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# AN ANALYSIS OF FACTORS INFLUENCING THE DEVELOPMENT OF SELF-EMPLOYMENT DIGITALIZATION BASED ON FUZZY LOGIC

Andrei Plotnikov<sup>1,\*</sup>, Taras Vorobets<sup>2</sup>, Anna Urasova<sup>3</sup>

<sup>1</sup>Perm National Research Polytechnic University, Perm, Russia

<sup>2</sup>The Institute of economics The Ural branch of the Russian academy of sciences, Perm, Russia

<sup>3</sup>The Institute of economics The Ural branch of the Russian academy of sciences, Perm, Russia

\*plotnikov-av@mail.ru

*Self-employment in the Russian Federation is a special tax regime; tax on personal income is a simplified form of entrepreneurship. The self-employed are often associated with freelancers. The exponential growth of information increases uncertainty, and the development of digitalization levels out uncertainty. This work analyses the factors influencing the digitalization development of self-employment as an integral indicator that can affect the sustainability of self-employment. The main method used is a topological method based on the polymerase chain reaction method, as well as the model based on fuzzy sets theory – Mamdani fuzzy inference algorithms. The data for the study were collected through a survey posted on Google Forms. The respondents were experts in the self-employment sector. Eight people participated in the survey (4 – self-employed; 4 – university professors). The self-employed comprised the following areas: developer – 1; service worker – 1; online marketer – 1; musician, event host – 1. Further calculations were performed in Matlab. According to the study results, the level of factors in the development of self-employed digitalization is 0.502, which corresponds to the third interval of the five-level classifier and has growth potential.*

*Keywords: fuzzy logic, self-employment, digital economy, digital transformation, digitalization, information technology*

## 1 INTRODUCTION

The prerequisites for this study were the potential and credible sanctions against the Russian Federation.

The digitalization of the labour market is reflected in the reduction of bureaucratic entry barriers into international markets, and the decrease in migration activity from developing to developed regions and countries. The development of digital platforms for freelancers to access work remotely is due to income inequality, the standard of living, and the cost of living in different countries and regions [1–2].

Despite theoretical advances in understanding the process of value co-creation, there is still much to be done in understanding how salespeople can influence this process. As the role of the seller has changed and become more dynamic, the opportunity and potential to influence behaviour beyond direct transactions (e.g., knowledge brokering and value co-creation) have become increasingly evident [3]. Constant changes in the business environment influence customer expectations not only from the use or possession of a product but also in the process of choosing that product. The exponential growth of information increases uncertainty and the development of digitalization levels out uncertainty [4]. Thus, this paper analyses digitalization as an integral indicator that influences the sustainability of self-employment. Next, let us consider the characteristics chosen to form the integral indicator, "the digitalization of self-employment".

Online advertising. Content credibility depends on quality and impartiality [5]. In other words, users trust social media ads less than natural recommendations. The impact of different types of on-demand promotions and conversion rates are different [6–7]. Entrepreneurs mostly use targeted advertising on social networks (Facebook, VK, Instagram) and contextual advertising (Google Ads, Yandex Direct). Google Ads is a possible tool for recruiting and tracking a diverse sample of people [8–9]. Online advertising in social media has the function of personalized advertising in traditional media [10]. Moreover, such a feature is inherent not only in Facebook but also in other social networks, such as LinkedIn and VK. It is recommended to use different media since it is not completely clear which medium helped to make the conversion. To do this, there are attribution models that can be used to estimate the contribution of each source/medium to conversion [11–12]. In other words, the user visited the website three times before leaving an application. There is a possibility that the user has made a conversion on the website due to previous visits; therefore, these three visits are also of value. Thus, the last-click model underestimates content integration or medium integration and overestimates content separation [13–14].

Interaction with the client through CRM. The study of the human-technology interaction is based on the technology affordance theory. According to Vo-Thanh et al. (2021) [15] and Gibson (1977) [16] developed the genesis of this theory. The essence of this theory is to reconcile the usefulness of technology and the understanding of the

application of technology [17]. Understanding the application of technology is based on human perception. Thus, the theory focuses on flattening the understanding of the use of technology and the perception of the usefulness of technology among different groups of people. Thus, according to the study that the implementation of the CRM (customer relationship management) system meets the expectations of only 30% of entrepreneurs, while the rest have a lack of understanding of the technology. In other words, managers implemented a CRM system, and the business was not prepared to interpret the customer's path to purchase. This confirms that people have different approaches to the use of technology and consequently different perceptions of the usefulness of technology [15]. The main issue that drives the development of this theory is that the customer does not take advantage of the potential value of the CRM system.

