has a significant growth potential in the production of vehicles. With the successful development of the Russian economy, Russia can move from the third group to the first "star" group. At the same time, the development of negative social and economic processes in the Russian economy can lead to the transition of Russia to the "dog" group.

The fourth group of "dog" countries consists of 27 countries, including: Puerto Rico, Finland, Afghanistan, Ukraine, Bangladesh, Singapore, Kazakhstan, Greece, and Bermuda. The main characteristic of these countries is the minimal market share and negative or minimal growth rates. The maximum growth rate does not exceed 2%. The prospects for this group in terms of production of vehicles are ambiguous, since the factors affecting sales of products - demand and cost of production do not allow for the growth of the market. The forecast for the countries of this group is negative. Positive shifts may be noted if the countries of this group implement a pre-term program to stimulate the automotive industry. Otherwise, the growth of the automotive industry and the automotive market in these countries is unlikely.

Summing up the results of the conducted research, it is possible to draw a conclusion about the possibility of using methods and methods of cluster analysis and matrix of the Boston consulting group for the purposes of forecasting in the market of vehicles.

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