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A MULTIDIMENSIONAL CLASSIFICATION FOR THE INFORMATION TECHNOLOGY MARKET[2]

This paper expands the existing informational and analytical opportunities of application of the results of business tendency surveys which solve the problem of the loss of valuable statistical information in its traditional aggregation into simple and composite indicators. Based on methods of multidimensional classification, we develop and discuss an algorithm of statistical analysis that significantly raises the analytical opportunities for the more wide measurement of trajectories of development and short-term fluctuations of the information technology (IT) industry. This allows the construction of behavioural models of business tendency data which improve the understanding of the business cycle in more detail. Furthermore, the empirical results confirm the possibility of receiving various information which increases the analytical potential of business tendency surveys.
JEL: C1; C81; C38; C83; E32; E39; L26; L1; O10; O11; O19; M2

1. Introduction

Diffusion of digital technologies into social and economic systems determines the scientific and practical significance of research on measuring the dynamics of the development of the information technology (IT) industry. As the driving force for transformations in the economy and other spheres, IT promotes successful innovation and accelerates technological changes in the information and communication technology (ICT) sector.

According to the general definition from the Organisation for Economic Co-operation and Development (OECD), ICT sector includes manufacturing and services industries (OECD, 2011). The former "must be intended to fulfil the function of information processing and communication including transmission and display, or must use electronic processing to detect, measure and/or record physical phenomena or to control a physical process," while

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the latter "must be intended to enable the function of information processing and communication by electronic means" (OECD, 2011, p. 58). Definitions used by Eurostat, UNCTAD, the UN Statistical Commission, and the World Bank follow the OECD definition or are quite close to it, varying only on the level of subdivision specification (World Bank, 2009).

IT industry belongs to the services division of the ICT sector. In this study, we follow the definition of IT industry proposed by the Ministry of Digital Development, Communications and Mass Media of the Russian Federation[3]. According to it, the IT industry is a set of organizations whose results are services that are mainly designed to fulfil (or facilitate the fulfilment of) the functions of collecting, converting, storing, presenting data and information electronically.

Global production of ICT goods and services accounts for about 6.5% of the global gross domestic product (GDP), and about 100 million people are employed in the ICT services (UNCTAD, 2017). However, unlike Russia, the ICT sector plays a much more important role in most developed countries – its share in the gross value added (GVA) of the business sector in OECD countries is 1.6 times higher than in Russia (3.4 and 5.4%, respectively), (Abdrakhmanova, Kovaleva, 2018). The absolute size of the IT industry in Russia remains relatively small: the share of IT expenditures in GDP in Russia is only 1.1%, while in developed countries it is 3-4% (Federal 'naja sluzhba gosudarstvennoj statistiki, 2017).

The global economic crisis and the subsequent fluctuations in business tendencies lowered the added value of ICT in general in most OECD countries and Russia, while in the IT industry, especially in the software development industry, it had been increasing. In 2017 the Russian ICT sector GVA gain (2.8% in real terms) was almost twice that of the GDP gain (1.6%). The main contribution to this was made by the IT industry, which grew by 12% (Abdrakhmanova & Kovaleva, 2018).

According to the OECD Digital Economy Outlook 2017, in 2015, investment in ICT in OECD countries was 11% of the total investment in fixed capital and 2.3% of the GDP. Almost 60% of the investment was made in computer software and databases, which are the dominant areas of the IT market, including Russia. In particular, the Russian investment in ICT was 3.1% of the GDP in 2016 (Indikatory cifrovoj jekonomiki: 2018, 2018) and in 2015 it accounted for 3.2% of the investment in fixed capital (Indikatory cifrovoj jekonomiki, 2017).

The important role of the IT industry in the development of the economy as a whole is connected with two channels of influence: firstly, with the development of the latest advanced technologies and, secondly, with the spread of the scale of existing innovations in other sectors of the economy, which can potentially have significant multiplier effects on value chains (Lola, Bakeev, Manukov, 2019). Consequently, along with the spread of IT and the increasing use of computing and communication devices, the dependence of other sectors of the economy on the IT industry is increasing. A particularly profound influence can be observed in high-tech and consumer-oriented segments such as electronics,

[3] Order of the Ministry dated December 30, 2014 No. 502. URL: http://www.consultant.ru/document/cons_doc_LAW_137802/.

communications, entertainment and retail (BCG, 2018). The McKinsey Global Institute (MGI) estimates that by 2030, digital technology can contribute 13 trillion US dollars to global GDP (McKinsey, Company, 2019).

At present, the research of the IT industry is focused on obtaining both quantitative and qualitative aggregated estimates. Available analytical frameworks are mainly represented by various information resources, which contain mainly cumulative estimates of the ICT sector and cover the IT industry only partially.

Ratings and indices are widespread sources of information, including RAEX (Jekspert RA, 2018), "UN E-Government Development Survey" (UN E-Government Development Survey, 2018), ICT Development Index (IDI) (ICT Development Index, 2017), "The Web Index" (The Web Index, 2018), e-Friction Index (Low J-R, 2015) etc. However, due to the aggregated approach of their construction and visualization, they do not allow to quickly measure short-term fluctuations of the IT industry. This is also true for analytical reports by various research organizations, such as (Gartner, 2018; Ernst & Young, 2018; J'Son & Partners, 2018) etc.

With the use of aggregated values, such data can be used in more detail to describe the development of ICT or to assess the achievement of the established purposes and tasks. For example, ICT Development Index (IDI) by the International Telecommunication Union (ITU) represents a unique control indicator of the development of ICT worldwide. This instrument tracks the so-called "digital inequality" between technologically advanced countries and other world. IDI includes 11 indicators of ICT access, usage and skills. Key aspects of ICT are covered by a single measure that allows comparisons between the countries and over time (ICT Development Index, 2017).