According to the source [18], CRM is a business strategy that aims to increase customer satisfaction by segmenting customers based on their expectations. A strategy, in this case, is long-term work with customers, as well as an increase in lifetime value. CRM affects the increase in the loyalty factor. Technological CRM tasks are implemented in functional departments: customer service and support, as well as in sales. CRM ennobles the culture of service from a technological point of view [19–20]. CRM refers to information technology and is suitable for the implementation of entrepreneurship (including self-employed), while enterprise resource planning systems are suitable for enterprise business. CRM makes it possible to systematise the interaction process with the client, based on fixing events in a chain of sequence to the complete satisfaction of the client. Small businesses tend to have fewer opportunities to digitize their businesses. CRM is a business management tool, which has different functionalities and a positive impact on business results by supporting the entrepreneurial culture of tracking the chain of events along the customer's path.

About 70% of all CRM implementation projects fail to achieve their expected goals [18, 21]. In other words, a technical or engineering feature may be present in the activities of an entrepreneur or self-employed person, but this feature is poorly implemented. Such a problem occurs when there is an imbalance of competencies, i.e., business competencies prevail over technical (IT) competencies. Thus, the authors of this paper proposed the "Availability of IT competencies in the self-employed" indicator.

Access to website builders. A website builder is an online platform or SaaS with which a user, without IT skills, can build and administer a website. It can be a business card, a page, a blog, or an online store. The essence of website builders is to use prefabricated elements to build a website based on zero-code or low-code principles. Thus, website builders neutralize the entrepreneur's lack of IT competencies [22–23]. Website builders contain template solutions, with which one can build an independent website in a short time without involving front-end and back-end developers [24]. Consequently, to create a website or landing page or eCommerce website, there is no need to hire a developer, and one can do it oneself by simply having marketing competence.

In these builders, all modern websites have a cross-device layout adapted for devices: laptops, tablets, and phones. Thus, the entrepreneur, or self-employed, saves on the desktop layout or mobile layout development.

The conversion rate is the effectiveness indicator of a website. Entrepreneurs lag behind corporate businesses due to limited investment in website development for businesses [25]. Thus, website builders allow entrepreneurs (self-employed) to cut down on the budget for developing a website, as well as reduce the time frame for its approval and development.

The popularity of online applications for services/products among consumers. Online user behaviour is based on the uses and gratification theory developed by Katz [26–27]. The above-mentioned conversion rate reflects the popularity of online applications on websites, social networks, and messengers. Customers prefer shopping online because online shopping saves time and money while providing more choices. Security, trust, and product quality play an important role in customer satisfaction, and consequently [28–29] affect the user's intention to fill out a form or leave their contact details on a website – thus, making a conversion.

Customer access to online payments. Customer access to online payments implies the technical ability to make payments. For the self-employed, it means taking care of customers and setting up online cash registers at web stores or other websites that provide services. The technical threat of accepting online payments is mediated by sanctions. Thus, with the reduction of sanctions, it is assumed that entrepreneurial activity will improve.

Social media access. Users can generate user-generated content that is distributed to target audiences according to usefulness. Usefulness is understood as the relevance of the content to the target audience. Accordingly, the content's usefulness may not always be reflected in the complexity or completeness of the information. In other words, the content must meet the expectations of the target audience.

In social networks, users can interact with each other based on text and audio messages and use private and public forms of interaction. This all accelerates the process of forming business loyalty [30–31].

The integration of social network promotion and the use of CRM systems can make it possible to gather knowledge about customer perception of products, as well as obtain timely information on customer needs [3].

"E-Interactivity" is the consumer's experience and satisfaction when interacting with a website. Electronic interactivity shapes online consumer behaviour [27].

Online consumer satisfaction is formed through the process of the consumer's online behaviour and product consumption. In other words, "hedonic value has less impact on satisfaction than the utilitarian value" [27].

For example, according to a study, online communications in organizations increase loyalty and change their behaviour towards the business. Thus, an outside observer is converted into a business supporter. Two categories define the basis of online communication: diagnosis and sincerity. The diagnosis makes it possible to identify the problem, which is transformed into a problem for which a solution is formed. Diagnosis includes competence. Sincerity makes it possible to level out the contradictions between real feelings and business intentions in relation to the client. Thus, sincerity is reflected in honesty towards the customer/user, which leads to an increase in customer loyalty [32].

Along with "social" compensations, "economic" competencies are no less important in the structure of marketing competence, such as knowledge, skills, and experience in conducting an optimal dynamic budget allocation policy for an Internet advertising campaign [33].

Access to messengers. Messengers are an intermediate link between social networking and phone calls. Messengers increase the accessibility of communication [34] and are a tool for businesses to interact with customers through mobile or desktop apps. In addition to basic communications (audio and video communication, file sharing, photos, video, text), it is possible to send newsletters and program chatbots.

The presence of marketing competencies (including online marketing) in the self-employed. Marketing in information technology is dynamic and different from classical marketing approaches. Marketing can be either product-or firm-focused or stakeholder-focused. Buyers are interested parties [35]. Thus, by adopting a stakeholder-centric approach, marketing becomes customer-centric. If one further develops the concept of customer-centricity, marketing will become personalized. Personalization is the basic principle of online marketing, which can be used to create chains of communication for different groups of potential customers.

