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Savych O.
Doctor of Economics,
Kyiv National Economic University named after Vadym Hetman, Ukraine;
e-mail: savych@kneu.edu.ua; ORCID ID: 0000-0001-5934-9002
Molchanova E.
Ph. D. in Economics, Associate Proffesor,
Kyiv National Economic University named after Vadym Hetman, Ukraine;
e-mail: ellanam@ukr.net; ORCID ID: 0000-0001-8043-1916

MODELLING OF GLOBAL CAR MARKET DEVELOPMENT
UNDER GLOBALIZATION IMPACT

Abstract. The aim of the article is to construct a model for the development of the market of passenger cars taking into account global impact, macroeconomics and marketing factors that enables automotive companies planning sales volumes, identifying potential markets for operational and efficient investments. The global processes as well as limitation in accessing to natural resources and their value increase, society digitalization, enforcement of competition and governmental regulations, all of them are key factors of car industry developments which have to be taken into account in the process of cars' producers marketing activity. Another important impact factor is innovations as a basic pillar of enterprises' competitiveness, which is functioning on the market. Therefore, the need in traditional approaches changes to marketing management under conditions of global changes in economy is very important for enterprises' on car market, which are creating higher value for clients and moreover in long-term prospective such enterprises will have strong market positions. The results of research define main significant factors influencing sales on the global automotive market. Quantative model that has been developed, will allow to effectively plan the marketing activity of enterprises both on the global market and on their regional clusters. Furtemore, the research helps automotive manufactores with the entry market and efficient investments desisisions. The methodology of the quantative forecast measurament of cars' sales both on global and its regional clusters is based on retrospective sales analysis and main quantitive impact factors. The quantitative model has been checked by real sales data under retrospective figures that confirms its real practical ability.

Keywords: car market indicators, cars sales, globalization, modelling, motorization, forecast.

JEL Classification L62, M31

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Савич О. П.
доктор економічних наук,
Київський націаональний економічний університет імені Вадима Гетьмана, Україна;
e-mail: savych@kneu.edu.ua; ORCID ID: 0000-0001-5934-9002
Молчанова Е. Ю.
кандидат економічних наук, доцент,
Київський націаональний економічний університет імені Вадима Гетьмана, Україна;
e-mail: ellanam@ukr.net; ORCID ID: 0000-0001-8043-1916

МОДЕЛЮВАННЯ РОЗВИТКУ ГЛОБАЛЬНОГО РИНКУ ЛЕГКОВИХ АВТОМОБІЛІВ
ПІД ВПЛИВОМ ГЛОБАЛІЗАЦІЇ

Анотація. Ціллю статті є побудова моделі розвитку ринку легкових автомбілів, ураховуючи фактори глобального впливу, макроекономічні і маркетингові показники, які дозволяють автомобільним компаніям планувати обсяги продажу, визначати потенційні ринки для оперативної діяльності та ефективного інвестування. Глобальні процеси, а також лімітовані природні ресурси та їхня постійно зростаюча вартість, диджитилізація

суспільства, посилення конкуренції та урядових регуляцій,— це все є основними факторами розвитку автомобільної промисловості, які потрібно враховувати у процесі маркетингової діяльності автомобільних виробників. Іншим важливим чинником впливу розвитку ринку є інновації як основний фактор конкурентоспроможності компаній. Тому постає потреба в змінах традиційних підходів до управління маркетинговою діяльністю під впливом глобальних змін в економіці, що є дуже важливим для компаній на автомобільному ринку, направлених на створення високих цінностей для клієнтів і посилення позицій компаній у довготерміновій перспективі. Результати дослідження полягають у визначенні найважливіших факторів впливу на продажі глобального ринку автомобілів. Кількісна модель забезпечує ефективне планування маркетингової діяльності компаній як на глобальному ринку, так і на його регіональних кластерах. Більше того, дослідження допомагає автомобільним виробникам ухвалювати рішення щодо виходу на той або інший регіональний ринок та приймати виважені інвестиційні рішення. Методологія кількісного прогнозу виміру потенційних продаж автомобілів як на глобальному, так і регіональних ринках базується на ретроспективному аналізі як продажів, так і у кількісному вираженні основних факторів впливу на нього. Побудована кількісна модель була перевірена на реальній ретроспективній статистиці продажів, що підтверджує її дієздатність у практичній площині.

