Perception of New Technologies: Constructing an Innovation Openness Index

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Abstract

Rapid technological progress is one of the basic processes in the modern world. It is an integral part both in the field of labor and employment and in leisure and recreation. The request for an accelerated implementation of digital technologies in the economy and social sphere, which is inherent in one of the national development goals of the Russian Federation, makes this topic more important. In the presence of technological challenges, people have to adapt to constantly emerging innovations. Meanwhile the perception of innovations together with other individual characteristics and socioeconomic traits of different social groups could be considered determinants of openness to technological innovations. Based on this assumption, the authors of this article set the following objectives: they evaluate the openness of the population to innovation (through the construction of the index), examine the perception of innovation (by identifying factors of the perception of new technologies), and test the relationship between openness to innovation and the perception of new technologies. The multi-domain index of openness to innovation combines assessments of individual attitude, acceptance, and trust in innovations related to various spheres of the population's life. The perception of innovation is revealed through the F. Davis Technology Acceptance Model and includes: perceived ease of use of new technologies; the perceived usefulness of new technologies; perceived security and reliability of new technologies; and perceived elitist features of the new technologies. This study demonstrates that openness to innovation depends upon the perception of new technologies and that this is differentiated among population groups.

Keywords: innovation; perception of innovation; openness to innovation; technology acceptance model; multidimensional index; technological progress

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In the modern world, ideas are constantly being generated to create new, and modernize existing technological devices designed to improve living standards and increase labor productivity. However, such devices are adopted in different ways: some people eagerly wait for the release of the next new gadget, while others get stressed even by relatively simple, commonly used technologies. One way or another people increasingly have to use technological innovations, voluntarily or they are forced by the circumstances, for example, due to the digitization of various sectors or because their employer strives to optimize the duration and content of work processes. An ageing population and increasingly diverse work histories (among other things due to increased retirement age) that reflect the potential need to change profession, take an integrated retraining course, and master new technological devices, add to the urgency of the problem of coping with innovations. As a result, the ability to master innovations becomes a key to adapting to new realities.

In an attempt to assess the Russian public's openness to innovations, their perception of new technological devices was analyzed. This data will help to gauge the readiness of Russian society for the new era – the "sixth technological paradigm" – which is increasingly referred to in political statements and expert discussions [*Grinin, Korotayev*, 2015] as digitization and the "smart economy" [*Ansong, Boateng*, 2019; *Negrea et al*., 2019; *Nepelski*, 2019].

Our study aims to assess Russians' attitudes toward technological progress, compile profiles of more advanced groups, and identify the determinants of openness to innovations.

To accomplish these objectives, a specialized three-domain index was constructed using an originally developed methodology, which allows one to measure the public's openness to innovations. Further, the perception of new technological devices was studied through factor analysis; and finally, its relationship with openness to innovations was tested in the context of demographic and socioeconomic characteristics. Thus, this study accomplishes both methodological and analytical objectives to reveal specific features of the public perception of innovations.

A Review of International Practices

Numerous experts have studied attitudes toward innovations. Countries at different stages of economic development were analyzed with different access to cutting-edge technological solutions. A number of studies offer cross-country analyses of innovation potential and the current development level. For example, according to the World Bank, R&D expenditures as a share of GDP in Russia is almost two times higher than in India, but four times lower than in Korea.[1] In the Global Innovation Index Russia ranks 47th of 131, while Switzerland, Sweden, and the United States are the top three [Cornell University et al., 2020]. Various studies compare the actual level of and the potential for innovation-based development in two or more countries based on relevant macro-data [*Polterovich*, 2009].

However, it would not be possible to comprehensively compare the public perception of innovations across countries due to the very limited range of cross-national surveys and insufficient availability of microdata. The Eurobarometer survey which has been carried out in EU countries since the 1970s should be mentioned here. It periodically includes modules designed to assess attitudes toward science and innovation. The poll results indicate growing public attention to advanced technological solutions, with the Scandinavian countries taking the lead. The Eurobarometer reflects different socio-demographic groups' perception of innovations' impact upon various aspects of life [European Commission, 2014]. However, since Russia does not regularly participate in these polls, we have no data to compare its domestic situation with that of other countries.[2] According to the available data for 2006, Russians' opinions on new technologies' impact upon life are quite pessimistic: in terms of the share of positive assessments, Russia is close to the bottom, lagging behind European countries, the US, and Canada [*Shuvalova*, 2007]. Nevertheless, after 15 years, the situation seems to be changing, which is evidenced by the data obtained in the framework of the 2019 survey "Monitoring innovation activities of innovation process participants"[3] by the HSE Institute for Statistical Studies and Economics of Knowledge. According to this survey, Russians and residents of EU countries assess the prospects for applying new technologies at work similarly, welcoming robotization but fearing job cuts in the future.

Under these circumstances, the only way to compare Russia with other countries is using indicators measuring the public's access to the internet and their computer skills. The country ranks seventh in the world by the number of internet users and Russian is one of the ten languages most commonly used on the internet.[4] In 2016 the number of fixed broadband internet subscribers in Russia exceeded

[1] https://data.worldbank.org/indicator/GB.XPD.RSDV.GD.ZS, accessed on 27.01.2021.

[2] The "Eurobarometer in Russia" project has been regularly implemented by the Centre for Sociological Research of the Russian Presidential Academy of National Economy and Public Administration since 2012. However, the survey does not include comparable questions relevant for the topic of this study. For more, see: https://www.ranepa.ru/nauka-i-konsalting/strategii-i-doklady/evrobarometr/evrobarometr/, accessed on 15.12.2020.

[3] https://issek.hse.ru/news/311950906.html, accessed on 18.02.2021.

[4] https://www.internetworldstats.com/stats4.htm, accessed on 27.01.2021.

20% of the population,[5] which is comparable with Italy and China, but significantly lower than in France or Korea (where this figure is close to 40%) [*Bobylev, Grigoriev,* 2018]. At the same time, as the HSE ISSEK data suggest, Russians access the internet to make purchases and use banking services less often. However, the most recent factor affecting the development of the public's digital skills has been the COVID-19 pandemic. In the context of lockdown and the shift to remote employment and education, Russians began to more actively use various software and applications in everyday life[6] including for self-education and the development of human capital.[7]

However, if in terms of digital skills, Russians generally tend to lag behind Europeans in terms of online social interaction (from making video calls via various applications to communicating on social networks) they are ahead of the European averages.[8] Russia is above average in terms of the innovation potential indicators available for comparison. Accordingly, we analyzed the perception of new technologies by Russians and developed a methodological tool which subsequently, when comparable international survey data becomes available, can be applied for cross-country comparisons.

Innovations as the Object of Social Research

Innovation became the focus of scientific interest for the first time in the classic work by Joseph Schumpeter "The Theory of Economic Development" [*Schumpeter,* 1934]. Initially it was of a purely economic nature. For a long time the concept of "innovation" was applied exclusively to production processes in the context of advancing them, and was considered only as a means of doing so.