Online marketing campaigns are measured by two types of results: results during communications leading up to a transaction, resulting from interactions with products or services after they are purchased and paid for [36].

Marketing competence can include three generalized categories: knowledge, skills, and abilities. This paper will not touch on general concepts of marketing but will consider only the context of online communications.

Online marketers make decisions based on their knowledge of online consumer behaviour trends. Their changes in behaviour are due to the increase in mobile devices with which they get information and make purchases and payments [37].

The study [38] shows the basing of online marketing competence on ambidexterity. Ambidexterity is the combination of IT competencies for the application of internet technology and business competencies (marketing) to understand the market and customer needs. Accordingly, the ambidextrous industry borders on digital product innovation and communication through social media platforms and omnichannel marketing [39].

The key takeaway from marketing competencies is that it is important to reduce one's confidence in one's knowledge, experience, and skills based on established mental models and theories [40]. It follows that marketers must update their beliefs and assumptions according to observed data [41].

Availability of IT competencies in self-employed people. The peculiarity of competencies is not the skills, knowledge, and experience in the development of complex information systems, but the ability, knowledge, and experience in the application of online marketing tools and services (Google Ads, Facebook Ads, Google Tag Manager, website builders, Google Analytics).

Access to freelance exchanges. Digital platforms (digital knowledge platforms, freelancing exchanges) are suitable for finding on-demand work according to the outsourcing model and relate to microentrepreneurship in the field of intellectual labour. Digital platforms are based on the following principles: digitalization [42–43] (tracking all interactions for later analysis; offline transactions are eliminated), social networking (user relationships based on common node traits), contracting and knowledge work (flexible assessment of requirements and complexity; agreement, contracting and execution) [2], mutual trust [44–45]. Platforms coordinate work planning within project tasks and allow for arbitration when disputes arise [46].

As Shree et al. (2021) [47] pointed out, the main factor in the success of digital platforms is customer focus and loyalty. Moreover, given customer focus and personalization, each customer has a different expectation for the product. This creates complexity due to the diversity of customer desires.

Internet speed. Users satisfied with basic speeds refrain from using high-speed Internet, even if it is readily available. Despite the segmentation of users with respect to different Internet connection speeds, there is a segment of users who have no Internet. Users without Internet access cannot exhibit online behaviour, while freelancers from this segment can show online entrepreneurial activity [48].

The provider's high level of reliability has a positive impact on customer satisfaction [49–50]. The prevalence of the Internet in the country affects the entrepreneurial activity of the self-employed.

Affordable electronic equipment for work. Electronic equipment (video cameras, laptops, monitors, equipment for video and audio studios, etc.) makes it possible for the self-employed to expand their list of activities. Access

means the availability of equipment and a pricing policy that allows the self-employed to buy into ownership. Accordingly, affordability is reflected in the price sensitivity of the equipment. If equipment is available, then entrepreneurial activity increases.

Access to software. Access to software training is about affordability and installability. With the help of software, the self-employed carry out their activities (programming, development, design, data analysis, video editing, copywriting, etc.). Accordingly, the lack of access to software reduces the entrepreneurial activity of the self-employed.

Automating the tax payments on income (1–5% depending on whom the self-employed will partner with) makes it possible to focus on business rather than bureaucracy. The self-employed cannot hire staff under Russian law, which means they will focus all their working time on business tasks.

Availability of state digital platforms to support the self-employed. Having government platforms increases the transparency of the public sector – it is a way of good governance [51]. These are information state portals with the ability to register as self-employed. So, in Russia to become self-employed one has to register remotely. The application is reviewed within 6 days. The key factor is "remotely", that is, the platform (mobile app) makes it possible to avoid going to the tax office in person.

## 2 MATERIALS AND METHODS

This article uses a topological method based on the polymerase chain reaction method to analyse the structure of factors influencing the development of digitalization of the self-employed and freelancers.

A model based on the theory of fuzzy sets – Mamdani fuzzy inference algorithms – is used to determine the factors influencing the development of digitalization of freelance services and the self-employed market [52–53].

The data for the study was collected through a survey posted on Google Forms. The respondents were experts in the field of self-employment. Eight people participated in the survey (4 were actual self-employed; 4 were university professors). The self-employed consisted of the following areas: developer – 1; service worker – 1; online marketer – 1; musician, host of the event – 1. Further calculations were performed in Matlab (Table 1).