Ключові слова: показники автомобільного ринку, продажі автомобілів, глобалізація, моделювання, моторизація, прогноз.

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Савич А. П.
доктор экономических наук,
Киевский национальный экономический университет имени Вадима Гетьмана, Украина;
e-mail: savych@kneu.edu.ua; ORCID ID: 0000-0001-5934-9002
Молчанова Э. Ю.
кандидат экономических наук, доцент,
Киевский национальный экономический университет имени Вадима Гетьмана, Украина;
e-mail: ellanam@ukr.net; ORCID ID: 0000-0001-8043-1916

МОДЕЛЕЛИРОВАНИЕ РАЗВИТИЯ ГЛОБАЛЬНОГО РЫНКА ЛЕГКОВЫХ АВТОМОБИЛЕЙ ПОД ВЛИЯНИЕМ ГЛОБАЛИЗАЦИИ

Анотация. Целлю статьи является построение модели развития рынка легковых автомобилей, учитывая факторы глобального влияния, макроэкономические и маркетинговые показатели, которые позволяют автомобильным компаниям планировать обьемы продаж, определять потенциальные рынки для оперативной деятельности и эффективного инвестирования. Результаты исследования заключаются в определении наиболее важных факторах влияния на продажи глобального рынка легковых атвомобилей. Количественная модель обеспечивает эффективное планирование маркетинговой деятельности компаний как на глобальном рынке, так и на его региональных кластерах. Более того, исследование позволяет автомобильным производителям принимать решения о целесообразности выхода на тот или другой региональный рынок и принимать взвешенные инвестиционные решения. Построеная количественная модель была проверена на реальной ретроспективной статистике продаж, что подтверждает ее дееспособность в практической плоскости.

Ключевые слова: показатели автомобильного рынка, продажи автомобилей, глобализация, моделирование, моторизация, прогноз.

Формул: 2; рис.: 1; табл.: 2; библ.: 21.

1. Introduction. Studying marketing activities of companies in the passenger car market and the prospects for their effective functioning is one of the important components of the

development of modern business, which can not be successfully carried out without studying world experience. It's necessary to take into account globalization processes, restrictions in access to and increase in prices of natural resources, society digitalization, strengthening of competition and state regulations, which are the key factors influencing the world automotive industry development. Another important impact factor is innovations as a basic pillar of enterprises' competitiveness, which is functioning on the market. Therefore, the need in traditional approaches changes to marketing management under conditions of global changes in economy is very important for enterprises' on car market, which are creating higher value for clients and moreover in long-term prospective such enterprises will have strong market positions.

From the point of marketing, the modern global car market is the important part of the world economy, that is characterized by the complex system of commercial relations as well as there is the necessity of plenty market subjects' quantity actions and their interests' synchronization. Moreover, the supply and demand fluctuating on this market can lead to economic crisis and slow down global economy development.

The purpose of the article is to identify the world economy component, which is characterized by a complex system of commercial communications in the global market for passenger cars, as well as the need to coordinate the actions of a large number of economic entities and their economic interests. The object of the research is the processes of ensuring the effective management of the marketing activities of car manufacturers in the market of cars in the conditions of globalization changes in the economy.

The practical and theoretical value of the research is the proposed methodological principles and methodical approach to increasing the competitiveness of the automobile industry through the systematic use of the marketing complex in the interconnection and interdependence of the trends of the development of national and international markets for automobile.

