Supplementary Notebook (RTEP - Brazilian academic journal, ISSN 2316-1493)

FORECAST OF EVOLUTION OF ICT SECTOR IN KHANTY-MANSI AUTONOMOUS AREA – YUGRA

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Abstract: The research paper "Forecast of Evolution of the ICT Sector in Khanty-Mansi Autonomous Area – Yugra" further develops the subject of "Forecasting the prevailing trends in the development of the communications and ICT sectors in the Khanty-Mansi Autonomous Area – Yugra until 2030". Both papers are part of the research project "Long-Term Forecasting of the Economic Evolution of a Resource-Producing Region Based on the Past Trends and Patterns of the Institutional Environment (Using the Example of the Khanty-Mansi Autonomous Area – Yugra)". The practical relevance of the present work is associated with the development of a mathematical model describing the evolution of the information and communications technology sector in the Khanty-Mansi Autonomous Area – Yugra. The results will be used for further research into the economic evolution of a resource-producing region using the example of the Khanty-Mansi Autonomous Area – Yugra. The theoretical significance of the study lies in the development of an approach to forecasting the evolution of the ICT sector in a region. The relevance of this research is underscored by the existing demand for this kind of study from regional authorities, which need it to make socioeconomic forecasts. A formalized method based on regression and correlation analysis was used. The evidence bases for our analysis comprised data from the "Regions of Russia. Socio-Economic Indicators" for 2005-2015 released by the Federal State Statistics Service. The principal output of this analysis is the development of an adequate regression model of the evolution of the ICT sector for the Khanty-Mansi Autonomous Area – Yugra with a mean absolute error of 7.5%. The maximum absolute forecast error equals 15.1% and its minimum level is 2.6%. The forecasts for the ICT sector were developed under three scenarios of regional development until 2028. The baseline scenario projects an average growth rate of spending on ICT at approximately 5%, which exceeds the official inflation projections of 2-4% for the period. Under the worst-case scenario, the annual average rate of 2.7% is projected, close to the expected inflation. According to modeling results, the best-case scenario projects the average growth rate at 8%, which is twice the inflation rate.

Keywords: Forecasting, trend line, regression analysis, information and communications technology, ICT, Khanty-Mansi Autonomous Area – Yugra.

INTRODUCTION

Information and communications technology (ICT) (Information technology, n.d.) has become common in every single area of human operation. Technology is advancing at exponential rates (Program "Digital Economy of the Russian Federation", n.d.), which indicates a growing dependence of other sectors on ICT. The wide-ranging government program "Digital Economy of the Russian Federation" is now in place, and one of the trends is the development of services powered by modern digital technology. This leaves no doubt regarding the relevance of forecasting the evolution of the ICT sector.

METHODS

Many authors have been active in this field of research (Dronova, 2007; Terekhova, 2016; Kuratova, 2015). Research is conducted at the national level, while only a few works are concerned with forecasting regional ICT sector development. This paper presents an approach to forecasting the development of the ICT sector in a federal subject of the Russian Federation using the example of the Khanty-Mansi Autonomous Area – Yugra. Forecasting is complicated where it concerns the ICT sector as it is not designated as a separate type of economic activity. Therefore, the suggestion is to use a measure reflecting the evolution of the ICT sector, namely, total ICT spending in the region, as shown in Table 1.

Table 1. Indicators characterizing the evolution of the communications and ICT sectors in the Khanty-Mansi Autonomous Area – Yugra

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total spending on ICT, million rubles	12,410	12,097	13,002	17,335	16,381	17,386	23,950	28,484	24,706	34,138

The methodology of forecasting is based on correlation and regression analysis and making trend equations (Förster, Röntz, 1983; Shashkov, 2003). The selection of factors for which time series could be built was based on correlation analysis (Tei, Burlutski, Tatiankin, 2017) and questionnaires (Bolshanik et al., 2017; Platform for regional human resources engagement, n.d.). Correlation analysis showed (Tei, Burlutski, Tatiankin, 2017, Bolshanik et al., 2017; Platform for regional human resources engagement, n.d.) the following significant influences on the evolution of the ICT sector: population – 0.77; number of personal computers per 100 employees – 0.78. Time series for the above factors are laid out in Table 2. Significant influence is determined where the respective coefficient of correlation is above 0.6.