Table 1. Calculations performed in Matlab

Expert	x1	x2	x3	x4	x5	x6	x7	x8	x9	x10	x11	x12	x13	x14	x15
SE 1 (D)	0.6	0.6	0.1	0.8	0.4	0.1	0.1	0.7	0.9	0.5	0.5	0.9	0.5	0.6	0.2
SE 2 (S)	0.9	0.9	0.2	0.8	0.2	0.4	0.2	0.4	0.7	0.3	0.3	0.3	0.5	0.3	0.3
SE 3 (OM)	1	0.8	0.1	1	0.6	0.1	0.1	0.6	0.9	0.8	0.8	0.9	0.7	0.7	0.1
SE 4 (MHE)	0.8	0.8	0.2	0.6	0.4	0.1	0.1	0.3	0.7	0.3	0.2	0.1	0.3	0.6	0.3
PT 1	0.4	0.4	0.2	0.8	0.7	0.2	0.1	0.8	0.7	0.5	0.6	0.4	0.7	0.6	0.3
PT 2	0.5	0.5	0.1	0.8	0.8	0.1	0.1	0.9	0.8	0.4	0.7	0.6	0.9	0.8	0.1
PT 3	0.5	0.5	0.2	0.9	0.6	0.1	0.1	0.8	0.6	0.4	0.5	0.4	0.7	0.6	0.1
PT 4	0.5	0.5	0.2	0.8	0.7	0.1	0.3	0.8	0.8	0.6	0.7	0.6	0.8	0.7	0.1
Mean	0.65	0.63	0.16	0.81	0.6	0.2	0.14	0.66	0.76	0.48	0.54	0.53	0.638	0.613	0.188
SD	0.21	0.17	0.05	0.11	0.2	0.1	0.07	0.2	0.1	0.16	0.19	0.26	0.18	0.136	0.093

SE – self-employed; PT – professorial and teaching staff;

D – developer, S – service worker; OM – online marketer; MHE – musician, host of the event

A system of indicators was developed, which makes it possible to determine the level of factors influencing self-employed digitalization. Moreover, indicators are not counted in absolute values, but in terms (low level, average level, high level). Each term is a set. The fuzzy inference algorithm in this study is the Mamdani algorithm [54]. The algorithm is capable of fully mapping the parameters of the digitalization system [55].

The fuzzy logic inference algorithm uses a generalized inference tree and responds to the sequence [56]:

- the monitoring of the external and internal functioning of the market to determine the hierarchical structure of factors, which influence the development of digitalization and affect the functional sustainability of the market.
- based on the hierarchical structure of influencing factors, a cross-cutting system of indicators is formed which describes the sustainability of digitalization for the self-employed (Table 2);

Table 2. Representation of factors influencing the development of digitalization using functioning characteristics

Digitalization	$K_i$	$Z_i$	Indicators	$x_i$
	Communications $K_1$	Social communications $Z_1$	Social media access	$x_1$
			Access to messengers	$x_2$
Business		Interaction with the client through CRM	$x_3$	

$K_i$	$Z_i$	Indicators	$X_i$
	communications $Z_2$	Access to online advertising	$X_4$
		Access to freelance exchanges	$X_5$
State regulation $K_2$		Automation of income tax payment	$X_6$
		Availability of state digital platforms to support the self-employed	$X_7$
Competencies $K_3$		Availability of IT competencies in self-employed people	$X_8$
		The self-employed have competencies in online marketing	$X_9$
K <sub>4</sub> Technologies		Affordable electronic equipment for work	$X_{10}$
		Access to website builders	$X_{11}$
	SaaS $Z_3$	Access to software	$X_{12}$
		Customer access to online payments	$X_{13}$
	Online behavior $Z_4$	Popularity of online applications for services/products among consumers	$X_{14}$
		Internet speed	$X_{15}$

Source: compiled by the authors

When compiling the indicator base, the authors considered including the following indicators: application and development of machine learning in digital platforms [57]. However, this indicator was rejected because its interpretation was not a valid representative sample of respondents.

Let us compare different combinations.

It could be combined as follows: marketing, software, hardware. As a consequence, one can obtain the following hierarchy:

The software part ( $Z_1$ ): access to social networks ( $x_1$ ), access to messengers ( $x_2$ ),

customer interaction through CRM ( $x_3$ ), access to online advertising ( $x_4$ ),

access to freelance exchanges ( $x_5$ ), automation of income tax payments ( $x_6$ ), availability of state digital platforms to support the self-employed ( $x_7$ ), availability of IT competencies for the self-employed ( $x_8$ ), access to website builders ( $x_{11}$ ), access to software ( $x_{12}$ ).

The marketing part ( $Z_2$ ): the presence of competencies in online marketing among the self-employed ( $x_9$ ), customer access to online payments ( $x_{13}$ ), and the popularity of online applications for services/products among consumers ( $x_{14}$ ).

Hardware ( $Z_3$ ): available electronic equipment for operation ( $x_{10}$ ), Internet speed ( $x_{15}$ ).

It was assumed that the "Hardware" ( $Z_3$ ) and "Software" ( $Z_1$ ) parts would go further into "Technology" ( $K_1$ ), and the marketing part would be autonomous.

It was discussed earlier that the indicator "Access to messengers" reflects the marketing part, not the software part, as the keyword is "access" and not "development." Nevertheless, the authors agreed that the key feature is still "messenger," and this belongs to the software part.