2. Literature review and the problem statement. There is a need to explore the peculiarities of industrial enterprises marketing activities management in the automotive market. From a marketing standpoint, the modern global car market is an important component of the world economy, which is characterized by a complex system of commercial communications, as well as the need to coordinate the actions of a large number of business entities and their economic interests. Fluctuations in demand and supply in this market can provoke economic crises and can slow down the development of the world economy. So we need to change traditional approaches to managing marketing activities in the face of globalization changes in the economy is essential for companies in the automotive market, which create a higher value for customers, and in the long run will have significant market positions. To do this, we need to plan our own sales in the long run, as well as forecast possible scenarios for market development. This will allow automakers to more effectively distribute their efforts, marketing budgets and avoid investing in times of crisis in the market and in the economy as a whole.

The researches of enterprises' marketing activity on global car market and its efficient functioning is one of important part of the modern business development, that is impossible to run successfully without world experience studying. So, adopting of national car markets development to world economy global conditions is one of the main tasks of car producers' marketing researches. In addition, the global processes as well as limitation in accessing to natural resources and their value increase, society digitalization, enforcement of competition and governmental regulations, all of them are key factors of car industry developments which have to be taken into account in the process of cars' producers marketing activity. Therefore, the need in traditional approaches changes to marketing management under conditions of global changes in economy is very important for enterprises' on car market, which are creating higher value for clients and moreover in long-term prospective such enterprises will have strong market positions.

Thus, G. Assel (Assel, 1999) prospected company strategies as the main method of influencing buyers in specific markets and planning the activities of the companies in terms of their use of strategies in specific markets. At the same time, P. Kotler (Kotler, 2012) determined the target markets of the enterprise depending on the purchasing power of the buyers, and V.P.

Pylypchuk (Pylypchuk, 2011), believed that only push-sales formed the potential of markets. K.Hoffman (Hoffman, 2010) and P. Barden (Barden 2013) argued that effective branding and service marketing could create additional market demand in the future, and D. Kennedy (Kennedy 2015) and J. Konrath (Konrath, 2012) tried to model market development based on the human factor as the main driver of the impact on the sale of goods in a global environment. However, despite the significant contribution of these scholars to the development of the theory of marketing management by industrial companies, insufficient attention is given to questions and problems of modeling of global car market development under globalization impact.

3. Research results. The theoretical and methodological basis of the study were the following techniques, such as expert judgment analysis (for assessing the effectiveness of management, analysis of marketing activities, and determining the competitive positions of the company); sociological research (in the process of questioning specialists in order to form competitive marketing strategies for autoproduces); comparison, economic analysis (to determine the effectiveness of marketing activities of autoproduces); economic-mathematical modeling (for predicting capacity of the car market); cluster analysis (to determine consumer preferences and effectiveness of marketing tools). For the effective use of these techniques, statistical data from 2006 to 2018 was used. All predicted data was built from 2007 to 2019. Data for 2018 on sales volumes is left without analysis in order to compare the result of calculating using the model with real data that was not taken into account when constructing it. The following methods were outlined in the basic scientific methods: systematic approach, synthesis, abstraction and modeling.

The methodology of sales volumes measuring within global market and its regional parts taking into account marketing factors impact that differs from existing methodologies in markets' clusterization and definition of key impact factors at cars' sales volumes in forecasted prospect, that, in its turn, allows efficient marketing budget spending of cars' producers has been offered by authors.

In our research we modofied the methodology for calculating the potential volume of the automobile market. We used the current level of motorization index in Eastern Europe, Europe, Asia and the world, as well as the corresponding population and dynamics, which allows more reasonably to develop marketing strategies and make strategic marketing decisions at the level a diferrent producing company.

