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The impact of the COVID-19 pandemic on the intellectual labor market

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ABSTRACT

BACKGROUND AND OBJECTIVES: The impact of the COVID-19 pandemic on labor markets are extensive. One of the few labor sectors where demand has exceeded supply as a result of the impact of the pandemic is the intellectual labor market. It is explained by two factors. First, intellectual work is the engine for scientific and technological progress, which helps to overcome the crisis. And, secondly, in most cases, such employees can work at home.

METHODS: The "loosened rock" method, factor analysis were used to determine the factors influencing supply and demand in the labor market before and after the COVID-19 pandemic in Ukraine. STATISTICA software (version 13.0) was used to conduct all the analyses.

FINDINGS: The results showed that the demand on the labor market is affected by 3 factors: the number of implemented scientific-innovative developments (dispersion 65.93%), the volume of their financing (dispersion 12.19%), and the level of their legal protection (dispersion 11.13%). Supply depends as well on three factors: the potential volume of scientific developments in Ukraine (the dispersion of 48.61%), the number of employees engaged in intellectual labor (the dispersion of 24.79%), and the level of qualitative supply of executors of scientific-innovative developments (the dispersion of 14.23%). The monitoring of supply and demand in the market of intellectual labor showed that there was an excess of supply over demand (by 13%) before the pandemic COVID-19, and there was an excess of demand (by 20%) after the pandemic COVID-19.

CONCLUSION: These results can provide employers with important information to optimize the organization and planning of intellectual work, which will help to resolve the conflict between the possible consequences of the COVID-19 pandemic and scientific and technological progress, may be applicable in Ukraine and other countries.

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INTRODUCTION

The year 2020 brought forth the unprecedented changes in the global economy and in the world of work (Tayyebirad and Vakil, 2020; Shcherbak *et al.*, 2021). On March 11, 2020, the World Health Organization declared the outbreak of a new coronavirus as a pandemic, calling on governments around the world to get ready for the first wave of emergency condition in health care through a series of transformative measures, one of which in many countries was a universal lockdown (stay-at-home restrictions) (WHO, 2020). Approximately 2.7 billion people (80% of the world's working age population) (Alanezi and Alanzi, 2020) experienced the impact ofthe COVID-19 pandemic restrictions. Employers have had to take into considerationthe structural features of demand that are determined by a country's epidemiological situation, to be prepared for possible new waves of the epidemic and their consequences, such as those that recently occurred in Japan, Singapore, and South Korea (Baker *et al.*, 2020; Barbosa *et al.*, 2020). Most companies that were able to use new work practices in as short a time as possible could not only protect lives and health of people, but also to prevent irreversible damage to the economy (Bendau *et al.*, 2020). Social distancing measures - school closures, airline shutdowns, no meetings, and workplace closures - have been one of the primary anti-coronavirus measures and a means of its spread retardation (Buckee *et al.*, 2020). The number of part-time and full-time remote workers has gradually increased in recent years (Chan, 2009; Fatoki, 2011; Ganushchak-Efimenko *et al.*, 2018). The pandemic has certainly accelerated employers' acceptance of the remote work format (Davis *et al.*, 2020). In a pandemic situation, remote work has proved itself as an important factor to ensure continuity of business (Andreeva and Garanina, 2017; Appuhami, 2007). Meanwhile, under normal conditions, its advantages include reduced commuting time, the ability to focus on work tasks away from office distractions, and finding an optimal work-life balance (Chitsaz *et al.*, 2019; Ganotakis, 2010; Hasbullah, 2006). Remote mode offers greater freedom to choose work schedules as well as alternative work locations outside of the employer's premises (Mushrel, 2014; Portes, 1998). Before the pandemic, only a small proportion of employees worked remotely from time to time (Intarakumnerd *et al.*, 2002; Mayo, 2002). In the European Union (EU), the prevalence of regular or occasional telecommuting (home-based and mobile work combined) ranged from 30 percent or more in Denmark, the Netherlands, and Sweden to 10 percent or less in the Czech Republic, Greece, Italy, and Poland (Ngatno and Apriatni, 2016). According to various studies, up to 20 percent of the labor force in the United States worked on a regular basis or occasionally from home or another alternative location, in Japan 16 percent, and in Argentina only 1.6 percent (Pena, 2002). Thus, in most countries the labor market is undergoing structural changes (Yli-Renko *et al.*, 2001). New forms of work organization and employment coexist with traditional forms of employment (Okafor, 2012). New forms of employment first appeared in high-income countries, but at present time have spread to developing countries (Pittaway *et al.*, 2004). They are characterized by very short contracts, mediation through digital platforms, and changes in work organization (Roxas, 2008). Some of these changes are as well related to a redefinition of working relationships, especially in terms of forms of employment on the line of employment and self-employment (Salamzadeh *et al.*, 2019). The COVID-19 pandemic has shown the increasing ability of companies and employees to be engaged in economic activity remotely (Ethelbhert *et al.*, 2020; Kozlovskyi *et al.*, 2020). While the global community places reliance upon the recovery from the COVID-19 pandemic, new questions arise regarding the long-term impact of the pandemic on the quality of employment and the prevalence of various forms of employment (Gupta *et al.*, 2020). The emergence and growth of new forms of employment are related to two long-term economic trends: digitalization and globalization of value chains (Shiu, 2006). Both trends, as a result of the impact of the COVID-19 pandemic, have delivered benefits to businesses and employees to some extent (Kahn, 2020). Allocating strategically their operations in different jurisdictions, companies can optimize production processes and gain access to local pools of specialized knowledge and skills (Tsai, 2006). Algorithms and digital platforms can also improve businesses' ability to forecast demand and optimize the fitness of employees to tasks in time and space (Van Geenhuizen and Indarti, 2005). Some companies that invest in digital technology pay higher wages (Voydanoff, 2001), and digital platforms create employment opportunities abroad