Another option for grouping factors was considered:

Platforms ( $Z_1$ ):  $x_1, x_2, x_5, x_7$ ;

SaaS ( $Z_2$ ):  $x_3, x_{11}, x_{12}$ ;

Competencies ( $Z_3$ ):  $x_8, x_9$ ;

Hardware ( $Z_4$ ):  $x_{10}, x_{15}$ ;

Online behaviour ( $Z_5$ ):  $x_6, x_{13}, x_{14}$ .

Access to online advertising ( $x_4$ ) – offline.

In such grouping, it was assumed that "Platforms" ( $Z_1$ ), "SaaS" ( $Z_2$ ), "Hardware" ( $Z_4$ ), and the autonomous indicator "Access to online advertising" ( $x_4$ ) would go further to "Technologies" ( $Z_1$ ), and "Competencies" ( $Z_3$ ) and "Online behaviour" ( $Z_5$ ) will go to the "People" group. The authors abandoned this idea during the discussion.

The authors were also tempted to use off-the-shelf factors such as advanced data analytics, artificial intelligence and machine learning, big data infrastructure for structured data [58–59], big data infrastructure for unstructured data, digital sales tools, Internet of Things technology, blockchain technology, etc. [60]. These factors certainly affect digitalization, but given the context of self-employment, freelancing, and micro-entrepreneurship, the authors have not applied factors that are more suited to the enterprise segment.

### 3 RESULTS AND DISCUSSION

We can see factors influencing the development of digitalization in Table 3, which describes analytical expression based on fuzzy logic and its interpretation. In accordance with analytical expression based on fuzzy logic, we determine the digitalization value (Table 4).

Table 3. The representation of factors influencing the development of digitalization based on fuzzy logic (Compiled by the authors)

Interpretation	Analytical expression based on fuzzy logic
This level is judged unstable, but there is still a possibility of moving out of the "unsatisfactory (limiting)" state	$a1(R) = \begin{cases} 1 & \text{if } 0 \leq R \leq 0.1 \\ [22(0.2 - R)] & 0.1 \leq R \leq 0.2 \\ 0 & \text{if } 0.2 \leq R \leq 1 \end{cases}$
At this level, functioning may be retarded; if similar signs appear, it is rated as "satisfactory (below average)"	$a2(R) = \begin{cases} 0 & \text{if } 0 \leq R \leq 0.1 \\ [22(R - 0.1)] & 0.1 \leq R \leq 0.2 \\ 1 & \text{if } 0.2 \leq R \leq 0.3 \\ [22(0.4 - R)] & 0.3 \leq R \leq 0.4 \\ 0 & \text{if } 0.4 \leq R \leq 1 \end{cases}$
Functioning is stable, and its characteristic corresponds to the level "satisfactory (average)"	$a3(R) = \begin{cases} 0 & \text{if } 0 \leq R \leq 0.3 \\ [22(R - 0.3)] & 0.3 \leq R \leq 0.4 \\ 1 & \text{if } 0.4 \leq R \leq 0.5 \\ [22(0.6 - R)] & 0.5 \leq R \leq 0.6 \\ 0 & \text{if } 0.6 \leq R \leq 1 \end{cases}$
Functioning is accelerated, and its characteristic corresponds to "satisfactory (above average)"	$a4(R) = \begin{cases} 0 & \text{if } 0 \leq R \leq 0.5 \\ [22(R - 0.5)] & 0.5 \leq R \leq 0.6 \\ 1 & \text{if } 0.6 \leq R \leq 0.7 \\ [22(0.8 - R)] & 0.7 \leq R \leq 0.8 \\ 0 & \text{if } 0.8 \leq R \leq 1 \end{cases}$
Functioning is rapid, and its characteristic corresponds to "satisfactory (high)"	$a5(R) = \begin{cases} 1 & \text{if } 0 \leq R \leq 0.7 \\ [22(R - 0.7)] & 0.7 \leq R \leq 0.8 \\ 0 & \text{if } 0.8 \leq R \leq 1 \end{cases}$

Table 4 shows us the structure of the digitalization value.

Table 4. Presenting the level of factors influencing the development of digitalization (Compiled by the authors)

	$K_i$	$Z_i$	Indicators	$x_i$	Evaluation	
Digitalization <b>0.502</b>	Communications $K_1$ <b>0.5</b>	Social communications $Z_1$ <b>0.555</b>	Social media access	$x_1$	0.65	
			Access to messengers	$x_2$	0.63	
		Business communications $Z_2$ <b>0.5</b>	Interaction with the client through CRM	$x_3$	0.16	
			Access to online advertising	$x_4$	0.81	
			Access to freelance exchanges	$x_5$	0.55	
	State regulation $K_2$ <b>0.156</b>		Automation of income tax payment	$x_6$	0.15	
			Availability of state digital platforms to support the self-employed	$x_7$	0.14	
	Competencies $K_3$ <b>0.568</b>		Availability of IT competencies in self-employed people	$x_8$	0.66	
			The self-employed have competencies in online marketing	$x_9$	0.76	
	Technologies $K_4$ <b>0.5</b>		SaaS $Z_3$ <b>0.5</b>	Affordable electronic equipment for work	$x_{10}$	0.48
				Access to website builders	$x_{11}$	0.54
			Access to software	$x_{12}$	0.53	
			Online behaviour $Z_4$ <b>0.543</b>	Customer access to online payments	$x_{13}$	0.64
				Popularity of online applications for services/products among consumers	$x_{14}$	0.61
			Internet speed	$x_{15}$	0.19	

During the discussion between the co-authors of the article, it was decided to create the group in Figure 1.