First of all we identified patterns of certain factors' impact on the cars sales on world markets in order to obtain the possibility of forecasting sales volumes in the future. To achieve this goal, we propose to use a statistical selection for the following group of indicators: market («Car Sales», «Car Park», «Motorization»), demographic («Population», «Urbanization»), infrastructure («Major Roads Length», «Retail fuel cost (average for gasoline and diesel fuel)», macroeconomic («GDP», «Inflation», «Unemployment», «Population expenditures, consumption»), marketing («Annual Average Sold Car Price», «Average Fuel Consumption of Car Sold», «Average Cost of Sold Car Operation», «Car Manufacturer Localization in the Region», «Young generation as the largest consumer in the share of all consumers in the region», «The consumer's advantage in relation to compactness, safety, design, ecology, assortment, premium status, car efficiency in the region»,»The impact of the price and cost of ownership on the sale in the region», the efficiency of personal sales, online sales, coverage of the region, events, digital advertising, mass media, TV and radio advertising, family and friends' recommendations, motivations and qualifications of sellers by countries' clusters), world and regional indicators, clusters (cluster of the former CIS countries, the European Union, North American Free Trade Area (NAFTA), South America, Asia, Africa). These figures, according to our research, on the one hand characterize the world car market, and on the other influence its development (Boston Consulting Group, 2018; Focus to move, 2018; Deloite, 2017; World GDP…, 2019; World motorization…, 2017; World sales…, 2018).

Next year «Car Sales» indicator was defined as efficient one (Y). When forecasting cars' sales volumes it is necessary to select the factors that have the greatest influence, and build the corresponding economic-mathematical model on this basis. In modelling, we propose the use of a step-by-step regression method to determine the best subset of regressors for explanation of Y, which makes it possible to use a step-by-step procedure with sequential exclusion of variables in the

regression equation. When constructing mathematical models, it's necessary to provide such a number of observations that will exceed the number of parameters of these models. If the number of model parameters is less than the selection size, the model tries to most accurately reproduce the given data set. In the extreme case, when the number of model parameters is equal to the number of selection elements, the model will be able to accurately reproduce all data. With further increase in the number of parameters of the model, the possibility of error in reproduction of observations in the selection will equal zero. The deviation of the model's forecast from real values will not help to identify the patterns. To avoid such a phenomenon, it will be sufficient that the volume of the statistical selection was one observation greater than the number of parameters of the economic-mathematical model (Assel, 1999).

The study contains a selection of 14 indicators (Tabl. 1). Given the limited selection size (9 observations), we need to significantly reduce the list of input factors of the model. The final list of factors will be selected on the basis of the F-criterion, which is a statistical characteristic of assessing the significance of the explanation of the resulting variable by the input indicators. We will analyze the influence of variables on the «Car Sales» indicator, with further selection of the most important ones.

Table 1

Correlation of «Car Sales» with the corresponding index with a year lag

Indicators	World Total	CIS	EU	Asia
Car Park, thousands units	0,9	-0,6	-0,6	0,9
Motorization, Quantity of cars per 1000 of population	0,9	-0,5	-0,3	0,9
Population, number of people	0,9	-0,6	-0,8	0,9
Urbanization, %	0,9	-0,6	-0,7	0,9
Major Roads Length, km	0,9	-0,6	-0,6	0,9
Retail fuel cost (average for gasoline and diesel fuel), USD	0,2	0,3	-0,7	-0,5
GDP, USD	0,9	-0,1	0,3	0,9
Inflation, %	-0,8	-0,6	0,3	0,4
Unemployment, %	0,4	-0,6	-0,6	-0,3
Population expenditures, consumption, % of change	-0,1	0,7	0,6	-0,1
Annual Average Sold Car Price, USD	0,7	0,01	-0,1	0,3
Average Fuel Consumption of Car Sold, liters per 100 km	-0,9	0,5	0,6	-0,9
Average Cost of Sold Car Operation, USD	0,9	0,6	-0,7	0,5
GDP per capita, USD	0,9	0,1	0,9	0,9
Car Sales, it	0,9	0,3	0,7	0,9

Correlation coefficients between all of the indicators and the volume of Car Sales listed in Table 1 are paired (Y) with respect to all the indicators given by countries / markets. In addition, most correlation coefficients for «Car Sales» in the Asia, as opposed to others, are close to +1 and are closer to the correlation of these indicators in the world. This can be explained by paying attention to the initial values of the explanatory variables. The Asian region has been developing dynamically over the past 10 years, showing a positive trend towards the growth of all groups of economic indicators (World sales…, 2018). And the correlation coefficient is calculated as the sum of the multiplications of the subtractions of values of the studied indicators at the same moment of time from their average over the analyzed time interval, normalized to the multiplication of standard deviations. If both indicators are constantly increasing, then, at first, the subtractions of their values from their averages is negative (and their multiplication is positive), and then they become positive (as well as their multiplication). The sum of such subtractions' multiplication, adjusted for the multiplication of the mean square deviations, becomes a positive number approaching +1.