There are some advantages in identifying global tendencies using these sources, since, for example, the ratings show the conditions for the transformation of industries, allow to identify barriers and determine priorities for government policy. They make us think about how individual sectors, in particular, in the Russian economy, are not left out of the "digital revolution" and, on the other hand, create an ecosystem of strong ICT players, who can provide ideas and strategies for the new era of big data.

There are frequent changes in calculations for assessing the ICT sector, which often include changes caused by stereotypes, the geopolitical situation and the dynamics of key national macroeconomic trends. Thus, along with their advantages, some problems of the most widespread information content are the variety and instability of methodological approaches, the representativeness of samples, the instability of the distribution of published information, a narrow range of composite indicators for the business climate estimated on the basis of business tendency observations. It is difficult, therefore, to isolate and detail the development of the IT industry at various stages of the business cycle. In the OECD, questions about the measurement of these services in the system of National Accounts (SNA) and the sufficiency of the statistical framework both for large-scale research of industrial processes and for obtaining detailed estimates are becoming increasingly relevant (OECD, 2017).

It is possible to collect more, and more reliable, information using the analysis of the development of the IT industry at the company level when carrying out business tendency surveys. When modelling the business climate, such timely estimates can accelerate the adoption of strategic corrective actions, especially in post-recessionary or stagnant phases of the business cycle.

Long-term international and Russian research demonstrates that statistical time series and business-climate indicators (BCI), calculated on their basis, are necessary for the integrated and local monitoring of industry tendencies in various sectors of the economy (European Commission, 2017; OECD, 2003). However, in the present, in the practice of countries, there are no published aggregated indicators for the measurement of the IT industry, based on business tendency surveys.

In Russia, for the analysis of the IT industry, a system of nonparametric indicators and the composite index of enterprise confidence (IEC), calculated on their basis, are used. IEC is based on the average estimates of percentage changes in demand for services during the current quarter compared to the previous quarter and the expected changes in demand for services in the following quarter. This index has a wide circulation in the European Community and the Eurozone (European Commission, 2014).

The considerable uncertainty, associated with the digital shift, require direct communication with the participants of the technological process. In this regard, it is advisable to produce research based on the harmonized, methodologically developed statistical tools, allowing to measure key tendencies of the development of the IT industry in near real-time mode.

This paper proposes a technique of behavioural models construction to carry out a detailed structuring of the opinions of heads of IT companies on past, present and future tendencies, on the basis of business tendency surveys of the Russian IT industry. In particular, an algorithm for statistical analysis of business tendency surveys based on multidimensional classification is proposed, which allows building and to analyze behavioural models at the level of concrete objects of observation.

The obtained behavioural models allow us to study data from 2010-17, as an important evolutionary period of the development of the Russian IT industry in terms of emerging reactions to ongoing transformations and the level of flexibility of organizations' adaptive capabilities to various shocks. In particular, the method details the reaction of behavioural models during the period of post-crisis restoration after the economic crisis of 2008 and the subsequent short stage of dynamic development until the stagnation in 2015. The method also shows two subsequent phases of a business cycle until 2017. The results of the technique show the structuring of opinions of heads of IT organizations on planned development in 2018.

In general, the main objectives show that the development of IT organizations is well traced using business tendency surveys. The detailed identification of groups allows a careful situational analysis of the IT industry. It expands the analytical interpretation of business tendencies of the organizations determined by industry indicators; confirms the reliability of short-term forecasts from business tendency surveys; shows an objective reaction to the

arising business tendency shocks in various phases of the business cycle; promotes a more exact measurement of the adaptation potential in the IT industry to business shocks at various phases of the business cycle.

Considering that the IT industry is service-oriented and therefore extremely sensitive to the slightest fluctuations in the economy, the work addresses the problem of studying the behaviour of entrepreneurship at different phases of the business cycle, when aggregated industry analysis using various indicators alone is insufficient and may result in the loss of valuable information. In particular, on the proposed information base, the k-means method was tested to identify clusters of enterprises and study them using behavioural models.

2. Empirical base of research

The empirical basis of this research are the results of business tendency surveys of the organizations rendering IT services carried out during 2010-2017. In particular, these organizations carry out the following kinds of activity: development of the computer software, activity advisory and works in the field of computer technologies, activities for the management of the computer equipment, activities for data processing, rendering of services for placement of information and the activity related with it (Indikatory cifrovoj jekonomiki: 2018, 2018). Results of this activity can be realized both on internal and in foreign markets.

Within the framework of the development of statistical surveys of ICT sphere, since 2010 by the request of Institute for Statistical Studies and Economics of Knowledge NRU HSE, selective specialized business tendency monitoring of business activity of the IT industry organizations is carried out by Autonomous Non-Commercial Organization "Statistics of Russia". The technique of creation of behavioural models offered in this research is based on the sample of the nonparametric data obtained during annual polls of heads of more than 600 IT organizations in 30 regions of the Russian Federation.

The ongoing surveys have a longitudinal nature due to the comparability of their results. The sample of respondents during each poll is a panel in relation to the similar ongoing surveys in the previous periods. All units of pilot business tendency survey keep continuity when forming the sample, providing its multidimensional, stratified nature, and also representativeness on the key economic parameters of thirty regions of Russia.

According to the structure of a sample, the distribution of the reporting economic agents demonstrates the prevailing share of small private IT organizations (more than 70%). The methodology of the ongoing surveys, which is based on the international practice of researches of business climate taking into account the specifics of functioning of the Russian economy, is developed and updated with the use of the scientific and practical capacity of the international organizations and institutes (European Commission, 2014). In particular, the methodology of the ongoing studies relates to some international business tendency surveys, mostly provided by the organizations – members of the CIRET (Centre for International Research on Economic Tendency Surveys).

The business tendency surveys characterizing the conditions of business climate of the Russian IT industry are directed on expeditious receiving from businessmen in addition to official statistical quantitative data of short-term quality standards. The system of nonparametric indicators which is developed and annually updated for these surveys allows to carry out the analysis of the cross interrelations characterizing scales and short-term changes in a modern phase of economic development of the IT industry. The received information represents the main tendencies and dynamics of a situation with the orders for IT services of the organizations, development of the labour market, the main activities, competitive advantages, investment activity, pricing, the factors limiting their activity, and also many other parameters of business activity in this sphere.