Later definitions focused on other aspects. In particular, Peter Drucker proposed a broader approach which saw "innovation" not just as a technical concept but one combining economic and social dimensions, due to the creation of value added and consumer properties [*Drucker*, 1985]. In Boris Santo's work, innovation is seen as a result of economic development, a process of designing better technologies to obtain advantages [*Santo*, 1994].

In the 1990s, innovations were already understood not only as improved products, but also as more advanced production processes. Subsequently the focus has shifted to other areas of studying and applying innovation, including the social sphere,[9] work organization and management, media, and municipal policy. Finally, innovation was recognized as a multidisciplinary process which goes beyond the scope of organizations, countries, or scientific disciplines [*Gault, von Hippel*, 2009].

There are structuralist and process-oriented approaches to analyzing innovation.

In the first case innovation is seen as an element introduced into society at various stages of the life cycle, which remains unchanged [*Swan et al*., 1999]. An example is the concept of diffusion of innovations which defines this process as extended over time, with the duration of innovations' dissemination in society (or in another system) determined by the time it takes various individuals to decide to adopt them [*Rogers*, 2003]. Since not everyone accepts innovations equally and at the same time, a user classification was introduced based on technology adoption time.

Five groups were identified: innovators (2.5%), early adopters (13.5%), early majority (34%), late majority (34%), and finally, laggards (16%). Each next group accepts an innovation only after it was adopted by its predecessors: its members need more time to accept the innovation since they are unwilling to take risks. As a rule, to gain the critical mass required for public acceptance, the new product must be adopted by at least 50% of the population.

The second approach, a process-oriented one, grants innovations a greater dynamism believing their evolution is affected by various social, political, economic, and other factors. New ideas are generated, discussed, and communicated, and their subsequent application depends upon the organizational context [*Swan et al*., 1999].

The process approach is based on the OECD and Eurostat practices which define innovations as "new or improved products or processes (or their combinations) which are significantly different from previous analogues, available to potential users (in the case of a product) or applied in practice (in the case of a process)" [OECD, Eurostat, 2018]. Openness to innovations is discussed not only in a narrow practical context, but also in wider cultural and historical ones. In the 20th century, totalitarian regimes tended to significantly restrict individuals' aspirations to freely produce and adopt innovations,[10] which

[5] On the whole, three-quarters of Russian households currently have internet access (https://issek.hse.ru/news/316247475.html, accessed on 18.02.2021.)

[6] https://issek.hse.ru/news/438496284.html, accessed on 18.02.2021.

[7] https://issek.hse.ru/news/376501875.html, accessed on 18.02.2021.

[8] https://issek.hse.ru/news/377859466.html, accessed on 27.01.2021.

[9] Social innovation is becoming a separate subject of innovation studies and also has many different interpretations.

[10] The problem of transgression and its consequences is generally relevant in the context of discussing the emergence and dissemination of innovations. However, the risks are especially high for those who create and adopt innovations in authoritarian and totalitarian regimes, where innovation activity can lead not only to losing one's reputation in the community, but also to expulsion from it. [*Wegner*, 2019].

among other things affected the mentality of a dominant part of the Russian public and determined the specific features governing the perception of innovations in the country.

The Technology Acceptance Model

The methodological basis of our work is provided by the Technology Acceptance Model (TAM) [*Davis*, 1989], which allows one to assess users' willingness to apply computer technology at work. The model is based on the assumption that the adoption and further application of a new information system depends on its perception by the user. The primary aspects of perception are perceived usefulness and perceived ease of use.

These variables explain the differences in users' intentions. Perceived usefulness shows the level of an individual's confidence that using the innovation will increase their productivity, while perceived ease of use - that adopting the innovation will not require a significant effort [*Davis*, 1989]. Subsequently the TAM model was applied to assess the adoption of not only computer technologies, but also various information systems (including in education, banking, financial services, and e-commerce), and the use of various mobile applications. In some cases, this model is supplemented with variables such as social influence and trust. It was assumed that social pressure in the form of subjective norms affects the intention to use particular technologies, since individuals can choose a behavior to match the expectations of their peers. It has been demonstrated that subjective norms significantly affect the ability to predict the intention to use a particular technology [*Venkatesh, Davis*, 2000]. By synthesizing various approaches, a unified theory of technology acceptance and use was proposed, according to which users' behavior is determined by their self-assessment of their own productivity (through perceived usefulness), possible effort (through perceived ease of use), social influence, and working conditions [*Venkatesh et al.*, 2003]. Since many new technologies, especially in the field of e-commerce or electronic financial services, put consumers in a situation of risk and uncertainty, there is also the question of trust in them.

Accordingly, a number of researchers incorporated into the technology acceptance model the trust variable, which affects individuals' intention to adopt innovations [*Gefen et al.*, 2003] since it is trust that largely determines users' willingness to participate in monetary exchanges and the dissemination of personal data via online networks [*Hoffman et al.*, 1999].

A number of studies were focused on the cultural component because the perception of technologies and their further application is not just the result of rational decision-making but is largely determined by cultural and country-specific characteristics [*Im et al.*, 2011]. National markets, the degree of technology penetration, and relevant government policies differ. The perception of innovative processes has intercultural aspects. This affects the public's ability to accept innovations in various areas. International differences in the perception of ease of use and usefulness were assessed on the basis of the cultural dimensions theory [*Hofstede*, 1984] and these parameters' contribution to the intention to adopt the technology depending on the national cultural context was compared. For example, an earlier study compared the results of applying the TAM model in Japan, Switzerland, and the US. The authors found that users' willingness to adopt technologies (email was used as an example) could be predicted in the United States and Switzerland, but not in Japan [*Straub et. al.*, 1997]. International comparison is not a specific objective of this study, but a reference to the importance of taking into account cultural aspects that emphasizes the fact that social factors must be kept in mind when the perception of innovations and openness to them are measured.[11]

For the purposes of this paper, we assume that the perception of innovations, along with other individual features and characteristics of socioeconomic groups can be a factor affecting the openness to new technological solutions, and thus promote their adoption. The study is structured into three sections as follows:

- assessing openness to innovations (using a specially constructed index);
- analyzing the perception of innovations (by identifying factors affecting perception of new technological devices);
- testing the correlation between openness to innovations and the perception of new gadgets.

Openness is understood as the individual inclination to adopt innovations in various areas of life, expressed through the attitude toward, acceptance of, and trust in them. The perception of innovations comprises subjective personal judgments concerning their characteristics.