Table 2. Factors driving the evolution of the communications and ICT sectors based on correlation analysis

Year	Population*	Organisations having websites, percentage
2005	1,469,011	16
2006	1,478,178	18
2007	1,488,297	21
2008	1,505,248	23
2009	1,519,962	25
2010	1,532,243	32
2011	1,537,134	36

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2012	1,561,238	41
2013	1,584,063	43
2014	1,597,248	42
2015	1,612,076	43

* Source: Population of the Khanty-Mansiysk Autonomous Okrug – Ugra, n.d.

Based on the questionnaire filled in by businesses in the ICT and communications sector, the most significant factors are (Tatiankin, Shitselov, Veprev, 2018): impact of the economy of the Khanty-Mansi Autonomous Area – Yugra – 14%, scientific and technological advance – 16%, level of competition – 14%, consumer interest in e-society – 36%. Considering the above factors, statistical evidence is only missing on the level of competition. "Gross regional product" (Federal State Statistics Service, n.d.) will be considered as a measure of economic impact as laid out in Table 3. The measure of "scientific and technological advance" will be "processor performance" based on Moore's law (2016 Report of the Institute of Electrical and Electronics Engineers, n.d.) as laid out in Table 3. Normalization to 1 is used for this time series. The measure of "consumer interest in e-society" will be "Internet user audience" (Trends of the indicator of "Internet user audience", n.d.) as shown in Table 3. This indicator measures the percentage of the population above 12 years old using the Internet on a daily basis.

Table 3. Factors driving the evolution of the communications and ICT sectors as seen by businesses

Year	Consumer interest in e-society, %	Impact of the economy of the Khanty-Mansi Autonomous Area – Yugra, GRP (million rubles)	Scientific and technological advance, value normalised to 1
2005	18	1,399,336	0.02
2006	23	1,594,097	0.03
2007	27	1,728,340	0.04
2008	32	1,937,607	0.06
2009	37	1,811,591	0.09
2010	41	1,971,871	0.13
2011	46	2,440,433	0.20
2012	51	2,703,559	0.30
2013	55	2,729,122	0.44
2014	60	2,860,499	0.67
2015	65	3,136,832	1.00

Accordingly, the following factors were selected for the regression equation for the ICT industry: x_1 is population; x_2 is the number of personal computers per 100 employees; x_3 is consumer interest in e-society; x_4 is the impact of the economy of the Khanty-Mansi Autonomous Area — Yugra; x_5 is scientific and technological advance.

RESULTS

Accordingly, these five factors were included in the regression equation for the ICT sector:

$$Y\_1 = 0.2529 \, x_1 - 848.6 \, x_2 - 362.7 \, x_3 + 0.0065 \, x_4 + 3{,}478.8 \, x_5 - 340{,}996$$

A trend equation was built for each of the factors, reflecting the main direction of change: $x_{1t} = -2{,}7848{,}578 + 14{,}618 \, t$; $x_{2t} = -3{,}109.8182 + 1.5636 \, t$; $x_{3t} = -9{,}350.8182 + $

4.672 t; x_{4t} = − 343,439,899 + 171,965 t; x_{5t} = − 168.75+ 0.08409 t. Trend equations were used to calculate forecast values of factors for the period until 2028 under three alternatives: the baseline (Table 4), the worst-case (Table 5) and the best-case scenario (Table 6) taking into account deviations based on the levels of standard errors in trend equations of the influencing factors.

Table 4. Forecast values of the factors driving the evolution of the communications and ICT sectors (baseline forecast)

Year	Population	Number of personal computers per 100 employees	Consumer interest in e-society, %	Impact of the economy of the Khanty-Mansi Autonomous Area — Yugra, GRP (million rubles)	Scientific and technological advance, value normalised to 1
2016	1,622,684.64	42.47	69.40	3,242,090.45	1.00
2017	1,637,303.32	44.04	74.07	3,414,055.73	1.00
2018	1,651,922.00	45.60	78.75	3,586,021.00	1.00
2019	1,666,540.68	47.16	83.42	3,757,986.27	1.03
2020	1,681,159.36	48.73	88.09	3,929,951.55	1.11
2021	1,695,778.05	50.29	92.76	4,101,916.82	1.20
2022	1,710,396.73	51.85	97.44	4,273,882.09	1.28
2023	1,725,015.41	53.42	100*	4,445,847.36	1.36
2024	1,739,634.09	54.98	100	4,617,812.64	1.45
2025	1,754,252.77	56.55	100	4,789,777.91	1.53
2026	1,768,871.45	58.11	100	4,961,743.18	1.62
2027	1,783,490.14	59.67	100	5,133,708.45	1.70
2028	1,798,108.82	61.24	100	5,305,673.73	1.78