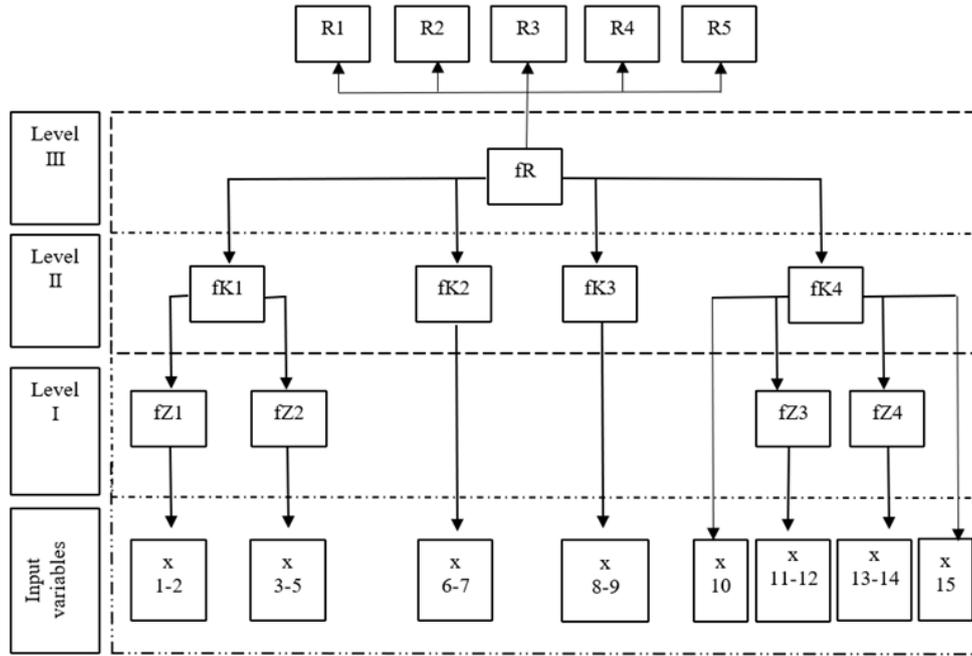


Fig. 1. The logical output tree of the integral digitization indicator

Let us determine the membership functions of the estimation terms of output variables corresponding to the vector of input values and intermediate variables in the hierarchy:

$$n = 1n_{\tau} [(K_j = K_j^{Nn_{\tau}}) \cap (K_j = K_j^{Sn_{\tau}}) \cap (K_j = K_j^{Vn_{\tau}})] \rightarrow R_j, i = 1, \bar{5}; j = 1, \bar{4}; \tau = 1, \bar{81}$$

$$n = 1n_{\tau} [(x_{gj} = x_{gj}^{Nn_{\tau}}) \cap (x_{gj} = x_{gj}^{Sn_{\tau}}) \cap (x_{gj} = x_{gj}^{Vn_{\tau}})] \rightarrow K_j, gj = 1, \bar{2}; \tau = 1, \bar{9}$$

$$n = 1n_{\tau} [(Z_{tj} = Z_{tj}^{Nn_{\tau}}) \cap (Z_{tj} = Z_{tj}^{Sn_{\tau}}) \cap (Z_{tj} = Z_{tj}^{Vn_{\tau}})] \rightarrow K_j, tj = 1, \bar{4}; \tau = 1, \bar{81}$$

$$n = 1n_{\tau} [(x_{gj} = x_{gj}^{Nn_{\tau}}) \cap (x_{gj} = x_{gj}^{Sn_{\tau}}) \cap (x_{gj} = x_{gj}^{Vn_{\tau}})] \rightarrow Z_1, > 1, \bar{2}; \tau = 1, \bar{9}$$

$$n = 1n_{\tau} [(x_{gj} = x_{gj}^{Nn_{\tau}}) \cap (x_{gj} = x_{gj}^{Sn_{\tau}}) \cap (x_{gj} = x_{gj}^{Vn_{\tau}})] \rightarrow Z_2, > 1, \bar{3}; \tau = 1, \bar{27}$$

$$n = 1n_{\tau} [(x_{gj} = x_{gj}^{Nn_{\tau}}) \cap (x_{gj} = x_{gj}^{Sn_{\tau}}) \cap (x_{gj} = x_{gj}^{Vn_{\tau}})] \rightarrow Z_3, > 1, \bar{2}; \tau = 1, \bar{9}$$

$$n = 1n_{\tau} [(x_{gj} = x_{gj}^{Nn_{\tau}}) \cap (x_{gj} = x_{gj}^{Sn_{\tau}}) \cap (x_{gj} = x_{gj}^{Vn_{\tau}})] \rightarrow Z_4, > 1, \bar{2}; \tau = 1, \bar{9}$$

$$\tau = 181 [g = 1 | 20(x_g = x_g^{N\tau}) \cap (x_g = x_g^{S\tau}) \cap (x_g = x_g^{V\tau})] \rightarrow X = X_A,$$