Empirical and Methodological Basis of the Study

The survey "Public perception of socio-economic changes in modern Russia" conducted in February 2017 (VNSEI) provides sufficient data for a comprehensive study of openness to innovations. This

[11] A brief overview of international differences in technology acceptance is presented in [*Im et al.*, 2011], along with an assessment of the differences in applying an improved version of the TAM for US and Korean users of internet banking technologies and digital players.

national representative survey is based on a unique sample built using a multimodal method: data was collected via face-to-face interviews and an online survey.[12] The total number of respondents was 5,087 (2,548 and 2,539, respectively); the sample was representative in terms of the social structure of the population.[13]

The survey included modules measuring the application of new technologies and innovations in various areas of life and questions to determine the attitude towards new technological devices based on the TAM. To assess the openness to innovations, the index method for measuring the living standard and quality of life was used [*Hallerod*, 1994; *Willitts*, 2006; *Decancq, Lugo*, 2013]. The constructed multidomain indicator allows one to receive an integrated assessment from each respondent (Formulas 1 and 2).

$$I_n = \frac{\sum a_i x_i}{\sum a_i} \times 100\,, \quad (1)$$

where:

I_n is the innovation index component (domain index);

x_i are domain components (1 - individual is inclined to use innovations, 0 - not inclined);

a_i is domain component weight (share of individuals not inclined to use innovations);

i is the number of domain components.

$$I = \sum b_n I_n\,, \quad (2)$$

where:

I is the innovation index;

I_n are innovation index components (domain indices);

b_n is the component (domain) weight calculated using univariate analysis;

n is the number of components (domains).

Individual perception of innovations was measured by identifying the factors affecting attitudes toward them using a set of questions about 17 variables (factor analysis conducted using the principal component analysis method), based on the TAM model.[14] Employees' willingness to use computer technologies and information systems at work was analyzed in education, banking, finance, and other sectors. The impact of new technology perception factors on the openness to innovations was tested using the linear regression method where the index is the dependent variable and a set of independent variables includes personality traits, demographic, and socioeconomic characteristics.

On the basis of the available data sources, it was established from the start that statements 1-4 describe perceived ease of use, statements 5-8 perceived usefulness, statements 9-12 safety and reliability, and statements 13-17 the social dimension of using new technologies.

Openness to Innovations

The survey results allow one to consider the public's openness to technological innovations in three dimensions:

- attitude toward applying cutting-edge technologies and discoveries in various fields;
- appeal of innovative products and services to respondents;
- type of help (from a technological device or a human) people would prefer to receive in various situations.

In other words, three structural aspects of the public's openness to innovations were studied: attitude, acceptance, and trust. For each of them a separate index domain was constructed (using Formula 1), while in combination (compiled according to Formula 2) they provide an integrated measure of individuals' openness to innovations or personal index values. Below we will describe the variables applied to construct each domain in more detail.

Attitude toward Innovations

This component is measured using questions about individuals' assessment of using cutting-edge technologies (software, new devices, scientific discoveries, etc.) in various areas.

On the whole, public perception turns out to be rather positive: the average scores exceed 4 on a five-point scale where "1" means completely negative and "5" means a completely positive attitude (Figure 1). Medical innovations have the highest approval rate: almost 50% of the respondents expressed a completely positive attitude. Approximately the same share supported technological development and innovations in agricultural production. The lowest approval rate was found for innovations in education: 43%, but even here the overall reaction is positive: in total, 76% of the public rather, or completely support the changes in this area.

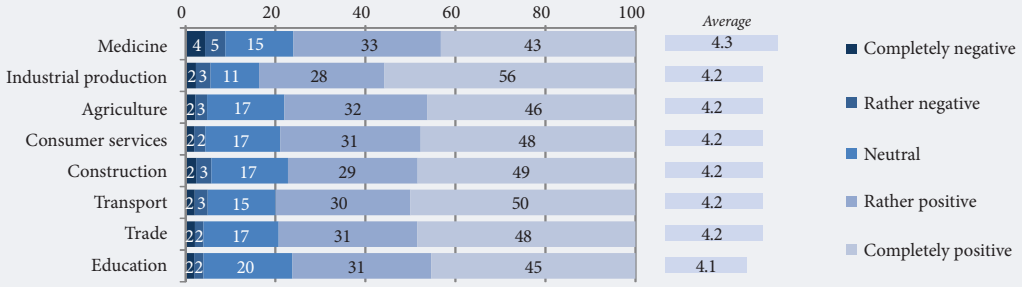
To summarize the data on the attitude toward using innovations in different areas into a single domain index (which is supposed to provide an integrated measure of the index component), the consistency of its components must be tested. The Cronbach's

[12] According to ESOMAR, a multimodal approach ensures the greater validity of the results compared to purely face-to-face or online interviews [*Cooke et al.,* 2008]. Combining these two techniques allows one to cover hard-to-reach regions and target groups, in the first case by conducting door-to-door personal interviews and in the second via online surveys which require certain population groups (age, region, settlement type, lifestyle, and income) to have adequate internet access.

[13] Sampling error does not exceed 1.5% with a confidence level of 0.95.

[14] Over the course of the pilot application of the toolkit, the respondents' interpretation of the statements was tested for subsequent adjustment.

Figure 1. **Public Attitude toward the Application of Innovations, by Area (%)**



Source: composed by the authors.

alpha scale reliability coefficient was used for this purpose. [15]

First, each of the variables was converted into a binary form: assigned the value "1" if the respondent was rather or completely positive about applying innovations in a certain area, and "0" if the answer was different. In our case, eight elements were grouped into a single domain with a high Cronbach's alpha value (0.919) and testing the domain index value for change by eliminating individual items gave grounds to leave them all in the index (Table 1).

The weight of the domain index components was determined by the share of the population negatively disposed towards innovations, i.e., it corresponds to the sum of segments where the responses varied between "completely negative" and "rather negative". Thus, according to the chosen methodological approach (e.g., similar to [*Hallerod*, 1994]), the smaller the share of the public who positively perceive innovations in a certain domain, the higher this component's contribution is to the final index for the respondents with a positive attitude toward innovations.

Acceptance of Innovations

The next index component, acceptance of innovations, is based on a set of questions about the appeal of innovative solutions (various goods and services), the answers to which range between "1" (not attractive to the respondent at all) and "4" (very attractive). Innovative food products have the lowest level of public trust: almost 60% of the respondents said such products have no appeal to them and only 8% found them very attractive (Figure 2). This is the only product group whose average rating on the aforementioned scale from 1 to 4 was in the rejection zone (below 2.5, the middle of the scale).

More than 40% of the respondents would not accept clothes and shoes made of radically novel materials and only 15% find such products attractive. Innovations in education also cause concern. A total of 37% of the public have no enthusiasm for digital educational programs and e-learning courses, while 17% seem to find such forms of education very attractive. More than 60% of Russians welcome innovative smartphone applications to one degree or another, and 20% completely approve of them. The respondents have shown significant openness toward cutting-edge medical procedures and operations: the acceptance rate reached almost 70%. At the top of the rating (with an 80% approval rate) were the latest household appliances and electronic devices.

To sum up, Russians are least likely to trust innovative products and services designed to meet basic personal needs (food, clothing), but are more open to technologies replacing other people's input (such as medical and consumer services). Innovations are also more readily accepted in areas where the technological race has been going on for a relatively long time (e.g., household appliances and electronics); conversely, in the domains where radical technological innovations emerge less frequently (e.g., education), people tend to be less enthusiastic about them.

