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INTERNET DEVELOPMENT MODELING

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Abstract

The article proposed a technique that uses the logistic function for modeling and forecasting indicators approaching the level of natural saturation. There are a large number of indicators that at a certain point in time begin to approach their natural limit, that is, to a certain level of natural saturation, when approaching which there is a natural slowdown in the growth rate. The proportion of Internet users in Russia was chosen as such an indicator approaching the level of natural saturation. For the simulation was used the logistic function proposed by P.F. Verhulst, the schedule of which resembles the Latin letter "S", laid on its side. The curve of this function has two inflection points: in the transition from a slow growth rate to a higher and in the transition from fast growth to deceleration. The purpose of the study is to create a model based on the logistic function of P.F. Verhulst, to analyze and predict the share of Internet users in Russia in 2018-2020. The use of the presented methodology for analyzing and forecasting relevant indicators provides the source material for developing conceptual solutions and preparing strategies for possible directions for further development both at the level of individual firms and relevant industries as a whole, which becomes much more relevant in the context of economic crises, sanctions, etc.

Keywords: Technique, forecasting, internet users, Verhulst's equation, logistic function, modeling.

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1. Introduction

As you know, there are many indicators in various industries, which at a certain point in time begin to approach their natural limit, that is, to a certain level of natural saturation, when approaching which a growth rate slows down. Such indicators, for example, can be the number of car owners in the country (world); the number of Internet users in the country (world); the number of families with washing machines in the country (world); the number of cellular users in the country (world), etc. (Parsons, 2018; Leong, Lim, Lam, Uemura, Ho, & Ho, 2018; Zhao & Hu, 2018; Huang, Yang, Chen, & Meng, 2018; Ryazanov, 2018; Puripat & Sarikavanij, 2018; He, Jiang, Zhao, Peng, & Shi, 2018; Miskinis & Vasiliauskiene, 2017).

For modelling and forecasting in this study, the proportion of Internet users in Russia was selected.

2. Problem Statement

For the analysis of the nature of development and forecasting the number of Internet users in Russia, approaching the level of natural saturation, a method is proposed that involves the use of the logistic function proposed by P.F. Verhulst (Wang, Zi, Ding, You, & Yu, 2018; Gevorkyan, Demidova, Velieva, Korol'kova, Kulyabov, & Sevast'yanov, 2018; Simin et al., 2017; Koch & Schropp, 2018). Logistic equation of P.F. Verhulst is traditionally used to predict population size.

In our methodology, this equation is used to model and predict the share of Internet users in the country.

3. Research Questions

In this study, we planned to answer the following questions:

How to change the proportion of Internet users in Russia in 2018-2020?

4. Purpose of the Study

The purpose of the study is to create a model based on the logistic function of P.F. Verhulst, to analyse and predict the share of Internet users in Russia in 2018-2020.

5. Research Methods

The logistic equation of P.F. Verhulst resembles the Latin letter "S", laid on its side. The curve of this function has two inflection points: in the transition from a slow growth rate to a higher (concave part of the curve) and in the transition from fast growth to deceleration (the convex part of the curve) (Lopez, Lupi, Leon, Lopez, Agudo, & Delgado, 2018; Miao, Hao, Guo, Wang, & Liang, 2017).

The equation for this function is as follows:

$$Y = (A/(1 + 10^{a+bx})) + C,$$

where

Y - the value of the function,

A - the difference between the upper and lower asymptotes,

x - the sequence number of the investigated period of time,

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C - the level from which the growth of the function begins,

a, b - values that form the nature of the change in the logistic curve (slope, bend and inflection points).

The proposed research method includes 6 stages:

Stage 1, the essence of which is to select the studied indicator for analysis and forecasting;

Stage 2 is devoted to determining the level of saturation of the indicator under consideration, the minimum value and the number of analysed values based on expert assessments;

Stage 3 is the calculation of indicators for the system of equations;

Stage 4 involves the compilation of a system of equations and the search for their solution;

Stage 5 is to obtain the desired calculated values;

Stage 6 is devoted to the construction of graphs showing the results obtained and the formation of conclusions.

At stage 1, choose one of the indicators that characterizes the level of Internet use in the country: the change in the proportion of Internet users in the Russian Federation in 1993-2017 (International Telecommunication Union (2018). Country ICT data.) (see Table 01).

Table 01. Share of Internet users in the Russian Federation, %

Years	Share of Internet users in the Russian Federation, %	x
1993	0,01	1
1994	0,05	2
1995	0,15	3
1996	0,27	4
1997	0,47	5
1998	0,81	6
1999	1,02	7
2000	1,98	8
2001	2,94	9
2002	4,13	10
2003	8,30	11
2004	12,86	12
2005	15,23	13
2006	18,02	14
2007	24,66	15
2008	26,83	16
2009	29,00	17
2010	43,00	18
2011	49,00	19
2012	63,80	20
2013	67,97	21
2014	70,52	22
2015	70,10	23
2016	73,09	24
2017	76,01	25

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At stage 2, we assume that C = 0, n = 20, A = 80%.