The analysis of the individual indicators' correlations on a regional basis with the resulting variable «Car Park» has a very high correlation coefficient with the indicator «Car Sales».

Especially in Asia, where there is a simultaneous growth of both these indicators. In Europe and in the clusters of the former CIS countries, the volumes of Car Parks continue to grow, however, sales of new cars are substantially reduced. If in Europe this reduction is due to the saturation of the market, then in the cluster of the former CIS countries, most likely, a decrease in solvent demand is due to falling rates of national currencies and lower real incomes.

Note that the coefficient of pair correlation indicates the power of the linear relation between the two indicators (Tabl. 2).

Table 2

Coefficients of pair correlation between variables in the world in general

Variables	Car Park	Motorization	Population	Urbanization	Major Roads Length	Retail Fuel Cost	GDP	Inflation	Unemployment	Population expenditures, consumption	Annual Average Sold Car Price	Average Fuel Consumption of Car Sold	Average Cost of Sold Car Operation,	GDP per capita	Car Sales
Car Park	1,0	0,9	0,9	0,9	0,9	0,2	0,9	-0,7	0,3	-0,2	0,7	-0,9	0,9	0,9	0,9
Motorization	0,9	1,0	0,9	0,9	0,9	0,1	0,9	-0,7	0,4	-0,2	0,7	-0,9	0,9	0,8	0,9
Population	0,9	0,9	1,0	0,9	0,9	0,2	0,9	-0,7	0,4	-0,2	0,7	-0,9	0,9	0,9	0,9
Urbanization	0,9	0,9	0,9	1,0	0,9	0,1	0,9	-0,7	0,4	-0,3	0,6	-0,9	0,9	0,9	0,9
Major Roads Length	0,9	0,9	0,9	0,9	1,0	0,1	0,9	-0,7	0,3	-0,1	0,8	-0,9	0,9	0,9	0,9
Retail Fuel Cost	0,2	0,1	0,2	0,1	0,0	1,0	0,5	0,4	0,1	0,2	-0,0	-0,2	0,3	0,5	0,3
GDP	0,9	0,9	0,9	0,9	0,9	0,5	1,0	-0,5	0,3	-0,1	0,6	-0,9	0,9	0,9	0,9
Inflation	-0,7	-0,7	-0,7	-0,7	-0,7	0,3	-0,5	1,0	-0,5	0,3	-0,4	0,8	-0,7	-0,4	-0,7
Unemployment	0,3	0,4	0,4	0,3	0,3	0,1	0,3	-0,5	1,0	-0,5	-0,2	-0,4	0,4	0,3	0,3
Population expenditures, consumption	-0,2	-0,2	-0,2	-0,3	-0,1	0,2	-0,1	0,4	-0,5	1,0	0,5	0,2	-0,2	-0,1	0,0
Annual Average Sold Car Price	0,7	0,7	0,7	0,6	0,8	-0,0	0,6	-0,4	-0,2	0,5	1,0	-0,6	0,6	0,6	0,8
Average Fuel Consumption of Car Sold	-0,9	-0,9	-0,9	-0,9	-0,9	-0,2	-0,9	0,8	-0,4	0,2	-0,6	1,0	-0,9	-0,9	-0,9
Average Cost of Sold Car Operation	0,9	0,9	0,9	0,9	0,9	0,3	0,9	-0,7	0,4	-0,2	0,6	-0,9	1,0	0,9	0,9
GDP per capita	0,9	0,8	0,9	0,9	0,8	0,5	0,9	-0,4	0,3	-0,1	0,6	-0,9	0,9	1,0	0,9
Car Sales	0,9	0,9	0,9	0,9	0,9	0,3	0,9	-0,7	0,3	0,0	0,8	-0,9	0,9	0,9	1,0