* Values are adjusted manually as the item shall not exceed 100%.
Source: developed by the author based on statistical data

Table 5. Forecast values of the factors driving the evolution of the communications and ICT sectors (worst-case forecast)

Year	Population	Number of personal computers per 100 employees	Consumer interest in e-society, %	Impact of the economy of the Khanty-Mansi Autonomous Area — Yugra, GRP (million rubles)	Scientific and technological advance, value normalised to 1
2016	1,620,589.88	41.93	69.20	3,171,466	1.00
2017	1,635,189.69	43.47	73.86	3,208,837	1.01
2018	1,649,789.50	45.02	78.52	3,246,648	1.02
2019	1,664,389.31	46.56	83.18	3,284,905	1.04
2020	1,678,989.12	48.10	87.84	3,323,613	1.05
2021	1,693,588.93	49.65	92.50	3,362,777	1.06
2022	1,708,188.75	51.19	97.16	3,402,402	1.07
2023	1,722,788.56	52.74	100*	3,442,495	1.09
2024	1,737,388.37	54.28	100	3,483,060	1.10
2025	1,751,988.18	55.82	100	3,524,102	1.11
2026	1,766,587.99	57.37	100	3,565,629	1.12
2027	1,781,187.80	58.91	100	3,607,644	1.14
2028	1,795,787.61	60.45	100	3,650,155	1.15

* Values are adjusted manually as the item shall not exceed 100%.
Source: developed by the author based on statistical data

Table 6. Forecast values of the factors driving the evolution of the communications and ICT sectors (best-case forecast)

Year	Population	Number of personal computers per 100 employees	Consumer interest in e-society, %	Impact of the economy of the Khanty-Mansi Autonomous Area – Yugra, GRP (million rubles)	Scientific and technological advance, normalised value
2016	1,624,779.39	43.02	69.60	3,312,714	1.21
2017	1,639,416.94	44.60	74.29	3,488,425	1.46
2018	1,654,054.50	46.18	78.97	3,664,137	1.76
2019	1,668,692.05	47.77	83.66	3,839,848	2.11
2020	1,683,329.60	49.35	88.34	4,015,559	2.54
2021	1,697,967.16	50.93	93.03	4,191,271	3.05
2022	1,712,604.71	52.52	97.72	4,366,982	3.67
2023	1,727,242.26	54.10	100*	4,542,693	4.42
2024	1,741,879.82	55.68	100	4,718,404	5.31
2025	1,756,517.37	57.27	100	4,894,116	6.38
2026	1,771,154.92	58.85	100	5,069,827	7.68
2027	1,785,792.48	60.44	100	5,245,538	9.23
2028	1,800,430.03	62.02	100	5,421,250	11.10

* Values are adjusted manually as the item shall not exceed 100%.
Source: developed by the author based on statistical data

Hindcast was further calculated from the regression equation to check model adequacy (Table 7).

Table 7. Hindcast of spending on ICT

Years	Spending on ICT, million rubles		Error, %
	actual	forecast	
2005	12,535	11,011	13.8%
2006	12,410	11,960	3.8%
2007	12,097	13,970	-13.4%
2008	13,002	15,319	-15.1%
2009	17,335	16,516	5.0%
2010	16,381	15,951	2.7%
2011	17,386	16,947	2.6%
2012	23,950	22,428	6.8%
2013	28,484	27,402	4.0%
2014	24,706	28,025	-11.8%
2015	34,138	32,894	3.8%

Source: developed by the author based on statistical data

As can be seen from Table 7, the maximum error equals 15.1%, while the mean absolute error is 7.5%. These results suggest that the regression model provides an adequate description of the research object. Then, the regression model and data in Tables 4-6 were used to calculate forecast values of spending on ICT until 2028 as shown in Figure 1.