Polls of heads of the organizations rendering information and computer services are carried out under specially developed questionnaires "Surveys of business activity of the organizations rendering information and computer services"; which are annually updated according to specifics of the present business tendency conditions. Monitoring is carried out by the method of self-filling of questionnaires by the directors or managers of the organizations possessing the necessary level of competence of the relation of the questions asked in the questionnaire. Selection of the organizations for carrying out polls about business tendencies are carried out by statistical territorial authorities of the state independently.

The system of indicators and the structure of appropriate questions in the programs of surveys of business climate is based on the following methodological principles: questions belong to characteristics of the activity of directly surveyed IT organization; questions reflect the dynamics of indicators in a year; three-category graduation is used on all questions concerning estimates of dynamics of indicators: growth (+), no change (=), decline (–); all information received during business tendency surveys has a qualitative nature.

The group of the variables included in the technique of creation of the behavioural models contains in the section of questionnaires — "Indicators of activity of the organization" and characterize the flowing and expected demand changes; investment activity; competitiveness; economic situation.

3. The creation of the behavioural models

It should be noted that the offered technique based on methods of multidimensional classification allows analyzing various processes of the deep industrial changes which arose owing to influence on the organizations of various on scale business tendency factors (Ajvazjan et al., 1974; Aleskerov et al., 2013; Arhipova & Mhitarjan, 2010). For the first time in Russian statistical practice, being based on the information base of the qualitative type containing estimates of financial and economic activity of the heads of IT organizations, without using the habitual aggregated estimates, changes in behavioral reactions to business shocks are revealed and analyzed. Using the models, the transformation of entrepreneurial mindsets during the business cycle over the last ten years that allowed to raise considerably the existing analytical opportunities of measurement of

business activity and an assessment of a cumulative condition of business climate of the IT industry in general is thoroughly investigated.

At the same time, in this research, it is proved that the cyclical analysis, which, based on calculations of balances of estimates of respondents and composite indicators of business climate is not the only measure of information potential of business survey tendencies promoting a careful analytical study of the industrial tendencies. A similar point of view is found in research studying the practical application and distribution of business polls (Mitchell et al., 2002; Crosilla, Malgarini, 2010). In particular, after the analysis, which is carried out, by Carlson and Parkin in many works, such as (Carlson, Parkin, 1975) the criticism of use only of a balance method of quantification of a final data of surveys was traced. It is necessary to understand the identification of the balance value as the difference of shares of the respondents who noted an increase or decrease of value in any indicator in comparison with the previous period x as a percentage).

Among the foreign researches studying problems of quantification of information, it is possible to note the work of the Italian researchers of ISAE (Proietti & Frale, 2007), based on the spectral analysis of the business climate tendency. The methods of quantification of surveys, in particular, the method of scaling of qualitative signs and their quantification are also discussed in one of the researches of ISAE specialists, (Crosilla et al., 2009) and in the paper of their German colleagues form the IFO institute – CESifo Group Munich, (Pesaran et al., 2015).

The logic of the processing and interpretation of results of surveys is that the initial data appear in the form of distributions of opinions who specified one of answers "increase", "no change", "decrease" or if the indicator is, "above normal level", "at normal level", "below normal level". In the classical theory of measurements, the scale is identified as an unambiguous display of empirical system on the relations in the numerical system with the corresponding relations. Within such questions between the surveyed objects, the sequence relations are established, and the corresponding qualitative signs are measured by a serial scale. Thus, at each point of such a scale, a certain number demonstrating the relative intensity of a qualitative sign is identified (Suppes, Zines, 1967; Pfanzagl, 1976).

International and Russian experience of representation of results of business tendency surveys on large and small businesses shows that the information weight of each separately taken position forming the balance of an indicator represents very important information. A more careful study of such information can represent useful data of various operational indicators of activity of IT organizations. This aspect is especially important when studying the cumulative behaviour of businesses during specific phases of the business cycle and when it is necessary to detail the reactions of businesses to real or expected economic events.

The conceptual framework behind the proposed methodology of behavioural models is close to the idea of the "economic microscope" proposed by Birch (1979). According to it, we should reach beneath aggregate statistics to have a fuller understanding of the way how the behaviour of individual firms causes economic changes. Birch uses different ways of disaggregation, considering separately the economic parameters of businesses of different size, geographical location, industry subdivision etc. Based on the business tendency

surveys data, we exploit another way of disaggregation. It is less structural in its nature: separate groups are identified by their attitudes towards external economic climate and the internal business situation on the basis of cluster analysis. Combining the disaggregation principle of the "economic microscope" with the longitudinal nature of our business tendency data allows us to study the dynamic aspects of the behaviour of firms in the more individualized and specified framework, where firms that are successful, moderate, and unsuccessful in their economic results are studied separately.

As information sources for studying behavioural models, there are primary results (answers in questionnaires) of annual business tendency surveys of the IT organizations used, which are carried out by Rosstat to the period from 2010 to 2017 (8 surveys). The sample for each surveyed period varied in the range of 650 sampling units. As variables, four indicators of business activity were chosen from a form of statistical monitoring as an expert way. An executive of an IT organization, comparing a situation in firm by each indicator during this period with the situation during the previous period and the subsequent with the current year, notes that situation improved, remained the same or worsened. From this, it follows that each firm was characterized by 8 variables, from which 4 are actual and 4 are expected. These include the following: demand for services (x1; x2); investment (x3; x4); company's competitiveness (x5; x6); assessment of overall economic situation (x7; x8).