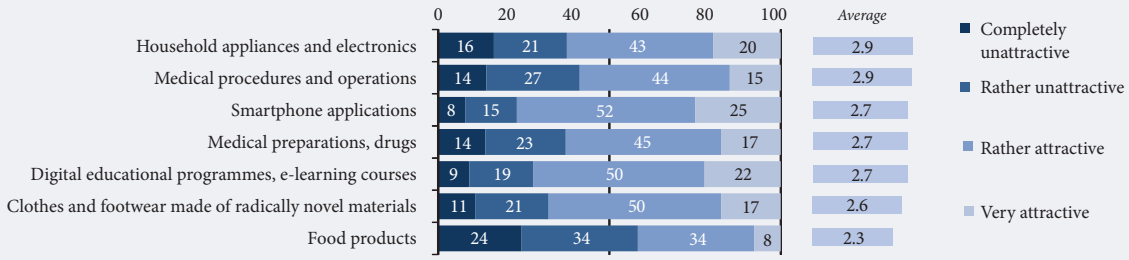
Table 1. **Consistency of the "Attitude toward Innovations" Domain Components and their Weight in the Domain Index**

Application area	Cronbach's alpha after excluding the item	Share of negative attitude (index weight, %)
Education	0.917	23.2
Medicine	0.910	16.0
Transport	0.909	21.1
Construction	0.906	20.5
Agriculture	0.908	22.2
Industrial production	0.905	19.9
Consumer services	0.906	20.1
Trade	0.910	22.7

Source: composed by the authors.

[15] Analyzing scale reliability using the Cronbach alpha model implies testing the correlation between the rank of each variable in the group describing a certain feature and the sum of the ranks of the remaining variables [*Taber,* 2018].

Figure 2. **Appeal of Innovative Products and Services (%)**



Note: These results are consistent with the data collected over the course of the project "Monitoring innovative behaviour of the population: the public's involvement in innovative practices" implemented by the HSE Institute for Statistical Studies and Economics of Knowledge. For more details see: https://www.hse.ru/monitoring/innpeople/news/page2.html, accessed on 15.12.2020.

Source: composed by the authors.

The domain index "Acceptance of innovations" measures attractiveness of innovations in all of the above product and service groups. This solution was verified by scale reliability analysis: with a high Cronbach's alpha (0.813), the index item exclusion test confirmed its components' consistency (Table 2). The components' weight was determined by the share of the population who did not accept innovations in each product and service group (i.e., the sum of segments where the answers ranged from "Rather ..." to "Completely unattractive").

Trust in Innovations

In the survey of public trust in technological innovations an alternative way of measuring was used (without using a scale). At this stage of the study, the respondents were offered a choice of alternatives: various life situations where one could ask another person for help or use a technological device instead.

Table 2. **Consistency of the "Acceptance of Innovations" Domain Components and their Weight in the Domain Index**

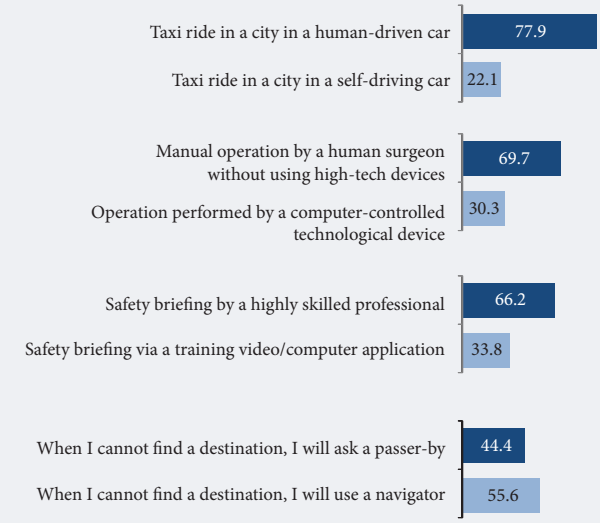
Application area	Cronbach's alpha after excluding the item	Share of negative attitude (index weight, %)
Food products	0.810	58.3
Medical preparations	0.780	32.2
Medical procedures	0.786	27.7
Education	0.786	37.2
Household appliances	0.784	22.9
Clothes and footwear	0.788	41.3
Digital applications	0.786	37.5

Source: composed by the authors.

The questionnaire captured the choices in four different contexts (Figure 3).

The public expressed the lowest amount of trust in unmanned vehicles, which is confirmed by data from other studies.[16] About 78% of the respondents would prefer a driver over a fully automated vehicle. Due to their relatively low prevalence, self-driving cars are still perceived as an element of futuristic dystopias and largely remain unavailable to the general public. Transport is still a source of increased danger to life,[17] so technologies which have not been used for long are perceived with distrust – even despite the extremely low assessment of public transport drivers' skills, in particular taxi drivers.[18]

Figure 3. **Respondents' Inclination to Trust a Stranger or a Technological Device (%)**



Source: composed by the authors.

[16] https://issek.hse.ru/news/202368869.html, accessed on 18.12.2020.

[17] https://wciom.ru/analytical-reviews/analiticheskii-obzor/bezopasnost-na-transporte-monitoring-1, accessed on 15.12.2020.

[18] For example, according to a study by the Romir holding, 54% of the capital's residents are concerned about the illegal status of carriers, 48% say taxi drivers do not know the city, and 35% pointed out to the poor state of the vehicle fleet. Plus, 35% of Russians noted a deterioration in driving culture (http://romir.ru/studies/taksi-vam-shashechki-ili-ehat, accessed on 15.12.2020).

Another source of potential risk to life is surgery. Respondents continue to trust doctors more than autonomous computers. If surgery becomes necessary, almost 70% of the respondents would prefer a human surgeon over a robot, despite the low overall trust in doctors.[19] A similar choice seems to be preferable when undergoing a safety briefing. Although a computer application or a video present information more clearly, demonstrate various situations, follow a strict instructional sequence, and guarantee a concise presentation, the public is more inclined to trust professionals. If there is a choice, only 34% of the respondents would opt to receive safety instructions without human involvement. Technological innovations which do not involve a risk to life and health seem to inspire greater trust (this is also confirmed by data from other studies, e.g. [*Voinilov, Polyakova*, 2016]). When it comes to finding a destination, most people would rather use a navigator (56%) than ask another person for directions (44%).

Apart from the relatively greater or lesser threat to safety, differences in the level of trust can also be explained by the degree of a technical device's autonomy from human control while it renders services. Unmanned vehicles imply fully automated decision-making in an ever-changing environment. Surgical interventions are most likely conducted after diagnostics performed by a specialist, according to the scheme they have chosen. A briefing is essentially a delivery of human-selected information. And navigation, although it is carried out in constantly changing conditions, leaves decisions for the user of the device.

The trust domain is based on quite different indicators measuring openness to innovations, so the Cronbach's alpha in this case is not as high as in previous ones (0.438). However, the analysis of consistency dynamics after excluding individual domain items shows that the Cronbach's alpha cannot be increased this way. In the absence of other ways to incorporate trust in the index when processing data, this domain can be based on four variables (Table 3).