At stage 3, we calculate the data for the system of equations (see Table 02).

Table 02. Calculation of data for the system of equations

A	x	Y	x^2	A/Y	A/Y-1=Z	lg Z	x lg Z
80	1	0,1	1	1600,00	1599,00	3,20	3,20
80	2	0,2	4	533,33	532,33	2,73	5,45
80	3	0,3	9	296,30	295,30	2,47	7,41
80	4	0,5	16	170,21	169,21	2,23	8,91
80	5	0,8	25	98,77	97,77	1,99	9,95
80	6	1,0	36	78,43	77,43	1,89	11,33
80	7	2,0	49	40,40	39,40	1,60	11,17
80	8	2,9	64	27,21	26,21	1,42	11,35
80	9	4,1	81	19,37	18,37	1,26	11,38
80	10	8,3	100	9,64	8,64	0,94	9,36
80	11	12,9	121	6,22	5,22	0,72	7,90
80	12	15,2	144	5,25	4,25	0,63	7,54
80	13	18,0	169	4,44	3,44	0,54	6,97
80	14	24,7	196	3,24	2,24	0,35	4,91
80	15	26,8	225	2,98	1,98	0,30	4,46
80	16	29,0	256	2,76	1,76	0,25	3,92
80	17	43,0	289	1,86	0,86	-0,07	-1,11
80	18	49,00	324	1,63	0,63	-0,20	-3,58
80	19	63,80	361	1,25	0,25	-0,60	-11,31
80	20	67,97	400	1,18	0,18	-0,75	-15,04
	210		2870			20,89	94,19

At the 4th stage, on the basis of the calculation, we make up the system of equations and solve it:

$$\begin{cases} 20a + 210\,b = 20{,}89 \\ 210a + 2870b = 94{,}19 \end{cases}$$

Multiply the first equation by 10.5:

210a + 2205b = 219,31

Transfer 2205b to the right side of the equation and get:

210a = 219,31 - 2205b

Substituting 210a into the second equation and we get:

219,31 - 2205b + 2870b = 94,19

From here we get:

665b = - 125,13

b = - 0,19

Substitute b:

20a + 210 * (-0,19) = 20,89

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We get:

20a = 60,4

a = 3,02

At stage 5, we substitute the data obtained into equation (1):

$$Y = 80/(1 + 10^{3,02 - 0,18x})$$

and calculate the desired values (see Table 03).

Table 03. Calculation of Y_x values

A	a	b	x	lg Z = a+bx	Y	Z = A/Y-1	Z+1	y_x = A/(Z+1)
80	3,02	-0,19	1	2,83	0,12	678,98	679,98	0,12
80	3,02	-0,19	2	2,64	0,18	440,25	441,25	0,18
80	3,02	-0,19	3	2,46	0,28	285,46	286,46	0,28
80	3,02	-0,19	4	2,27	0,43	185,09	186,09	0,43
80	3,02	-0,19	5	2,08	0,66	120,01	121,01	0,66
80	3,02	-0,19	6	1,89	1,02	77,82	78,82	1,02
80	3,02	-0,19	7	1,70	1,55	50,46	51,46	1,55
80	3,02	-0,19	8	1,51	2,37	32,72	33,72	2,37
80	3,02	-0,19	9	1,33	3,60	21,21	22,21	3,60
80	3,02	-0,19	10	1,14	5,42	13,75	14,75	5,42
80	3,02	-0,19	11	0,95	8,07	8,92	9,92	8,07
80	3,02	-0,19	12	0,76	11,79	5,78	6,78	11,79
80	3,02	-0,19	13	0,57	16,84	3,75	4,75	16,84
80	3,02	-0,19	14	0,39	23,32	2,43	3,43	23,32
80	3,02	-0,19	15	0,20	31,05	1,58	2,58	31,05
80	3,02	-0,19	16	0,01	39,56	1,02	2,02	39,56
80	3,02	-0,19	17	-0,18	48,11	0,66	1,66	48,11
80	3,02	-0,19	18	-0,37	55,96	0,43	1,43	55,96
80	3,02	-0,19	19	-0,55	62,57	0,28	1,28	62,57
80	3,02	-0,19	20	-0,74	67,76	0,18	1,18	67,76
80	3,02	-0,19	21	-0,93	71,61	0,12	1,12	71,61
80	3,02	-0,19	22	-1,12	74,35	0,08	1,08	74,35
80	3,02	-0,19	23	-1,31	76,25	0,05	1,05	76,25
80	3,02	-0,19	24	-1,50	77,52	0,03	1,03	77,52
80	3,02	-0,19	25	-1,68	78,38	0,02	1,02	78,38
80	3,02	-0,19	26	-1,87	78,94	0,01	1,01	78,94
80	3,02	-0,19	27	-2,06	79,31	0,01	1,01	79,31
80	3,02	-0,19	28	-2,25	79,55	0,01	1,01	79,55

At stage 6, we build a graphical interpretation of the results obtained, which is shown in Fig. 1, and draw conclusions.