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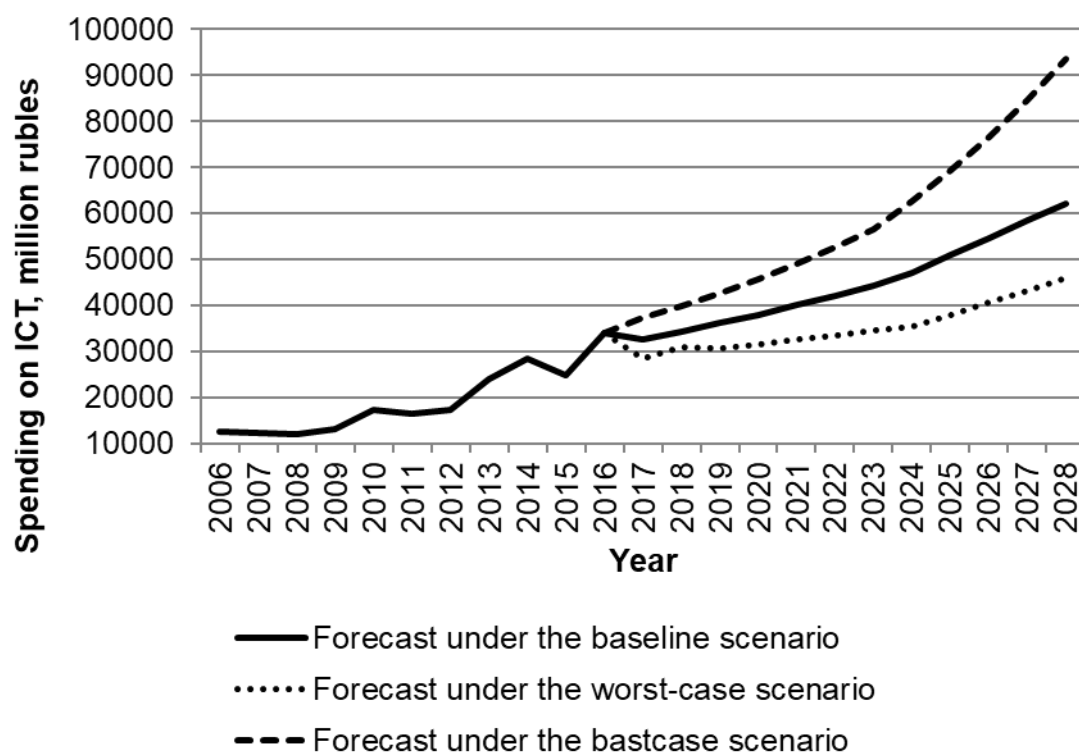
Figure 1. Forecasts of ICT sector development

FURTHER RESEARCH POTENTIAL

These results will be used for mathematical modeling of the economic evolution of a resource-producing region using the example of the Khanty-Mansi Autonomous Area – Yugra until 2030.

CONCLUSION

The principal output of this analysis is the development of an adequate regression model of the evolution of the ICT sector for the Khanty-Mansi Autonomous Area – Yugra, scoring a mean absolute error of 7.5%. The maximum absolute forecast error equals 15.1% and its minimum level is 2.6%. According to the modeling results, the baseline scenario until 2028 projects an average growth rate of spending on ICT at approximately 5%, which exceeds the official inflation projections of 2-4% for the same period. Such level of growth suggests a stage of "gradual expansion of production", which is largely confirmed by the results of questionnaires reflecting business expectations in the ICT sector (27.8%) (Tatiankin, Shitselov, Veprev, 2018). Under the worst-case scenario, an annual average rate of 2.7% is projected, close to the expected inflation, which indicates a stagnation stage. According to business opinions (Tatiankin, Shitselov, Veprev, 2018), there is no such expectation of a stagnation stage until 2028, and the worst-case scenario is unlikely. The most expected scenario, according to businesses, is that of "continued fast growth", a view shared by more than 70% of businesses surveyed (Tatiankin, Shitselov, Veprev, 2018). According to modeling results, an average growth rate of 8% is projected in this scenario, which is twice the inflation rate. Importantly, this forecast is only accurate

on the condition that the current trends of influencing factors are continued. In particular, Moore's law should be maintained, as well as the dynamics of oil and gas production, the budget-forming sector of the Khanty-Mansi Autonomous Area – Yugra.