Describing expert information on the ratio:

$$R_i = \int_W \frac{a^{R_i}(W)}{\omega}, (i=1;\bar{5}), \omega \in W$$

$$K_i = \int_{U_X} \frac{a^{K_j}(U_X)}{v}, (j=1;\bar{4}), v \in U_X,$$

$$Z_i = \int_{Q_X} \frac{a^{Z_j}(Q_X)}{q_X}, (t=1;\bar{4}), q_X \in Q_X,$$

$$x_g = \int_{X_A} \frac{a^{X_g}(X_A)}{x}, (g=1;\bar{15}), x_g = X_A,$$

where W – a universal indicator that sets R,  $R_i \in W, i=1;\bar{5}$ ;

$U_X$  – a universal indicator that sets K,  $K_j \in U_X, j=1;\bar{4}$ ;

$Q_X$  – a universal indicator that sets Z,  $Z_t \in Q_X, t=1;\bar{4}$ ;

$X_A$  – a universal indicator that sets x,  $x_g \in X_A, g=1;\bar{15}$ ;

$\alpha R_i^*(x)$  – a membership function of the variable x to the fuzzy term  $R_i^*$ .

The level of "Communications" based on the three-level The level of "State regulation" based on the three-level

classifier is shown in Figure 2.

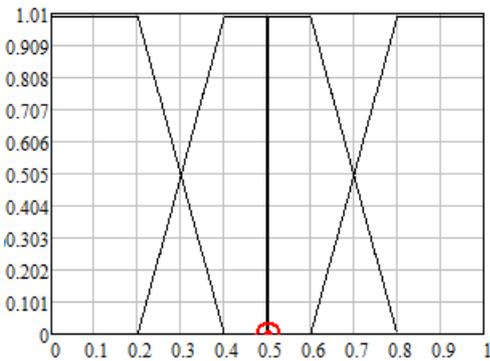


Fig. 2. Graphical representation of the level of "Communications" based on the three-level classifier.

classifier is shown in Figure 3.

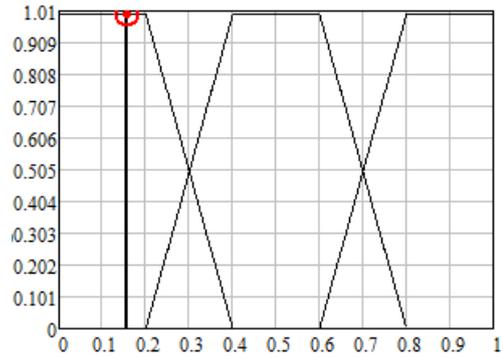


Fig. 3. Graphical representation of "State regulation" based on a three-level classifier (low level, medium level, high level)

The level of "Competencies" based on the three-level classifier is shown in Figure 4.

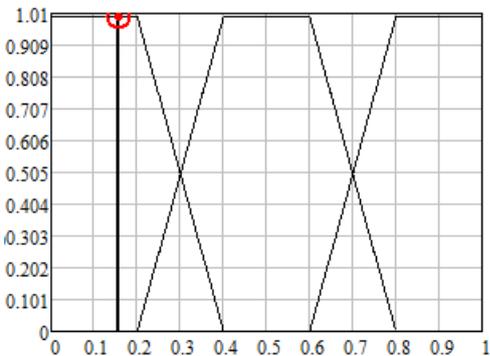


Fig. 4. Graphical representation of "Competencies" based on a three-level classifier (low level, medium level, high level)

The level of "Technology" based on the three-level classifier is shown in Figure 5.

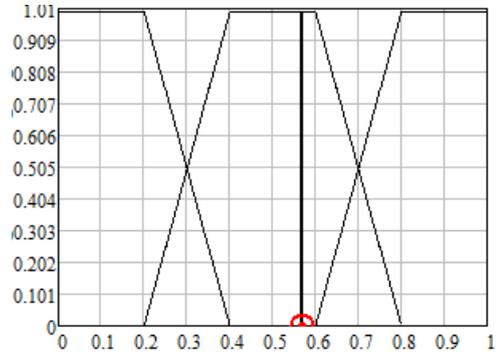


Fig. 5. Graphical representation of "Technology" based on a three-level classifier (low level, medium level, high level)

At the final stage, let us fuzzify the quantitative characteristic to obtain the most understandable assessment, consistent with the primary logic of judgment, which will also allow a graphical interpretation of the level of factors influencing the development of self-employed digitalization (Figure 6).