The basis for a choice of such indicators were the following reasons:

- the part of the indicators from the given set characterizing the actual and expected estimates of respondents are a part of the composite indicator of business climate – an index of enterprise confidence;
- throughout the entire period of carrying out business tendency surveys of IT industry expected short-term expectations of these variables are characterized by the best reference points of enterprise sentiment, and also further prospects of industry development;
- empirical experience of results of business tendency surveys shows that the current and expected (forecasted) estimates of respondents on each of the chosen indicators give complementary information on the position of the organization, give the accurate and coordinated auxiliary characteristic to industrial processes.

When carrying out the classification, the method of k-averages is applied. The formalized description of the algorithm is given below.

S – is a set of clusters, $S = \{S_1, \dots, S_K\}$, where K is the number of clusters. μ_i – is a centroid of the cluster S_i, $\mu_i \in R^N$. There are M objects of clustering, which are IT organizations in this research. (M = 600):

$$X = \{x_1, \dots, x_m\}, where\ \forall j = \overline{1 \dots M}\, x_j \in R^N \quad (1)$$

where $N = 8 * 1 = 8$ (annual data for 2010-2017).

As a proximity measure in this algorithm, the Euclidean metrics were used:

$$\rho(a, b) = \|a - b\| = \sqrt{\sum_{p=1}^{N}(a_p - b_p)^2}, \text{ where } a, b \in \mathbb{R}^N. \quad (2)$$

The classification problem is in the minimization of the total square deviation of objects x_i from the centroid of clusters μ_i and is as follows:

$$\sum_{i=1}^{k}\sum_{x_j \in S_i}\rho(x_j, \mu_i)^2 = \sum_{i=1}^{k}\sum_{x_j \in S_i}\|x_j - \mu_i\|^2 \to min \quad (3)$$

Functionality of quality – the minimization of a total square deviation of objects of x_i from the centers μ_i of clusters of S_i where i=1,2…9. Originally, its ideal representatives, with whom each studied object (organization) is compared, acted as the center of clusters.

As a result of the preliminary analysis, 9 clusters were allocated between three typological groups of companies: high (type A); average (type B) and low potential of business activity (type C).

The group of type "A" is presented by the organizations in which for the considered year positive estimates of these indicators were noted (i. e. businessmen in the questionnaire pointed to increase in demand, investments, competitiveness, etc.). The group of type "B" included the organizations with which during the studied period the dynamics of indicators remained without change of a rather previous year. The group of type "C" is presented by the organizations at which a decrease in economic activity in comparison with the previous monitoring period was observed.

As a result, 9 behavioural groups, together with the task of an initial arrangement of the centroid of the clustering, are presented to (Table 1) (μ_1 … μ_{91}). Each object of the clustering of x_i is characterized by a set of indicators:

= (sps_t_ft, inv_t_ft, kov_t_ft, eso_t_ ft, sps_s_et , inv_s_et, kov_s_ et, eso_s_et) (4)

Table 1

Centroids of clustering

Questions and answers Designation			Behavioural groups								
			TYPE «A»			TYPE «B»			TYPE «C»		
			AA	AB	AC	BA	BB	BC	CA	CB	CC
The actual trend (ft)	Demand	sps_t_ft	1	1	1	2	2	2	3	3	3
	Investment	inv_t_ft	1	1	1	2	2	2	3	3	3
	Company's competitiveness	kov_t_ft	1	1	1	2	2	2	3	3	3
	Assessment of overall economic situation	eso_t_ft	1	1	1	2	2	2	3	3	3
Expected trend(et)	Demand	sps_s_et	1	2	3	1	2	3	1	2	3
	Investment	inv_s_et	1	2	3	1	2	3	1	2	3
	Company's competitiveness	kov_s_et	1	2	3	1	2	3	1	2	3
	Assessment of overall economic situation	eso_s_et	1	2	3	1	2	3	1	2	3

Source: composed by the author

Results of the given technique are involved in the analysis of a condition of business climate of the IT industry for identification and a specification of the behavior of businessmen in the period of the most evident cyclic episodes and business tendency calls during 2010-2017.

4. Findings

According to the presented technique, for the formation of a detailed picture of the evolutionary development of the IT industry, we consider the obtained behavioural models reflecting the reaction of respondents. Along with quantitative indices, the results of the development of the Russian IT industry for the specified period were traditionally represented by the aggregated indicators of business activity that limits possibilities of carrying out expanded analytical interpretation of industrial changes, the decision was made to detail reaction of respondents and to present 8 behavioural models containing results of each business survey to the comparative analysis.

In particular, such timeline and its subsequent analysis covering retrospective results since 2010 in our opinion is an important and necessary condition in the achievement of one of the important research problems which are in the identification of adaptation potential of IT industry by the totals of 2017 that is possible only when comparing the happened changes in entrepreneurial mindsets seven years later. Earlier periods, in this case, are basic, allowing to compare models of behavioural groups of different years and by that to expand an analytical assessment of a condition of IT industry in general.

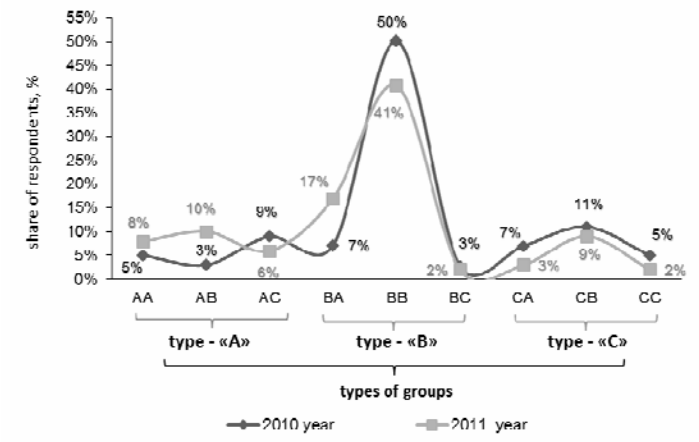
Besides, such extensive time coverage is actual from the point of view of the opening possibility of carrying out the careful comparative analysis between each model reflecting changes in entrepreneurial mindsets on the changing environment or the arising shocks. It should be noted that the development of the IT companies in the studied time interval happened within enough difficult micro- and macroeconomic transformations. First of all, it is about the period of the general unstable business climate in Russia created as a result of the financial and economic crisis of the end 2008 – the beginning of 2009, whose consequences continued to have a negative impact on their positions at the advance of development on the market of the corresponding services within the next several years.