REFERENCES

1 2016 Report of the Institute of Electrical and Electronics Engineers. Retrieved from: https://irds.ieee.org/images/files/pdf/2016_MM.pdf.

2 Bolshanik, P.V., Evlanov, E.A., Islamutdinov, V.F., Islamutdinova, D.F., Kovalev, V.Z., Rybina, V.B., Sannikov, D.V., Tatiankin, V.M., Tei, D.O., Ustiuzhantseva A. N., Shubina V.I. (2017). Issledovanie evolyutsii, institutsionalnykh uslovii i faktorov razvitiya otraslei ekonomiki severnogo resursodobyvayushchego regiona (na primere Khanty-Mansiiskogo avtonomnogo okruga - Yugry) [Study of the evolution, institutional conditions and factors of development of industries of the northern resource-producing region (using the example of the Khanty-Mansi Autonomous Area — Yugra)]. Khanty-Mansiysk: Yugra State University.

3 Dronova, O.V. (2007). Statisticheskii analiz i prognozirovanie razvitiya otrasli svyazi v Rossiiskoi Federatsii: abstract of Cand. Sci. (Econ.) dissertation [Statistical analysis and forecasting the development of the communications sector in the Russian Federation]. Moscow: Moscow State University of Economics, Statistics and Informatics (MESI).

4 Federal State Statistics Service. Retrieved from: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/publications/plan/

5 Förster, E., Röntz, B. (1983). Metody korrelyatsionnogo i regressionnogo analiza: a guide for economists [Methods of correlation and regression analysis: a guide for economists]. Moscow: Finansy i statistika.

6 Information technology. Retrieved from: http://ru.wikipedia.org/wiki/Информационные_технологии#История.

7 Kuratova, L.A. (2015). Prognozirovanie obema uslug organizatsii otrasli svyazi [Forecasting service volumes at organisations of the communications sector]. Problemy prognozirovaniya, 1(148), 96-104.

8 Platform for regional human resources engagement. Retrieved from: www.кадровое-обеспечение.рф/anketa/.

9 Population of the Khanty-Mansiysk Autonomous Okrug – Ugra. Retrieved from: https://ru.wikipedia.org/wiki/Население_Ханты-Мансийского_автономного_округа_—_Югры.

10 Program "Digital Economy of the Russian Federation". Retrieved from: http://static.government.ru/media/files/9gFM4FHj4PsB79I5v7yLVuPgu4bvR7M0.pdf

11 Shashkov, V.B. (2003). Prikladnoi regressionnyi analiz (mnogofaktornaya regressiya) [Applied regression analysis (multivariate regression)]: Study guide. Orenburg: GOU VPO OGU.

12 Tatiankin, V.M., Shitselov, A.V., Veprev, A.E. (2018). Prognozirovanie preobladayushchikh trendov v razvitie otraslei svyaz i ikt v KhMAO-Yugre do 2030 goda [Forecasting the prevailing trends in the development of the communications and ICT sectors in the Khanty-Mansi Autonomous Area — Yugra until 2030]. Nauchnoe obozrenie: teoriya i praktika num 8, 69-77.

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13 Tei, D.O., Burlutski, V.V., Tatiankin, V.M. (2017). Issledovanie faktorov razvitiya otraslei IKT i svyaz v KhMAO-Yugre [Study of factors of development of the ICT secror in the Khanty-Mansi Autonomous Area — Yugra]. Nauchnoe obozrenie, 20, 96-99.

14 Terekhova, Iu.S. (2016). Issledovanie metodov kompleksnogo ekonomicheskogo finansovogo analiza i prognozirovaniya dlya primeneniya v telekommunikatsionnykh kompaniyakh otrasli svyazi [Study of methods of complex economic financial analysis and forecasting for use in telecommunications companies of the communications industry]. Ekonomika i predprinimatelstvo, 3-1(68), 674-678.

15 Trends of the indicator of "Internet user audience". Retrieved from: https://compress.ru.