That is, with a positive correlation with the growth of one indicator, the second one increases, and in the case of negative— it will decrease, but only in the case of a common normal distribution of random variables. T-statistics, distributed according to the Student's law, with n-2 degrees of freedom and Fischer (F-criterion) are used to test the hypothesis of zero-equality of the pair correlation coefficient. Determination coefficient (denoted as R^2 — R-square) is a statistic indicator used in statistical models as a measure of the dependence of the variation of a dependent variable on the variation of independent variables, indicating how the observations confirm the model. For a pair coefficient of correlation, the critical value of t-statistics is calculated initially, and later on the basis of it the critical value of the correlation coefficient is calculated. If the calculated value is more than critical, then the hypothesis about the zero equality of this correlation coefficient is denied at the appropriate probability level. Similar conclusions are made when checking the

significance of partial correlation coefficients. Since in our task the explanatory variables for the year precede the effective indicator, then by their change we can draw conclusions, whether to expect increase or decrease in the volume of car sales the next year. And the closer the value of the correlation to unit by module (up to ± 1), the greater the confidence of the correctness of such a forecast. If the value of the correlation coefficient is close to zero, then there is no linear relation between these two indicators. So, when constructing a model, our task will be to select the variables that have the most correlation in module with the indicator «Car Sales» and provide the significance for the F-criterion and the highest accuracy of prediction in the test selection.

When selecting the factors for the model, it is important to ensure their logic in explaining the resulting indicator. That is, with the growth of the population, the demand for cars in the unchanged conditions should increase. For Europe and the countries of the former CIS countries cluster, there is a reverse situation: the population is increasing, and car sales are reducing. It is clear that the causes are different (in Europe it is due to the over-saturation of traffic, the increase in the cost of owning vehicles and the efficient development of public transport, and in the CIS cluster — due to the decline in real incomes), the correlation between population and the volume of car sales is negative. It is better not to include such controversial factors to the model of forecasting the «Car Sales» indicator.

The last line in Table 1 contains coefficients of autocorrelation of the «Car Sales» indicator. The coefficient of autocorrelation is calculated through the data of dynamics series, when the actual levels of one series are considered as the value of the factor's characteristic, and the levels of the same series with the shift in one period are taken as a resulting feature. The deviation of the actual levels from the trend is defined, which characterizes the main trend of each row of dynamics. The question of the feasibility of using this indicator, as well as other variables from the Table 1, in one or another model for forecasting the volume of sales of cars for each of the selected regions or the world in general will be solved separately in the process of their further construction.

Table 2 provides a pair correlation between market variables of world indicators, which will serve as the basis for constructing a model. Linear regression serves as a basis for the construction of economical and mathematical models of forecasting the volume of cars sales, due to the simplicity of construction and the transparency of the interpretation of the results (the positivity/negativity and the value of the pair coefficient in the variable can be used to drive conclusions as to its effect on the resultant indicator). The analytical form of the linear regression record looks as follows:

$$Y = a_0 + a_1 \cdot X_1 + \ldots + a_n \cdot X_n, \tag{1}$$

where Y is the value of «Car Sales» indicator;

X_i is the value of i-factor a year prior to forecasted variable;

a_i is linear regressional dependence parameters;

a_0 is the equation paremeter, constant.

The essence of constructing a linear regression is to find its parameters a_i, $i = \overline{0,n}$, which, on the basis of the vector of input variables {X1, ..., Xn}, will allow the output to be obtained as close as possible to the corresponding real value of the resulting parameter Y. The search for the parameters of the model is based on a standard procedure based on least squares method. In order to obtain the most effective model for forecasting car sales in the world and in a particular region, it is necessary first of all to determine the list of input factors, to optimize the parameters of the model and to evaluate its adequacy according to the F-criterion and test data.