Table 3. Consistency of the "Trust in Innovations" Domain Components and their Weight in the Domain Index

Application area	Cronbach's alpha after excluding the item	Share of negative attitude (index weight, %)
Transport	0.361	77.9
Medical operations	0.406	69.7
Navigation	0.405	44.4
Instructional briefings	0.294	66.2

Source: composed by the authors.

The Overall Openness to Innovation Index

When domains are combined into the overall index, the need to check their consistency becomes irrelevant due to the heterogeneous nature of the measured phenomena. The issue of differentiating the domain weights within the indicator comes to the fore. In this case we determined the weights using a univariate model: a technique suggested in a number of studies with similar methodological objectives [*Jacobs, Smith*, 2004; *Popova, Pishnyak*, 2017]. The weights of the index domains were established using factor analysis (maximum likelihood model) (Table 4). The "decision-making" component makes the largest contribution to the overall indicator, followed by "attitude toward innovations" and "trust in innovations".

The index values range between 0 and 100 and the average for the total population is 60.4, due to a shift towards higher values. This indicates the public's openness to innovations, but this in itself is not informative. The index method is better suited for comparing different groups, i.e., for use as a comparative analysis tool. Subsequently the index was used as a dependent variable in regression analysis to identify the determinants of public openness to innovations.

The differentiation of index values is considered from various perspectives, to demonstrate the tool's suitability in this context. As shown in Figure 4, residents of large cities tend to be more receptive to innovative solutions, while small towns and villages demonstrate rigidity. High index values are typical for population groups with a higher education and sufficient income.

Perception of New Technologies

Russians' attitudes toward adopting innovative technologies were measured using a set of 17 statements based on the TAM model. Most of the respondents agreed with the proposed statements or reacted to them neutrally (Figure 5). Average scores on a five-point scale for all statements except "*Only well-to-do*

Table 4. Domain Weights of the Openness to Innovations Index

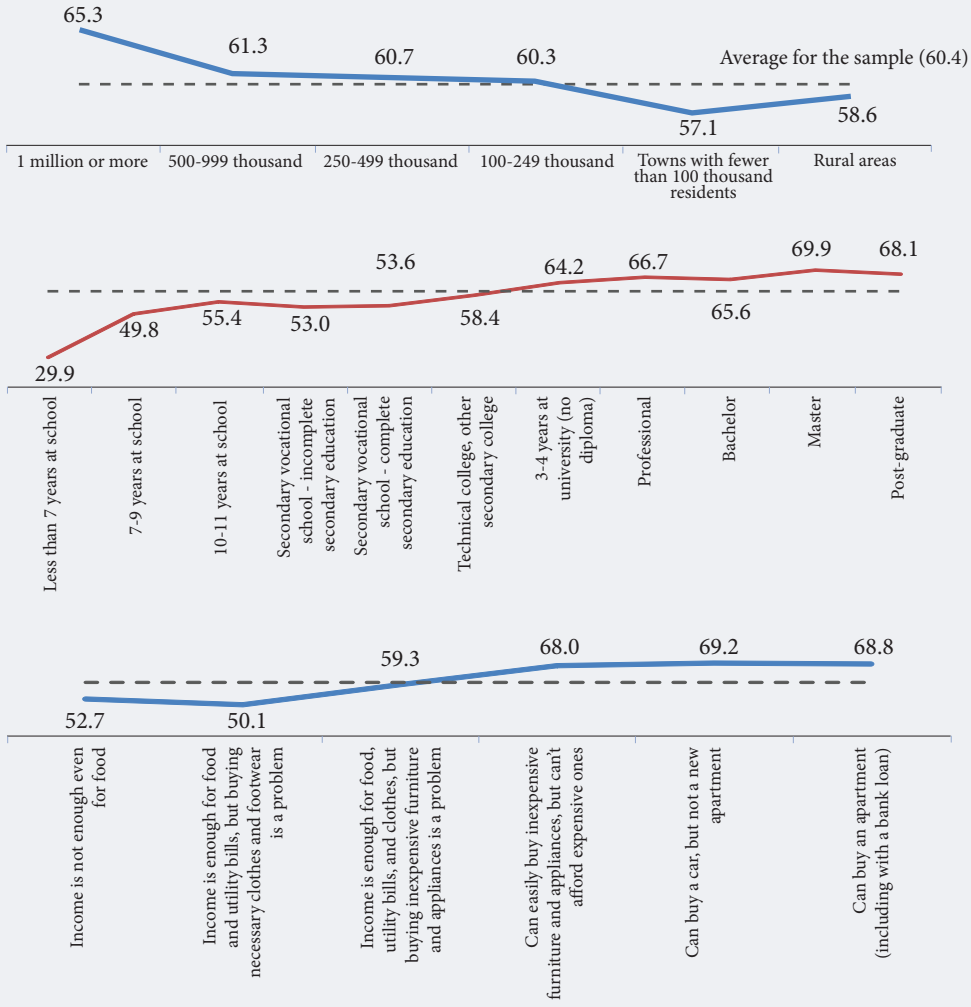
Domain	Factor load coefficients* (weight in the index)
Attitude towards innovations	0.237
Acceptance of innovations	0.632
Trust in innovations	0.131

* Based on the results of univariate analysis conducted using the maximum likelihood method. Variance explained - 49%.

Source: composed by the authors.

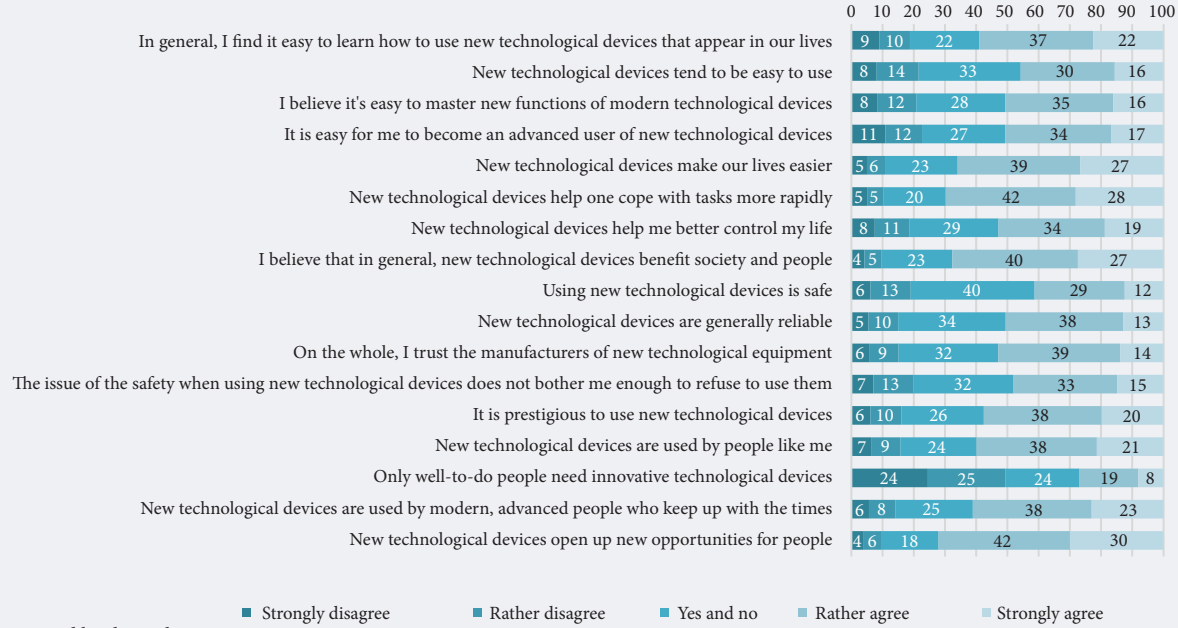
[19] According to VCIOM, only one third of Russians completely trust doctors (https://vtb24privilegiya.bfm.ru/news/365547/, accessed on 15.12.2020).