Thus, we consider the behavioural models reflecting changes in IT organizations in groups according to the reaction of entrepreneurs to the post-crisis business tendencies, which developed during the base period (2010-2011).

At estimation of the received behavioural models, specifically, we track the distribution of the organizations not only possessing high and low potential (type "A" and "C", respectively), but also the surveys making throughout the entire period the most stable group "B". Figure 1 visualizes the behavioural models reflecting groups of the organizations according to their reaction to economic changes in 2010 and 2011.

Figure 1

The changes in the behavioural models of IT organizations (2010-2011)



Source: composed by the author.

Proceeding from the received groups, it is possible to draw a conclusion that in 2010 and 2011 the majority of firms (60% on selection) belonged to type "B" and were concentrated around a neutral position on the relation as to the current estimates, and short-term expectations. However, in 2011 in the group with neutral answers there was an expansion of the BA group reflecting a growth in neutral/positive mood of respondents.

The signals of improvement of a situation in a segment were also given by changes in groups "A" and "C". So, if in 2010 the general share of the organizations in group "C," which heads gave mainly negative estimates to the developed tendencies and expectations, made 23%, then in 2011 their share decreased to 14%. At the same time, the general share of the successful organizations increased from 17 to 26%. In addition, in all groups, the tendency of growth of positive estimates concerning prospects of development of the companies in 2012 was noted. Thus, proceeding from Fig. 1, it is possible to draw a conclusion that the IT industry in 2011 followed in a waterway of the stabilization post-crisis measures which caused functioning of business in more favourable market conditions.

Nevertheless, despite 2011 sated with post-crisis compensation activity, it would seem to put all prerequisites for further formation of IT industry for future periods, in 2012 the economic situation began to become aggravated. Dynamics of development of the companies was slowed down, and the come period was rather conservative.

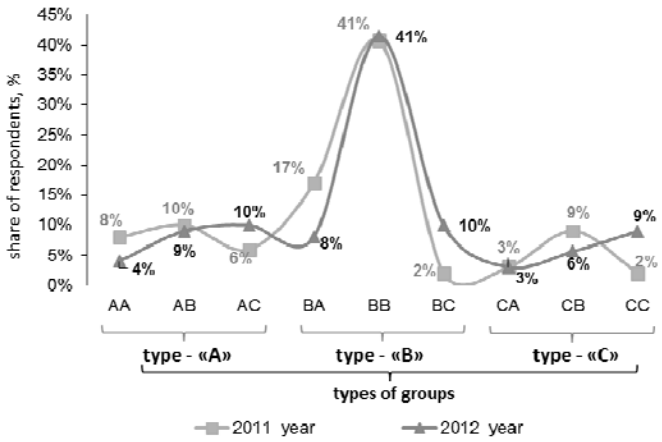
The happening changes in 2012 and 2013 rather brightly reveal in behavioural models that reflect changes relatively 2011.

Based on the distinction among the groups described above, we examine Figure 2. In all groups, the increase of pessimism in answers respondents is distinctly traced and growth of

groups with negative estimates is recorded. Therefore, relatively 2011 the AC group in 2012 increased from 6 to 10%; "BC" – from 2 to 10%; "CC" – from 2 to 9%. However, in general, the group "A" decreased slightly: from 26 to 23%. Growth of a share of the companies of type "C" made from 14 to 18%.

Figure 2

The changes in the behavioural models of IT organizations (2011-2012)



Source: composed by the author.

Thus, based on Fig. 2, we can conclude that the resumption of growth in business activity was accompanied by the willingness of companies in other sectors of the economy to invest in modern IT technologies in order to increase the efficiency of their business. One of the clear positive trends that ensured a relatively stable development of companies in the IT services market in this period should be attributed to the continued implementation of the pent-up demand for services that had accumulated both in the crisis and in the recovery period, which contributed to the further "mothballing" of not only many suspended large projects, but also the introduction of new ones.

Stagnation, which swept the enterprises of the real sector of the economy as main customers of services during 2013 and 2014, actually caused a subsequent rigid correction and compression of the IT market. Thus, if the last periods can be characterized as "resuscitation and recovery", 2014 became critical for the industry.

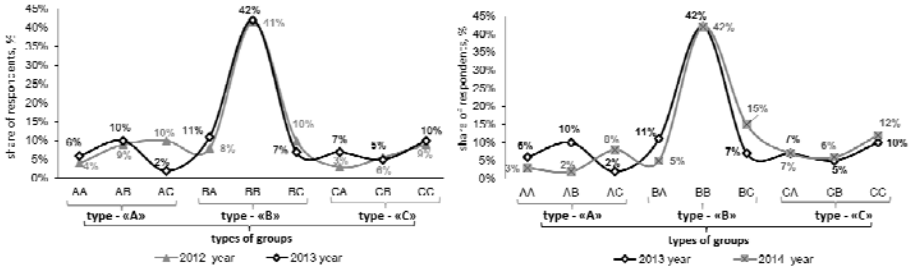
Similar changes also showed particular behavioural groups, as presented in Figure 3. Careful analysis of enterprise intra-group estimates indicates pessimistic sentiments of respondents in each type of the organizations concerning short-term prospects of development of business. In all intra-industry groups, in 2014 the pessimistic sentiments regarding industry rates of development in 2015 were noted. In each cluster, accumulating estimates of the expected changes for the next year (AC, BC, CC), traced signals about a new phase of economic reduction. This tendency especially was shown in group "C".