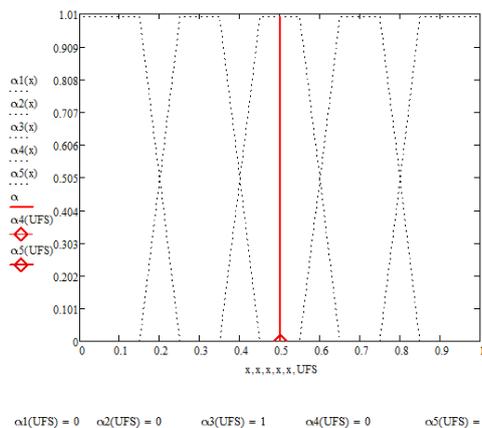


Fig. 6. Graphical representation of "Digitalization" (UFS) based on a five-level classifier

According to the results of the calculations above, it follows that the value of factors influencing the development of digitalization of the self-employed in the Russian Federation is 0.502, which corresponds to the third interval of the five-level classifier. The defined set is characterized by the following linguistic definition – digitalization is stable,

and its characteristic corresponds to the average level. In other words, the level of digitalization of the self-employed has growth potential.

It should be noted that the result of the evaluation is both the initial variable, which is an integral indicator of the factors influencing the digitalization development of self-employment, and the output variables by levels of hierarchy. For example, for the third level of the hierarchy, the results were obtained for four characteristics: Communications, Government Regulation, Competencies, and Technologies, which in turn are the input variables for determining the integral indicator – Digitalization of the Self-Employed. It should be noted that three characteristics (Communications, Competencies, and Technology) show an average level of the indicator, and State Regulation shows a low level of the indicator.

#### **4 CONCLUSION**

It is possible to make generalizations and conclusions about the high-performance characteristics. Delacroix et al. (2019) [61] note that technical competencies are offset by the spread of P2P platforms (two-sided market: VK, Facebook buy-and-sell, Avito (Russian marketplace), freelance marketplaces). Thus, the lack of IT competencies can be compensated for when interacting on P2P platforms. The next alternative to compensate for the lack of IT competencies of entrepreneurs is the sharing economy. The sharing economy takes one back to natural exchange. P2P platforms focus on entrepreneurs with limited financial and technical resources.

Low Internet speeds and sometimes no E, 3G, or LTE Internet connection are the most pressing problems in the provinces. In urban agglomerations, there is no such problem and people cannot imagine their life without the Internet. It is important to consider that the availability of the Internet affects the speed of business communications. That is why this indicator was included.

With the introduction of sanctions, hardware or electronic equipment will be less accessible to the self-employed due to its higher cost, and therefore, according to the law of economics, all costs will be distributed to all customers, and therefore the purchasing power of customers will decrease, and hence the development of the self-employed.

Regarding software, there will be import substitution in the Russian Federation, as well as the distribution of pirated software. The presence of pirated equipment will worsen business ethics and perhaps become the "new norm" among entrepreneurs and self-employed.

The model integrates both qualitative and quantitative approaches to assessing the digitalization of the self-employed. It identifies 15 input linguistic variables characterizing the digitalization development factors. Using fuzzy inference based on the Mamdani algorithm makes it possible to obtain the numerical value of digitization, the linguistic description of the digitization, and the degree of expert confidence in the contribution of each structural element. The results of the study will allow government agencies that regulate self-employment to prioritize the development of factors affecting digitalization [62].

The mechanism of the digitalization structure analysis based on fuzzy logic has a wide range of possibilities. The disadvantages of this approach are subjectivity in the choice of membership functions and the formation of fuzzy input rules.

#### **5 RESEARCH LIMITATIONS AND FUTURE RESEARCH**

We conducted a study in January-February 2022, and accordingly, when selecting factors for analysis, we did not consider internal sanctions. Facebook and Instagram (Meta) social networks are shut down by internal sanctions and the termination of Google Ads activity under the ban of the Russian authorities. External sanctions are termination initiatives initiated by foreign companies. Internal and external sanctions are "The Black Swan" and affect the digitalization of the self-employed much more than the factors we have chosen. The final impact of the factors will be noticeable in 0.5-1 year.

The following limitation of the study is the selection of factors relevant for digitalization (questions to Xi-level experts) with their subsequent structure (Zi-level; Ki-level). We could pick up other factors (questions for experts) when constructing the structure of factors. For example, an exciting factor not included in the study is the "level of state regulation of the Internet". Since unused factor may be a second-level factor (Zi-level or Ki-level), on which online marketing depends (Social media access (x1), Access to messengers (x2), Access to online advertising (x4)). This factor implies a ban on access to foreign sites and involves using the "Russian" Internet. Thus, we will conduct a similar study in 0.5-1 years to determine the influence of factors that were not included in this study. We are also interested in conducting a similar study with these and other experts to compare the available results (January-February 2022) and future results (for example, January-February 2023). Conducting a repeat study will allow us to find deviations and determine trends in the weight and significance of factors affecting the digitalization of self-employment.

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