Figure 4. **Average Openness to Innovation Index Values for Various Population Groups**



Source: composed by the authors.

Figure 5. **Public Attitudes toward Innovative Technical Devices (%)**



Source: composed by the authors.

Table 5. **Key Features of the Factor Analysis Model (rotated component matrix)**

Statement	Component			
	1	2	3	4
It is easy for me to become an advanced user of new technological devices	0.836			
I believe it is easy to master new functions of modern technological devices	0.818			
In general, I find it easy to learn how to use new technological devices that appear in our lives	0.809			
New technological devices tend to be easy to use	0.720			
New technological devices are used by people like me	0.530			
New technological devices are used by modern, advanced people who keep up with the times		0.719		
New technological devices open up new opportunities for people		0.705		
It is prestigious to use new technological devices		0.679		
New technological devices help one cope with tasks faster		0.656		
New technological devices make our lives easier		0.646		
I believe that in general, new technological devices benefit society and people		0.625		
New technological devices help me control my life better		0.516		
Using new technological devices is safe			0.747	
On the whole, I trust the manufacturers of new technological equipment			0.727	
New technological devices are generally reliable			0.713	
The issue of the safety of using new technological devices does not bother me enough to refuse to use them			0.604	
Only well-to-do people need innovative technological devices				0.928

Extraction technique: Principal Component Analysis. Rotation method: Varimax with Kaiser normalization.
a. Rotation converged in five iterations.
Source: composed by the authors.

people need new technological devices" exceeded 3.3. The statement about the usefulness of new technologies got the highest approval rate. [20]

Nearly 70% of the respondents agreed, to varying degrees, with the statements that new technologies:

- open up new opportunities for people (72%);
- help one to deal with various tasks faster (70%);
- benefit society and people (68%).

The statement about only wealthy people needing new technologies turned out to be the most controversial one: almost half of the respondents did not agree with it (49%) and every fourth replied neutrally. Doubts were also raised about safety: 40% took a neutral attitude and 19% a negative one.

Based on the results of the factor analysis conducted using the principal components method (Table 5), four perception attitudes were identified:[21]

- ease of use (statements 1-4, 14);
- usefulness (statements 5-8, 13, 16, 17);
- safety and reliability (statements 9-12);
- exclusivity (new technologies as an attribute of wealthy people) (statement 15).

The respondents' attitudes identified using the above statements somewhat differ from the initial assumption, but confirm the relevance of the chosen model.[22] Moreover, the selected factors open up prospects for further analysis of the social foundations of innovations, i.e., the strength of personal opinion about one's abilities and the possibilities for applying new technologies in social interaction. Ease of use also includes a self-identification component ("*New technological devices are used by people like me*"), while perceived usefulness among other things implies there is prestige in using new technologies: belonging to a group of people keeping pace with the times. Mastering innovations seems to be easy, especially in a supportive environment, while being able to use them and reap the benefits makes one feel advanced.

Perception of technological innovations is affected by the social status and environment, and depends upon various demographic and socioeconomic characteristics, which can be demonstrated by calculating weights and average factor values for each respondent. A positive value indicates a stronger attitude and indirectly suggests which population groups can act as agents of innovation-driven changes.

To establish the differences in attitudes toward new technologies between various socio-demographic groups, weights and average factor values were cal-

[20] In this study, innovative and new technologies/technological tools/devices are used as synonyms.

[21] The number of factors was determined in line with the original methodology of the study and explains 67% of the variance.

[22] The Cronbach's alpha scale reliability test yielded a good result amounting to 0.884 for the first attitude, 0.878 for the second, and 0.800 for the third one. In each case the changes in the Cronbach's alpha after eliminating any of the individual items suggest that these combinations do not require modifications.

culated for each respondent. A slight discrepancy in the gender perception of technological innovations was discovered: for men ease of use comes first, and for women – new devices' usefulness. No gender-related specifics were revealed in assessments of safety and reliability, or in status perception of technologies (Figure 6).

With age, the perception of new technologies changes. Young people over 16 years of age show a high level of perceived ease of use and a stronger belief that technology is an attribute of wealthy people than other respondents expressed.

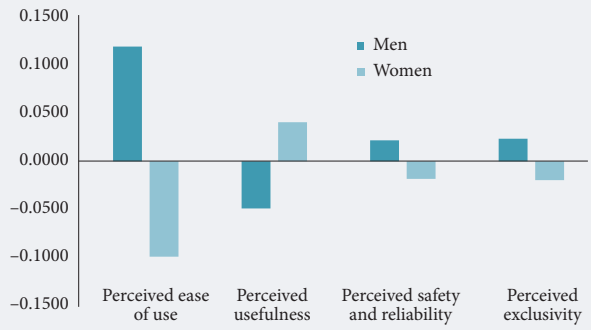
After 40, the assessment of new technologies' ease of use decreases and after 60 mastering something from scratch turns out to be the hardest part. At the same time, starting from the age of 40 comes the highest awareness of new technologies' usefulness, while people over 50 (like the young ones aged 16-19) are more inclined to believe them to be safe and reliable. The question of whether this is due to trust based on acquired skills and knowledge, or, conversely, to blind faith combined with a lack of information and experience, requires additional study (Figure 7).

The level of respondents' education, as expected, affects their perception of innovations' ease of use. Only for people with higher education, the average factor loadings of perceived ease of use are clearly positive. For the rest, they fall in the negative value zone, increasing with a decrease in the level of education. Technology is seen as a wealthy people's attribute primarily by those whose education level is below secondary vocational. For holders of secondary vocational diplomas, this factor is not pronounced, while for university graduates, it has a negative median load, i.e., members of this group do not share this attitude at all (Figure 8).

The level of income can also affect people's attitude toward technologies, since the high costs at the market launch stage limits devices' availability to the general public. The poorest population groups who lack funds for food, or for clothes and shoes, tend to be negative about innovations; more than anyone else they are convinced that only the rich have demand for them. Perceived ease of use, safety, reliability and usefulness also have negative loads (but only among those who do not have enough money even for food).

The perceived ease of use clearly depends upon the level of income: the average values increase as the respondents' assessments of their financial situation improves. As income rises, so does the strength of beliefs about innovative technological devices' safety and reliability. In the top income group, this factor's average values are negative, i.e., its members do not perceive innovations as safe and reliable (Figure 9). Perhaps this caution is due to being aware that any innovation has its limitations and that more wealthy people face increased risks of fraud.