Validly, according to the further chronology of the development of the industry, 2014 is the last moderately positive period for IT market.

Thus, the visualization of behavioural groups shows that opinions of businessmen in 2014 were enough sensitive measurement not only for current, but also for future industrial changes. Against the background of the sharp deterioration of a condition of the business climate, there was a regrouping of forces among IT organizations and the corresponding change in the behavioural models (Figure 4).

Figure 3

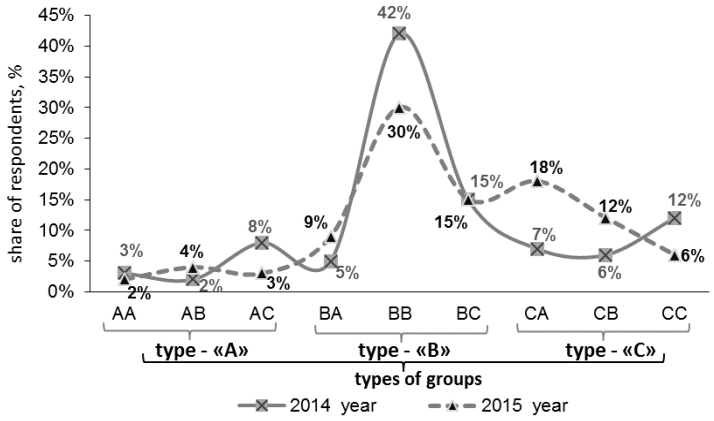
The changes in behavioral models of IT organizations (2012-2014)



Source: composed by the author.

Figure 4

The changes in the behavioural models of IT organizations (2014-2015)



Source: composed by the author.

Concerning clusters "B" and "C", the group "A" that collected IT organizations, which had the highest potential of development, shrinks considerably. The share of such organizations in 2015 for all sample decreased to unprecedentedly low 9%, having established the second anti-record (even in 2010 the minimum value made 17%).

At the same time, the happening changes in the behavioural models reflecting a significant increase in comparison with 2014 in a share of the organizations, which got to a cluster "C", to 36% are presented.

Against two presented groups, a certain optimism causes a condition of the group "B" that included IT organizations, whose heads remained insensitive to current changes and were rather positive to the expected changes in business tendencies. Though this fact is a little levelled by a decrease in BB group from 42 to 30%, in general in group "B" the maximum majority of the companies (54%) continued to concentrate being characterized by primary resistance to an external environment.

Nevertheless, the specification of each group allowed noting that in 2016 there would be favourable changes. First of all, it is reflected by such groups as – "CC", the share of the companies in which in 2015 decreased to 6 against 12% and "CA" – growth to 18 against 7% in 2014, and also "AC" – decrease from 8 to 3%, respectively.

In 2016, rather noticeable compensation processes that were expressed in a change of negative dynamics of the indicators characterizing business climate are revealed. Positive changes are distinctly visualized by comparing behavioural models of 2015 and 2016 (Fig 5.). Thus, the adverse business atmosphere, characteristic for 2015 in the Russian IT industry, considerably improved, and depressive estimates of heads in 2016 were replaced with more optimistic. Tactical realities, acting as a platform for a creative, continued to increase resistance to stress and adaptability of the IT organizations.

According to the survey conducted in 2017, this industry for the first time since 2014 returned to positive growth rates having shown positive development tendencies. The depressive estimates of respondents created in last surveys considerably were levelled that promoted noticeable updating of the current and expected tendencies.

Changes in the behavioural models of 2015 and 2017 illustrate a rise in IT and a levelling off of negative tendencies. In each group (Figure 5.), the positive regrouping of IT organizations is expressed in the doubling, relative to 2015, of the proportion of successful companies from 9 to 18%, and in the noticeable shrinking of the group "C" from 36 to 8%. It should be noted that the reached values are the best according to the nature of the happening processes since 2010. The behaviour of the type B companies representing group "B" which increased from 54 to 74%, emphasizes their adaptation opportunities to the fast economic restoration and their subsequent growth also attracts attention. This fact shows that as of the end of 2017, despite internal restructuring and continuous optimizing reorganization of administrative schemes in practically all industries of the economy, the Russian IT market shows high rates of development.

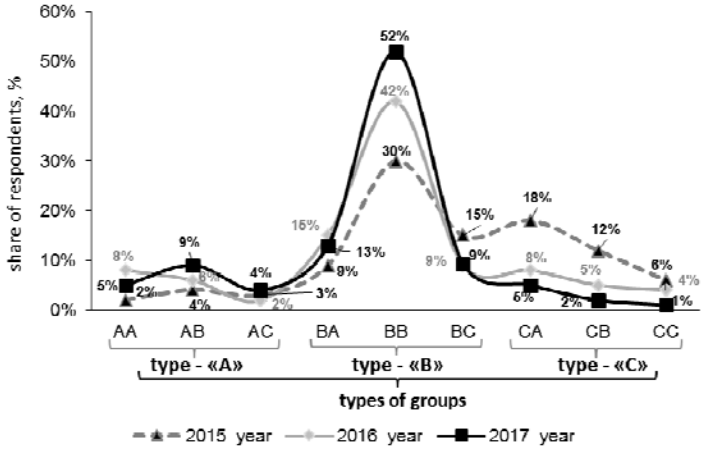
Based on the specifics of the results, it is possible to conclude that the observation over a share of "neutral" answers of respondents (group "B") prevails over the remained, fluctuating from 60% to 75% during 2010-2017.

On the example of comparison of the changes happening to IT organizations within two cyclic episodes in 2011 and 2017, we see that maintained neutrality of developing business tendencies is an important feature as this group is the most representative. This is an important indicator of the general potential and degree of adaptability of businesses and

allows the concretization of the potential level of IT companies in the current and retrospective phase of development. In particular, this demonstrates the exclusive mobility and quick adaptation of the Russian IT industry to the changing conditions in the post-crisis periods 2010 and 2011, and in 2017, after the recession of 2015.