From the full list of explanatory variables, we should select the variables with the highest degree of linear relation with the indicator of «sales next year» (see Table 1) In the process of selection of input factors for the model, it is important to avoid the phenomena of multicollinearity. The result of multicollinearity is a significant decrease in the accuracy and stability of the results of calculations, increase in the variance of the estimates of parameters, increase in the sensitivity of the parameters to the volumes of statistical selection, shifting of parameters and erosion of the content of the model in general (Nakonechny, 2005). Accordingly, in the process of selection of factors to the model it is necessary to ensure a minimum level of correlation between them.

We will construct a regression model for forecasting the volume of car sales in the world in general, in accordance with the above-mentioned provisions, subject to the conditions for the absence of multicollinerarity. We will calculate the correlation matrix for all variables for the world in general (see Table 2). Note that the coefficients of pairwise correlation between all variables given in Table 2, are auxillary when constructing a model for car sales forecast. At the start, the model will select the factors that have the greatest impact on the output variable «Car Sales», on which conclusions can be drawn based on the data of the Table 1.

From the list of explanatory variables model forecasting car sales in the world, the indicators «Retail fuel cost (average for gasoline and diesel fuel)» and «Population expenditures, consumption» were removed. However, among the remaining variables, ten have a correlation coefficient with a resulting index of about one. In addition, they are highly correlated with each other. This means that, with the involvement of any of them, virtually all other explanatory variables can not be included in the model, since there will be manifestations of multicollinearity.

The first factor in this model is the «GDP per capita» indicator. In Table 2, let's choose a list of variables with which it does not have a high correlation value. These variables include: «Retail fuel cost» (correlation with «GDP per capita» is 0.548), «Inflation» (-0.443), «Unemployment» (0.310), «Population expenditures, consumption» (-0.112) and «Annual Average Sold Car Price» (0.557). Involving any other factor in the model at once will result in multicollinearity and, accordingly, its degeneration.

Among the selected factors, we will get rid of two immediately, because they have no impact on the resulting variable— the correlation between the indicator «Retail fuel cost» and «Car Sales» next year is 0.170, and the indicator «Population expenditures, consumption» is (-0.112). Of the other selected variables, the highest linear connection with the resulting indicator is «Inflation», which is -0.780 (see Table 2), then — «Annual Average Sold Car Price» (0.715) and «Unemployment» (0.420). Among themselves, all of these variables do not have a significant correlation, so they can all be included in the model at the same time.

We begin, in turns, to add factors to the global car sales volumes forecasting model by the degree of their impact on the resulting variable, checking each time the accuracy of the model by the F-criterion. We will check the accuracy of the *model (1)* with different sets of variables, as with the inclusion of the constant a_0, and without it.

Explanatory variables are data from 2006 to 2017, and forecasted data is derived from 2007 to 2019. Data for 2018 on sales volumes is left without analysis in order to compare the result of calculating using the model with real data that was not taken into account when constructing it. Moreover, data for 2018 is not provided yet by International Organization of Motor Vehicle Orgainization (World sales…, 2018).

We build a model of forecasted volumes of world cars sales based on «GDP per capita» and «Inflation». The determination coefficient R^2 of such a model without the constant a_0 is 0.998, and the F-criterion is 2086.26 with seven degrees of freedom. When adding the constant R^2 falls to 0.942, and the F-criterion — to 48.46 with six degrees of freedom. It is clear that the accuracy of the model is extremely high in both cases, although without a free term a_0 model is more efficient (despite the fact that it has fewer parameters and more degrees of freedom).

We will continue to gradually add explanatory variables to the model. With the involvement of two already selected factors of the indicator «Annual Average Sold Car Price», the determination coefficient of the model without the constant a_0 is 0.999, and the F-criterion is 3578.62 with six degrees of freedom, and with the constant a_0 it is 0.964 and 45.44 with five degrees of freedom, accordingly. With the addition of the fourth factor «Unemployment», the R^2 of the model without the constant is 0.999, the F-criterion is 2249.98 with six degrees of freedom, and with the constant it is 0.983 and 58.27 with four degrees of freedom, respectively.

