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Correlation dependence between the volume of russian advertising market and the Brent crude oil barrel price

Dependencia de correlación entre el volumen del mercado publicitario ruso y el precio del barril de petróleo crudo Brent

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ABSTRACT:
The level of the media advertising industry development is closely related to the level of the regional economic development – in particular, to the gross regional product volume, level of purchasing power and general living standards. Previously, the author made quite successful attempts to prove the existence of the direct correlation dependence between the volume of the Russian advertising market and two global indices: the region's investment attractiveness index and the investment risk index. A hypothesis about the connection between the volume of Russian advertising market and the Brent crude oil barrel price is put forward within this article. The dependence is justified using the correlation and regression analysis. As a result, the linear regression equation of linear type was built, which describes the dependence found.
Keywords: Advertising market, correlation, oil price, advertising market valuation.

RESUMEN:
El nivel de desarrollo de la industria de publicidad en medios está estrechamente relacionado con el nivel de desarrollo económico regional, en particular, con el volumen bruto de productos regionales, el nivel de poder adquisitivo y los estándares generales de vida. Anteriormente, el autor realizó intentos bastante exitosos para demostrar la existencia de una dependencia de correlación directa entre el volumen del mercado publicitario ruso y dos índices globales: el índice de atractivo de inversión de la región y el índice de riesgo de inversión. En este artículo se presenta una hipótesis sobre la conexión entre el volumen del mercado publicitario ruso y el precio del barril de petróleo Brent. La dependencia se justifica utilizando el análisis de correlación y regresión. Como resultado, se construyó la ecuación de regresión lineal de tipo lineal, que describe la dependencia encontrada.
Palabras clave: mercado publicitario, correlación, precio del petróleo, valoración del mercado publicitario.

1. Introduction

The advertising market is subject to the multitier dependence on the economy state,

especially the consumer market, thus encouraging the multilateral communication with business, consumers, media and the sociocultural environment. The advertising market seeks to maintain its function in the economy crisis, adapting quickly to the changing conditions of the business environment and paying particular attention to fluctuations in supply and decline in effective demand (Nazarov 2011; XXth International research-to-practice conference, 2016; XIXth International research and methodological conference, 2015).

The very idea of the market economy initially assumes constant competition between the market participants. Aggravating competition among producing advertisers is a challenge for the media advertising industry, which forces to be in a constant fighting shape, seek and find new approaches and ways to solve the problems of customers. A certain degree of combat readiness of the advertising industry is also added by the rapid transformation of the media landscape, caused by the rapid growth of online communications, their demand from advertisers and consumers of advertising, as well as reluctance of traditional media to lose the customary leading positions in the advertising distribution. All this encourages the dynamics of the advertising industry advancement and enriches it with new practices, methods, techniques and technologies. Previously, the author (Doroshenko, Gushchina and Chesnokova 2013) proposed the direction of improving marketing technologies for the Russian advertising market, and (Mashentseva, Doroshenko and Goncharova, 2016) put forward and justified the hypothesis of a statistical relationship between the level of the country's GDP and the volume of advertising market.

2015 was one of the most difficult years in modern history of the Russian economy. Some experts described the combination of negative circumstances for the Russian economy as an "ideal storm": sharp drop in oil prices was complicated by the ongoing sanctions war, the problem of corporate debt aggravated and became a threat to the entire Russian economy in the conditions of national currency depreciation against the world currencies. The general complication of foreign policy relations between Russia and a number of foreign countries also had a negative impact on the Russian economy.

Processes in the oil market have never been analyzed before in the advertising market valuation, because though a connection between oil prices and advertising sales certainly exists, it seemed very indirect until the last moment. Russia remains a country with a predominantly raw materials export structure. The fall in energy prices, followed by other raw materials, which began back in 2014 and continued in 2015, led to a significant weakening of the currency inflow to the country and the national currency depreciation. It is clear that when the advertising market is valuated in dollars, it results in significantly smaller volumes due to the rate fluctuation (Directory AKAR – 2014, 2014).

2. Methods

A correlation and regression analysis is used within this article to justify the relationship between the volume of Russian advertising market and change in oil prices. The analysis consists in building and analyzing the economic and mathematical model as a regression equation (correlation relationship), which describes the dependence of the characteristic on the factors that determine it. 2000 to 2015 were taken as years of the period under study. The author used Statistica 6.0 software to find empirical coefficients and empirical regression equation.