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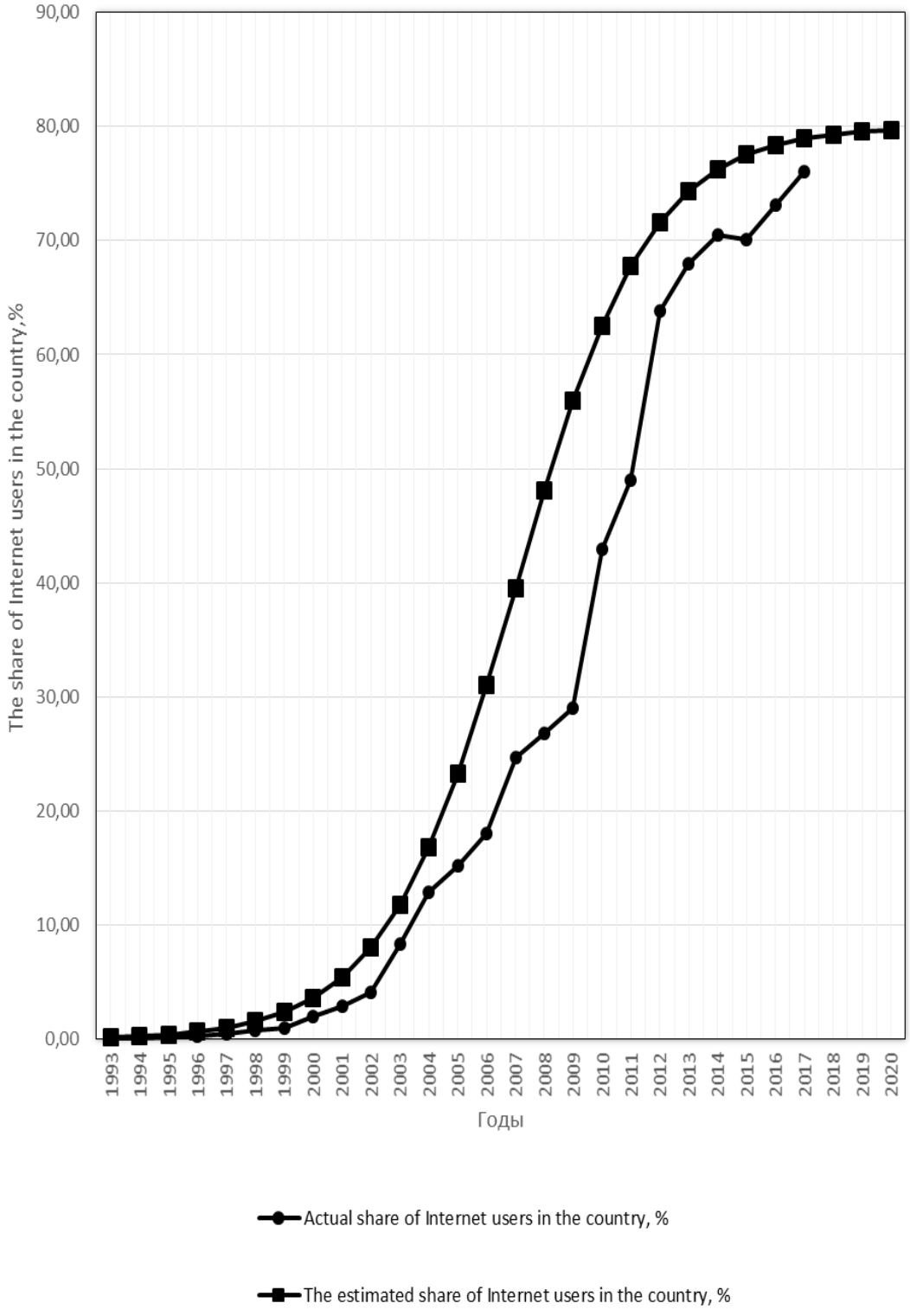

Figure 01. Share of Internet users in the Russian Federation, %

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6. Findings

In fig. 01 presents both statistical data and calculated values of the share of Internet users in the Russian Federation, which show certain deviations at the stage of accelerated growth in 2002-2017, the causes of which are: changes in investment flows in the telecommunications of the Russian Federation, the impact of the global financial crisis, further growth in demand on Internet services, change of tariffs and conditions for providing access to the Internet, competition with other types of communication, etc. At the same time, it is especially important in the process of implementing this technique to correctly determine the level of natural saturation of the studied indicator (Qin, Zhao, Chen, Huang, & Liang, 2018).

As can be seen from built in Fig. 1 schedule and calculations, in 2020, the share of Internet users in the Russian Federation can reach 79,7%, that is, come close to the 80% mark.

7. Conclusion

The use of the presented methodology for analysing and forecasting relevant indicators provides source material for developing conceptual solutions and preparing strategies for possible development directions both at the level of individual firms and relevant industries as a whole, which becomes significantly more relevant in the context of economic crises, the imposition of sanctions, etc. (Schmidt, 2018; Anikin & Anikin, 2017).

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