The most accurate among the constructed models for cars sales volume forecast in the world in general, was a linear regression based on three factors without a constant, which takes on an analytical form:

$$Y_{world\ total} = 4427,8 \cdot X_1 — 167158770,5 \cdot X_2 + 1064606,2 \cdot X_3, \text{ where} \qquad (2)$$

X_1 — GDP per capita;

X_2 — inflation;

X_3 — average sold car price.

The real world car sales quantity for the period 2007—2017 and their forecast based on the *model (2)* for the period 2007—2019 are shown in Fig. 1.
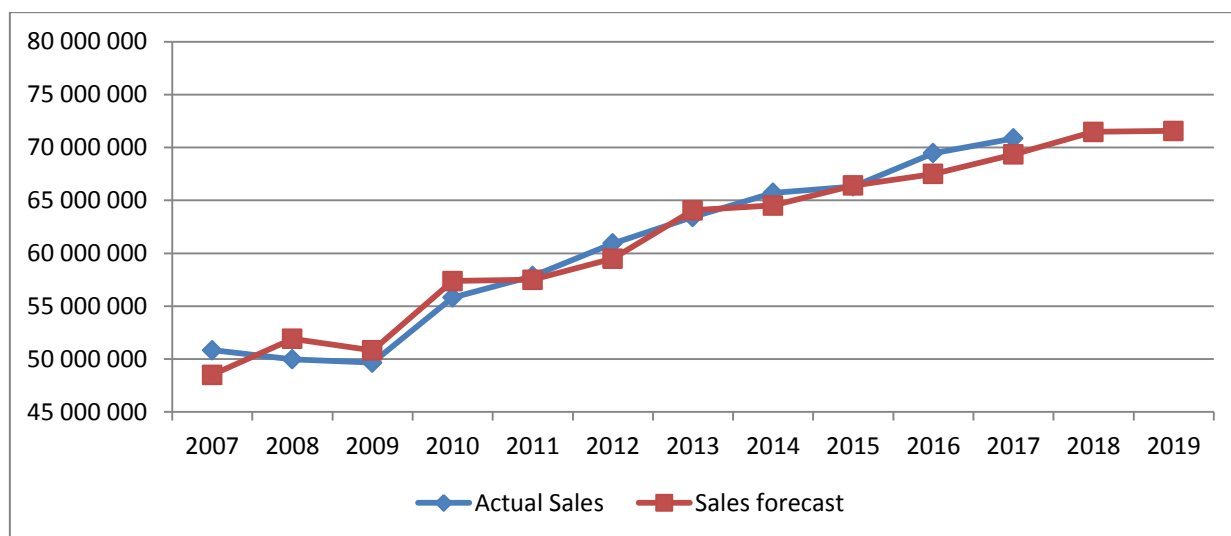

Fig.1. World Car Sales Forecast based on Model (2)

The forecast of world car sales in 2017 by the *model (2)* was 69 342 thousand units, while in reality 70 849 thousand were sold. That is, the forecast deviation from reality is within 2% that can be considered an acceptable result. The model predicts the slow down of global car narket growth up to 1% in 2018 and stability with furter trend to decline beginning from 2109 due to global inflation level growth.

4. Conclussions. The basis of our research is identified and found:

1. The main significant factors influencing sales on the global automotive market have been determined among the many investigated: GDP per capita; inflation; Average annual price of the car sold.

2. The car market is highly interdependent, primarily from macroeconomic factors: GDP, GDP per capita, inflation and unemployment, and less from marketing (the average car sales price).

3. Author's model of forecasting is developed that will allow to effectively plan the marketing activity of enterprises both on the global market and on their regional clusters.

4. The proposed model is effective because it has a slight margin of error of up to 2%.

5. The model predicts the slow down of global car narket growth up to 1% in 2018 and stability with furter trend to decline beginning from 2109 due to global inflation level growth. We expect negative trend in 2020—2022 due to global macroeconomics factors forecasts of Global organazations and market maturity in Asia.

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