Figure 5

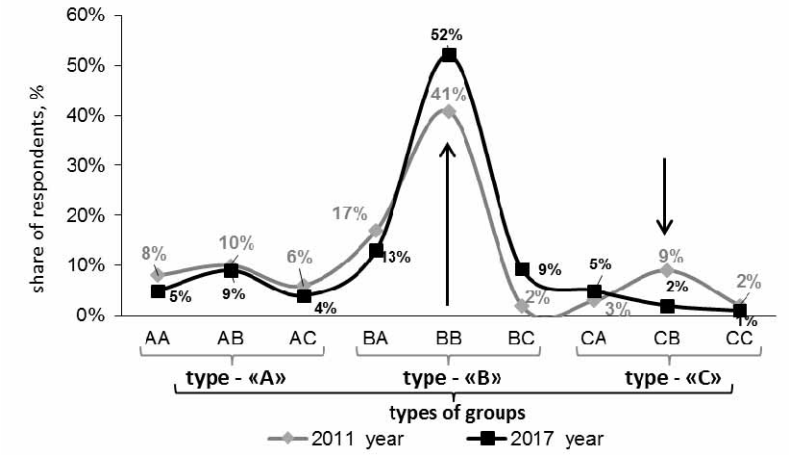
The changes in the behavioural models of IT organizations (2015-2016)



Source: composed by the author.

Figure 6

The changes in behavioral models of IT organizations (2010-2017)



Source: composed by the author.

It should be noted that despite expeditious restoration after the crisis in 2010 and 2011 the share of IT companies which were concentrated on a neutral position on the current estimates and short-term expectations was much lower than in 2017. The expansion of group "B" which began in 2016 and continued in 2017, having made 74% against 60% in 2010 allows to note that the enterprise potential and adaptability to macroeconomic fluctuations became considerably stronger (Figure 6). This represents a significant shift from the situation at the beginning of 2010s, when in the context of Russian specifics there was no such prevalence of IT services and the demand for them was more vulnerable to the external socioeconomic conditions than in the second half of 2010s.

The results confirm that such a disaggregated manner of analysis of survey results can be useful during any period, but is most effective at a time of expansion, destabilization, and compensation restoration. When sharp transformations of enterprise estimates are possible, aggregation can lead to a loss of valuable information at the firm level.

5. Conclusions

The growing importance of the IT in the economy, as well as the digital transformation of the society, necessitates studying the key trends of its integral component – the IT industry, which is characterized by a high rate of change. The rapid spread of IT services, which are integral engines of the information society, makes it increasingly difficult to identify and monitor current and emerging trends in this market. Abrupt transformations require flexible and modern statistical tools that can quickly and comprehensively reflect the results of the activities of IT service providers.

In this work, using cluster analysis, a detailed structuring of the opinions of IT company leaders regarding current and future industry development trends during 2010-2017 is carried out. The detailed identification of groups and their analysis using the proposed behavioural models' technique allowed to conduct a thorough situational analysis of the IT industry, which:

a) expanded the available information about the IT industry trends in comparison with the traditional methods of aggregation into simple and composite indicators;

b) confirmed the reliability of short-term forecasts of entrepreneurial estimates obtained in the course of business tendency surveys;

c) revealed the increase in adaptation potential of the IT industry during 2010-2017.

In each considered time interval, the ability of various groups of IT companies to provide an objective response to emerging market shocks was confirmed, which once again emphasizes the high significance, objectivity and relevance of conducting business surveys at any phase of cyclic development.

A detailed visualization of models revealed and concretized the behavior of all the designated groups of entrepreneurs during various periods of the business cycle. In particular, a comparison of the models of enterprise groups in 2010 and 2017, allows us to conclude that in general, the Russian organizations rendering IT services considerably

strengthened their economic potential and increased their adaptability to the arising shocks of recent years.

Based on the specifics of the results obtained, we can conclude that it is equally important to monitor the proportion of "neutral" responses of respondents (group "B"), which, as a rule, prevails over the remaining ones. A comparison of the changes taking place with IT organizations in the two cyclical episodes of 2011 and 2017, which remained neutral regarding the current situation, can be very useful, since this group, as the most representative, is an important indicator of the overall potential and degree of adaptability of entrepreneurs.

Considering the increasing significance of the IT industry for the Russian economy and the conditions of frequent destabilization of business confidence, the integration of this method into statistical practice is relevant for the development of additional operational anti-recessionary measures and the stabilization of political decisions. In this regard, the practicality of the results and the subsequent analysis lies in the use of this method as an instrument of modelling the IT industry's future profile, improving conditions for its accelerated transformation. Particularly, new indicators and indexes may be analyzed in further research, revealing the aspects of digitalization, digital activity of companies, demand and supply for particular digital technology services.

References

Abdrakhmanova, G. I., Kovaleva, G. G. (2018). Sektor IKT v Rossii [The ICT sector in Russia]/ISSEK NRU HSE. Available at: https://issek.hse.ru/news/227732702.html (accessed 18 November 2018).

Ajvazjan, S. A., Bezhaeva, Z. I., Staroverov, O. V. (1974). Klassifikacija mnogomernyh nabljudenij [The classification of multidimensional obervations]. Moscow: Statistika. 240 p.: fig.

Aleskerov, F. T. et al. (2013). Analiz patternov v statistike i dinamike: Primery primenenija k analizu social 'no-jekonomicheskih processov [The analysis of patterns in statistics and dynamics: The examples of application to analysis of social and economic processes]. Moscow: Biznes-informatika, № 4(26): pp. 3-20.

Arhipova, M. Ju., Mhitarjan, V. S. (2010). Ispol'zovanie nelinejnyh modelej v jekonometricheskih issledovanijah: monografija [The using of non-linear models in econometric researches: monography] / Moscow: Izd-vo MJeSI. 91 p. Table – Bibliogr.: pp. 89-91.