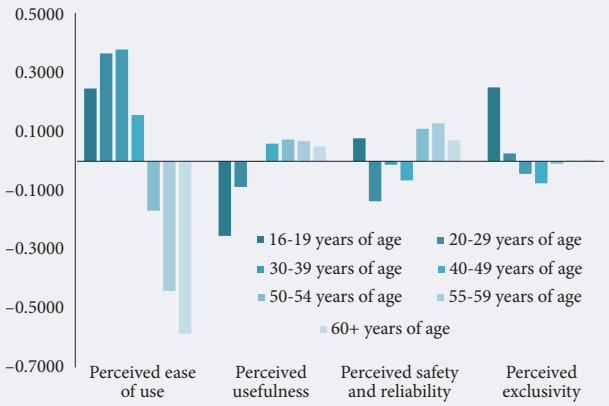
Figure 6. **New Technology Perception Factors by Gender***



* Here and in the subsequent figures, the factors for which significant differences in mean values were discovered (at the level of 95%) are underlined.

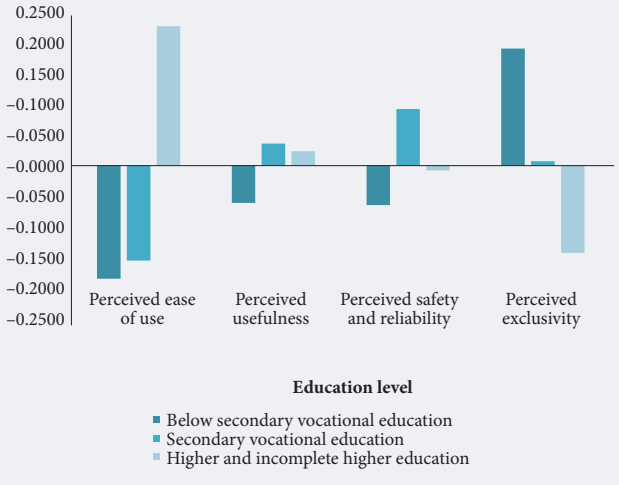
Source: composed by the authors.

Figure 7. **New Technology Perception Factors by Age**



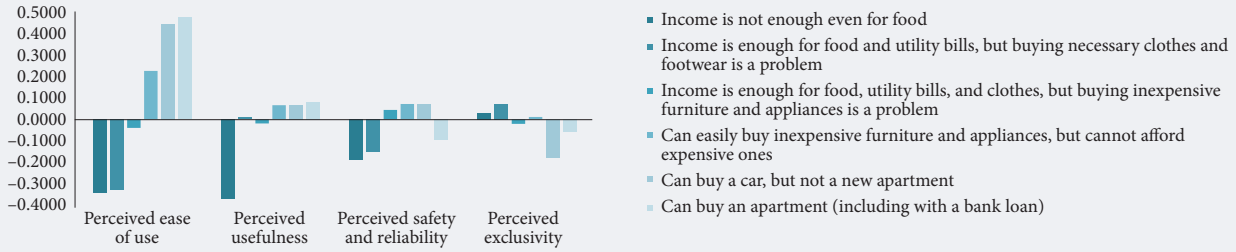
Source: composed by the authors.

Figure 8. **New Technology Perception Factors by Qualification**



Source: composed by the authors.

Figure 9. **New Technology Perception Factors by Personal Assessment of Income Level**



Source: composed by the authors.

In terms of place of residence, residents of megacities were the likeliest to agree with all of the proposed statements, in particular that technology is an attribute of wealth (probably due to the high-income differentiation in large cities). A similar attitude was also noted in small towns (fewer than 100 thousand residents).

Ease of use was perceived as high mostly in cities with up to 100 thousand residents; in small towns and villages the average values were negative, i.e., people who live there are less likely to believe mastering innovations is easy.

In small cities (up to 249 thousand), residents tend not to recognize the benefits of innovations. In rural areas, people are aware of their usefulness, but consider them difficult to use and unsafe (Figure 10).

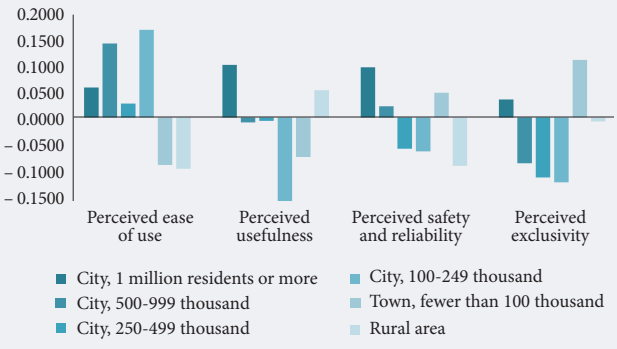
The internet as a radical innovation has changed the perception of new technologies, making it easier to access information about them. Assessing the level of internet usage via laptop and desktop computers, smartphones, and tablets[23] revealed significant differences between the perception of ease of use and exclusivity. Internet users predictably have an easier attitude toward technologies, while those who make do without online access tend to consider them an exclusive attribute of people with high income or status (Figure 11).

Determinants of Openness to Innovations

The relationship between the perception of innovations and openness to them was analyzed using the index determinants in the form of a regression model. The choice of the model and the dependent variable format were based on the innovation diffusion concept [*Rogers*, 2003] according to which "innovators", "early adopters", and "early majority" together account for 50% in any society. Their acceptance of an innovation serves as a kind of signal to everyone else: the innovation is useful and interesting, and worth adopting.

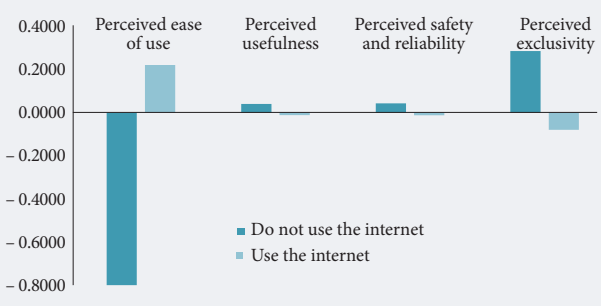
Assuming that the distribution of the Openness to Innovations Index values makes it possible to approximately define the above groups, the latter comprise the individuals for whom the index value exceeds the median[24] (i.e., 50% of the population). In other words, innovators are associated with the

Figure 10. **New Technology Perception Factors by Place of Residence**



Source: composed by the authors.

Figure 11. **New Technology Perception Factors by Internet Access Patterns**



Source: composed by the authors.

[23] It was assumed that the respondent actively uses the internet if answering the questions about how often they use it via a laptop/desktop computer and/or a tablet/smartphone, they chose the option "several times a month or more".

groups highly open to innovations identified using the index method and they ensure that innovations are adopted by the majority of the public. A binary logistic model in its general form presented in Formula 3 seems to provide optimal basis for regression analysis to identify the determinants of innovators' position:

$$p = \frac{1}{1+e^{-z}}, \quad (3)$$

where:

$Z = b_1X_1 + b_{22} + ... + b_nx\,X_n + a;$

X are independent variables' values;

b are coefficients calculated using binary logistic regression; and

a is a constant.