3. Results and discussion

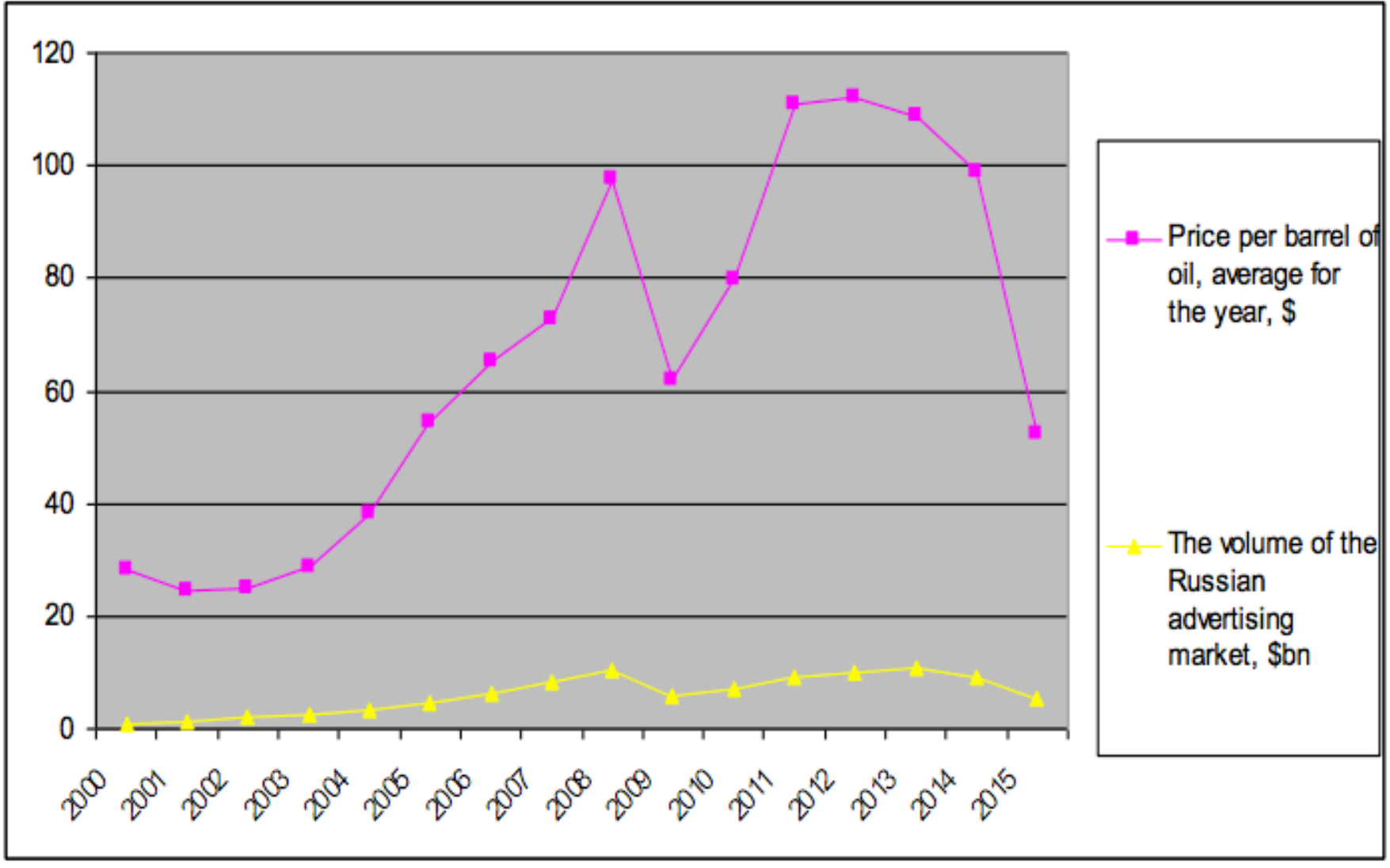
The fall in oil prices became the main threat to the Russian budget and Russian business in 2015: while in 2014 the average price for Brent crude oil was $99 per barrel, in 2015 it was $54. Although the authors estimate the state of the oil market in 2015, they must note that the downward trend also continued in the first quarter of 2016, when the price fell as low as below $30 (Table 1). Figure 1 shows the dynamics of changes in the volume of Russian advertising market and oil prices.