BCG. (2018). A Leadership Agenda for the Next Decade. Available at: https://www.bcg.com/publications/2018/winning-the-20s-leadership-agenda-for-nextdecade.aspx (accessed 30 September 2019).

Birch, D. (1979). The Job Generation Process. MIT Program on Neighborhood and Regional Change, Vol. 302. Available at SSRN: https://ssrn.com/abstract=1510007.

Carlson, J. A., Parkin, J. M. (1975). Inflation expectations. Economica. № 42: pp. 123-138.

Crosilla, L., Leproux, S., Malgarini, M., Spinelli, F. (2009). Factor Based Composite Indicators for the Italian Economy. Available at: https://ebiblio.istat.it/digibib/Working_Papers/WP_116_2009_Malgarini.pdf (accessed 14 November 2018).

Crosilla, L., Malgarini, M. (2010). Behavioural models for manufacturing firms: an analysis based on ISAE survey data. Available at: http://ec.europa.eu/economy_finance/db_indicators/surveys/documents/workshops/2010/ec_meeting/crosilla_malgarini_isae.pdf (accessed 16 November 2018).

UN E-Government Development Survey 2018, Available at: https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2018-Survey/E-Government%20Survey%202018_FINAL%20for%20web.pdf (accessed 15 November 2018).

Ernst & Young. Available at http://www.ey.com/RU/ru/Home (accessed 12 November 2018).

European Commission. (2014). The Joint Harmonised EU Programme of Business and Consumer Surveys. A User Manual to the Joint Harmonised EU Programme of Business and Consumers Surveys. Resource document. Available at: http://ec.europa.eu/economy_finance/db_indicators/surveys/method_guides/index_en.htm (accessed 15 November 2018).

European Commission. (2017). The Joint Harmonised EU Programme of Business and Consumer Surveys. User Guide. Available at: https://ec.europa.eu/info/sites/info/files/bcs_user_guide_en_0.pdf. (accessed 15 November 2018).

Federal' naja sluzhba gosudarstvennoj statistiki 2017, Monitoring razvitija informacionnogo obshhestva v Rossijskoj Federacii. Available at: http://www.gks.ru/free_doc/new_site/business/it/monitor_rf.xls. (accessed 13 November 2018).

Gartner, Available at: http://www.gartner.com/technology/analysts.jsp. (accessed 15 November 2018).

ICT Development Index 2017, Available at: http://www.itu.int/net4/ITU-D/idi/2017/index.html (accessed 14 November 2018).

Indikatory cifrovoj jekonomiki 2017 [The indicators of digital economy: 2017]/National Research University Higher School of Economics. Available at: https://www.hse.ru/data/2017/08/03/1173504122/ICE2017.pdf (accessed 15 November 2018).

Indikatory cifrovoj jekonomiki 2018 [The indicators of digital economy: 2018]/National Research University Higher School of Economics. Available at: https://www.hse.ru/data/2018/08/20/1154812142/ICE2018.pdf.pdf (accessed 15 November 2018).

J'Son & Partners, Available at: http://web.json.ru/markets_research/analytical_reports/ (accessed 13 November 2018).

Jekspert RA 2018, Available at: http://raexpert.ru/ (accessed 13 November 2018).

Lola, I., Bakeev, M., Manukov, A. (2019). Effects of Influence of Economic and Technological Development of IT Segments on Digital Transformation of Retail Trade / NRU Higher School of Economics. Series WP BRP "Science, Technology and Innovation". No. WP BRP 102/STI/2019.

Low, J.-R. (2015). Greasing the Wheels of the Internet Economy. Available at: https://www.itu.int/en/ITU-D/Regional-Presence/AsiaPacific/Documents/Events/2015/June-GSMA-ITU/ICANN.pdf (accessed 13 November 2018).

McKinsey & Company. (2019). Twenty-five years of digitalization: ten insights how to play it right. URL: https://www.mckinsey.com/~/media/mckinsey/business%20functions/mckinsey%20digital/our%20insights/twenty-five%20years%20of%20digitization%20ten%20insights%20into%20how%20to%20play%20it%20right/mgi-briefing-note-twenty-five-years-of-digitization-may-2019.ashx (accessed 30 September 2019).

Mitchell, J, Smith, R. J., Weale, M. R. (2002). Aggregate versus disaggregate survey-based indicators of economic activity. London: National Institute of Economic and Social Research, № 194: 33 p. Series: National Institute discussion paper.

OECD. (2011). OECD Guide to Measuring the Information Society 2011. Available at: http://dx.doi.org/10.1787/10.1787/9789264113541-en (accessed 2 May 2020).

OECD. (2017). OECD Digital Economy Outlook 2017. Available at: http://dx.doi.org/10.1787/9789264276284-en (accessed 17 November 2018).

Pesaran, M. H., Weale, M. R. (2015). Survey expectations – CESifo working papers, No. 1599. Available: https://www.econstor.eu/bitstream/10419/19063/1/cesifo1_wp1599.pdf (accessed 12 November 2018).

Proietti, T., Frale, C. (2007). New proposals for the quantification of qualitative survey data. Available at: ftp://www.ceistorvergata.it/repec/rpaper/No-98.pdf (accessed 12 November 2018).

Suppes, P., Zines, Dzh. (1967). Osnovy teorii izmerenij [The basics of measuring theory]. Moscow: Mir.

The Web Index 2018, Available at: http://thewebindex.org/ (accessed 15 November 2018).

World Bank. (2010). Measuring foreign direct investment in the area of information and communication technology (Vol. 2) : Deliverable 1 - Definition of the ICT Sector. Available at: http://documents.worldbank.org/curated/en/757361468248669440/pdf/688700ESW0P1170BLIC00ICTEgypt0vol2.pdf (accessed 2 May 2020).

UNCTAD. (2017). Information Economy Report 2017: Digitalization, Trade and Development. Available at: https://unctad.org/en/PublicationsLibrary/ier2017_en.pdf (accessed 14 November 2018).