If P < 0.5 it can be assumed the event will not occur, otherwise it will.

The dependent variable takes the value "1" if the index value for the individual exceeds the median and "0" if it does not.

At the first stage the following independent variables were tested:

- factors affecting the perception of new technologies' ease of use, usefulness, safety and reliability, and exclusivity;
- gender;
- age;
- education;
- employment;

Table 6. **Regression Model Summary**

Step	–2 Log-likelihood	Cox and Snell R-square	Nagelkerke's R square
1	6182.242[a]	0.157	0.209

a. The assessment was terminated at iteration 4 since the parameter estimates changed by less than 0.001.

Source: composed by the authors.

Table 7. **Regression Classification**

			Predicted		
			Index value above median		Percentage of correct ones
			0	1	
Step 1	Index value above median	0	1656	862	65.8
		1	755	1814	70.6
	Total percentage				68.2

Note: Cut-off value — 0.500

Source: composed by the authors.

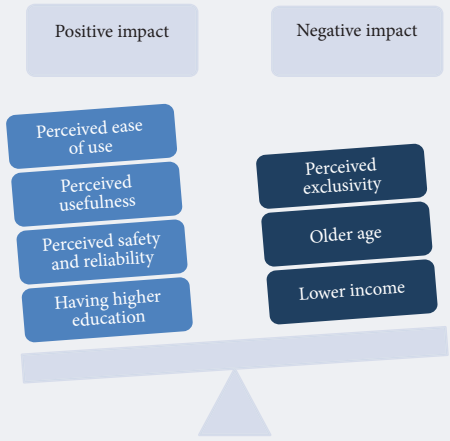
Table 8. **Regression Model Statistics**

	B	Root mean square error	Wald	Degree of freedom	Significance	Exp (B)
New technology perception factors						
Ease of use	0.482	0.037	170.224	1	0.000	1.619
Usefulness	0.532	0.034	242.711	1	0.000	1.702
Safety and reliability	0.416	0.033	160.231	1	0.000	1.517
Exclusiveness	–0.066	0.032	4.209	1	0.040	0.937
Age						
Number of full years	–0.014	0.002	35.169	1	0.000	0.986
Education						
Have higher education	0.326	0.064	26.090	1	0.000	1.385
Income						
Compared to those who do not have enough money even for food:						
Income is enough for food and utility bills, but buying necessary clothes and footwear is a problem	0.192	0.190	1.013	1	0.314	1.211
Income is enough for food, utility bills, and clothes, but buying inexpensive furniture and appliances is a problem	0.397	0.181	4.813	1	0.028	1.487
Could easily buy inexpensive furniture and appliances, but could not afford expensive ones	0.807	0.182	19.744	1	0.000	2.241
Could buy a car, but not a new apartment	0.731	0.207	12.485	1	0.000	2.078
Could buy an apartment (including with a bank loan)	0.946	0.288	10.748	1	0.001	2.574
Constant	–0.209	0.198	1.114	1	0.291	0.811

Source: composed by the authors.

[24] Median value divides the distribution into two equal parts.

Figure 12. **Determinants of High Openness to Innovations**



Source: composed by the authors.

- place of residence (settlement type);
- number of household members;
- having children under 16 years of age;
- income.

Testing various combinations of variables and the aggregation options for categorical variables' codes did not reveal a meaningful relationship between certain independent variables on the list and being an innovator. These characteristics include gender, place of residence, number of household members, and having children under 16. Therefore, at the second stage, the five above variables were excluded from the model. The remaining set allowed the authors to build a regression with a prediction accuracy of 70% (a detailed description of the final model is given in Tables 6–8).

Three of the four perception factors (ease of use, usefulness, safety and reliability), higher education, and level of income are positively associated with a high degree of openness to innovations. The correlation with the fourth factor (perceived exclusivity of innovative technologies) is negative. Summarizing the mathematical model results with certain assumptions, it can be stated that the easier to master, the more useful, safe, and reliable an individual finds innovations, the more likely he/she is to be open to them. Conversely, if technology is perceived as a luxury, in most cases the respondent should not be expected to be an innovator. At the same time, with a decrease in income[25] and increase in age[26] the chances of being among those for whom the index value is below the median increase. Having higher education, on the contrary, speaks rather in favor of being open to innovations (Figure 12).

Conclusion

TThe accelerating pace of technological development poses new challenges. Adaptability to innovations, including technological ones, is directly related to improved living standards and increased human capital. Accordingly, openness to innovations commands the growing interest of researchers.

Our study proposes the Openness to Innovations Index based on a multidomain methodological principle for an integrated analysis of public opinion. Innovations in various areas (from medicine and education to transport and manufacturing) are assessed using three components: individual attitude, acceptance, and trust, which are aggregated into an overall indicator. To assess the impact of the perception of innovations on the intention to use them, the later versions of the TAM model were applied, designed to test technologies' adaptation to various areas of life. The respondents' attitudes toward technological innovations are viewed through the prism of perceived ease of use, usefulness, safety, reliability, and exclusivity.

These factors' strength varies between different socioeconomic population groups and determines the latter's role in the innovation process. Ease of use is often noted by men, young people, educated, and well-to-do residents of large cities. Usefulness is primarily important for women, people over 40 years old with secondary vocational or higher education, above average income groups, and residents of megacities. Safety and reliability are of primary importance for people over 50 with secondary vocational education and average income. Finally, young people under 20, people with education below secondary vocational (mainly due to their age), low income, and residents of large and small cities alike tend to see new technologies as an exclusive attribute.

Assessing these factors' impact upon the public's openness to innovations, a positive relationship with the perceived ease of use, usefulness, safety, and reliability of technological innovations was revealed. Having a higher education also increases the

[25] No significant difference was observed only between the population group with income not sufficient even to buy enough food, and those who can afford food and pay utility bills, but not new clothes and shoes. (Table 8).

[26] The analysis does not include adolescents under 18 years of age. This finding applies to older population groups.

likelihood of an innovator attitude, while perceived exclusivity, on the contrary, decreases it. Finally, people tend to become less enthusiastic about innovations as their age increases and income decreases. Accordingly, young, educated, and successful people who are not afraid of new technologies most often act as agents of innovation.

Further research could address the issue of whether openness to innovations in the long term guarantees better life prospects, advantages on the labor market, and an overall increase in income and quality of life compared to other individuals in the world of ever-changing technology.

This paper is based on materials produced in the scope of the project "Analysing socio-economic inequality and redistribution policy, assessing the standard and quality of life for various social groups, and studying factors of healthy, active longevity" implemented in the framework of the HSE Basic Research Programme in 2018. The study also uses the results of the project "Poverty, inequality, and social mobility in present-day Russia: an interdisciplinary analysis" implemented in the framework of the HSE Basic Research Programme in 2020.

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