Table 1

Dependence between the volume of Russian advertising market and the average annual oil barrel price

Year	Average annual oil barrel price, $ (Brent crude oil barrel prices, n. d.)	Volume of Russian advertising market, $ bln (Veselov 2015; Veselov 2014)
2000	28.3075	0.9
2001	24.41167	1.3
2002	24.99833	1.9
2003	28.8525	2.4
2004	38.2975	3.3
2005	54.43417	4.6
2006	65.39	6.1
2007	72.7125	8.5
2008	97.66	10.3
2009	61.86083	5.9
2010	79.63167	7.2
2011	110.9517	9
2012	111.9583	9.8
2013	108.845	10.6
2014	98.94417	9.2
2015	52.39917	5.3

Figure 1
Dynamics of changes in the volume of Russian advertising market ($ bln) and the Brent crude oil barrel prices ($)



Empirical coefficients of regression are obtained using the Statistica software: $b = 0.1007$, $a = -0.6528$
Regression equation (empirical regression equation):

$$y = 0.1007 * x - 0.6528$$

where x is the average annual oil barrel price, $;
y is the volume of Russian advertising market, $ bln.
Empirical coefficients of regression *a* and *b* are just estimates of the theoretical coefficients β_i, while the equation itself merely reflects the general trend in the behavior of the variables under study (Eliseeva 2007).

1. Parameters of the regression equation

Sample means.

$$\bar{x} = \frac{\sum x_i}{n} = \frac{1059.66}{16} = 66.23$$

$$\bar{y} = \frac{\sum y_i}{n} = \frac{96.3}{16} = 6.02$$

$$\overline{xy} = \frac{\sum x_i y_i}{n} = \frac{7949.41}{16} = 496.84$$

Sample variances:

$$\overline{S^2(x)} = \frac{\sum x^2_i}{n} - \bar{x}^2 = \frac{85780.6}{16} - 66.23^2 = 975.08$$

$$\overline{S^2(y)} = \frac{\sum y^2_i}{n} - \bar{y}^2 = \frac{748.25}{16} - 6.02^2 = 10.54$$

Standard deviation:

$$S(x) = \sqrt{s^2(x)} = \sqrt{975.08} = 31.226$$

$$S(y) = \sqrt{s^2(y)} = \sqrt{10.54} = 3.247$$

Correlation coefficient b can be found using the following formula and without solving the system:

$$b = \frac{\overline{x*y} - \bar{x}*\bar{y}}{s^2(x)} = \frac{496.84 - 66.23*6.02}{975.08} = 0.1007$$

$$a = y - b*x = 6.02 - 0.1007*66.23 = -0.6528$$

2. Correlation coefficient

Covariance.

$$\text{cov(x,y)} = \overline{x*y} - \bar{x}*\bar{y} = 496.84 - 66.23*6.02 = 98.23$$

Regression coefficient b:

$$r_{x,y} = b*\frac{s(x)}{s(y)} = 0.101*\frac{32.226}{3.247} = 0.969$$

The linear regression equation is as follows:

$$y = 0.101*x - 0.653$$

The regression coefficient $b = 0.101$ shows the average change in the effective indicator (in units of measurement y) with an increase or decrease in the value of the factor *x* per unit of its measurement. In this example, *y* increases by an average of 0.101 with an increase of 1 unit.

The coefficient $a = -0.653$ formally shows the predicted level of y, but only if x=0 is close to the sampled values. In our case, the relationship is direct.

3. Beta coefficient

$$\beta_j = b_j \frac{s(x)}{s(y)} = 0.101 * \frac{31.226}{3.247} = 0.969$$

In other words, an increase in *x* by the value of the standard deviation S_x will result in an increase in the average value of Y by 96.9% of the standard deviation S_y.

Let's estimate the quality of the regression equation using the error of absolute approximation. The approximation error in the range of 5-7% indicates a good selection of the regression equation in relation to the source data.

$$\overline{A} = \frac{2.839}{16} * 100\% = 17.75\%$$

On average, the estimated values deviate from the actual values by 17.75%. Since the error is less than 7%, it is not advisable to use this equation as a regression.

The empirical correlation ratio is calculated for all forms of communication and serves to measure the dependence tightness.

$$\eta = \sqrt{\frac{158.318}{168.64}} = 0.969$$

The correlation index for linear regression is equal to the correlation coefficient $r_{xy} = 0.969$. The obtained value indicates that factor x significantly influences y.

4. Determination coefficient

$R^2 = 0.969^2 = 0.9388$, i.e. the changes in x lead to a change in y in 93.88% of cases. In other words, the accuracy of selecting the regression equation is high. The remaining 6.12% change in Y is explained by factors not taken into account in the model (as well as specification errors).

5. Analysis of accuracy in determining the regression coefficients estimates

An unbiased estimate of the disturbance variance is the following value:

$$S^2 = \frac{10.33}{14} = 0.738$$

$S^2 = 0.738$ is the unexplained variance or variance of the regression error (a measure of the dependent variable dispersion around the regression line).

$$S = \sqrt{S^2} = \sqrt{0.738} = 0.86$$

$S = 0.86$ is the standard estimation error (standard regression error).

S_a is the standard deviation of the random variable a.

$$S_a = 0.86 * \frac{\sqrt{85780.6}}{16 * 31.226} = 0.5$$

S_b is the standard deviation of the random variable b.

$$S_b = \frac{0.86}{\sqrt{16} * 31.226} = 0.00688$$

6. Significant testing of the regression model is carried out using the F-test

The actual value of the F-test:

$$F = \frac{0.9388}{1 - 0.9388} * \frac{16 - 1 - 1}{1} = 214.63$$

Table value of the criterion with degrees of freedom $k_1 = 1$ and $k_2 = 14$, $F_{tab} = 4.6$

Since the actual value $F \geq F_{tab}$, the determination coefficient is statistically significant (the found estimate of the regression equation is statistically reliable).

The relationship between the F-test and Student's t-statistics is expressed in the equality:

$$t_r^2 = t_b^2 = \sqrt{F} = \sqrt{214.63} = 14.56$$

The statistical significance of the equation is tested using the determination coefficient and the F-test. It was found that 93.88% of the total variability of Y is explained by the change in X in the situation under study. It was also found that the parameters of the model were statistically significant. An economic interpretation of the parameters of the model is possible – an increase in X by 1 unit of measurement leads to an increase in Y by an average of 0.101 unit of measurement.

7. Autocorrelation coefficient

Coefficients of random data autocorrelation should have a selective distribution approaching the normal with zero expectation and standard deviation equal to

$$S_{ey} = \frac{1}{\sqrt{16}} = 0.25$$

If the autocorrelation coefficient of the first order r_1 is in the interval:

$-2.145 * 0.25 \le r_1 \le 2.145 * 0.25$, then it can be assumed that the data do not show the presence of an autocorrelation of the first order.

Using the calculation table, the following is obtained:

$$r_1 \approx \frac{\sum \varepsilon_i \varepsilon_{i-1}}{\sum \varepsilon_i^2} = \frac{4.411}{10.327} = 0.427$$

Since $-0.536 \le r_1 = 0.427 \le 0.536$, the independence property of the residues is satisfied. There is no autocorrelation.

4. Conclusion

The linear regression equation is as follows: $y = 0.101 * x - 0.653$. The regression coefficient is $b = 0.1007$ – with an increase by 1 unit of oil barrel price, the volume of the advertising market increases by an average of 0.1007. The relationship is direct in the provided example, 93.88% of changes in oil barrel price lead to a change in the volume of the advertising market. In other words, the accuracy of selecting the regression equation is high. The remaining 6.12% change in Y is explained by the factors not taken into account in the model (as well as specification errors). Since the actual value $F \ge F_{tab}$, the determination coefficient is statistically significant (the found estimate of the regression equation is statistically reliable). There is no autocorrelation.

As such, the hypothesis about the existence of the close connection between the volume of the Russian advertising market and the level of Brent crude oil barrel prices has been proved.

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