(Kraemer *et al.*, 2020). Besides, many new forms of employment are actualized remotely and can create opportunities for groups who have limited mobility due to health conditions or responsibilities related to aftercare (Keutzer and Simonsson, 2020). New forms of employment, especially the ability to work on digital platforms, offer improved opportunities for specific types of work such as intellectual work, where individualized schedules can significantly improve the quality of outcomes (Means *et al.*, 2020). The purpose of the article is to determine the extent to which the COVID-19 pandemic affects the level of digitalization of the intellectual labor market in Ukraine. The study was conducted on the basis of statistical data of Ukrainian enterprises in 2020.

MATERIALS AND METHODS

Survey design and data collection

The problem the research is aimed at solving is the necessity to determine the degree of impact of the COVID-19 pandemic on the intellectual labor market. The methodology of the research consists of the following actions: construction of the "loosened rock" graph, factor analysis, construction of supply and demand models in the intellectual labor market, monitoring of changes in supply and demand in the intellectual labor market as a result of the COVID-19 pandemic. The first stage includes using the method of "loosened rock", where the number of factors that influence the supply and demand in the labor market is determined by means of the point of sharp fall of the broken line slope). The second stage includes a factor analysis. Using this method, we have identified the most significant factors and their constituent indicators affecting the level of supply and demand in the intellectual labor market (Hair *et al.*, 2010). STATISTICA software is used to conduct factor analysis. Theoretically, the dependence of supply or demand on the identified indicators is described as follows (Eq. 1):

$$Y_{dem} / Y_{sup} = \sum_{j=1}^{N} F_j \quad (1)$$

Where Y_{dem} - demand for intellectual labor; Y_{sup} - supply of intellectual labor; F_j - *j*-th factor; *N* - number of factors identified in the first stage. The value of each factor is determined by Eq. 2:

$$F_{i,j} = \frac{1}{Expl.F_{i,j}} \times \sum a_{i,j} \times Dem_i / Sup_j \quad (2)$$

Where $Expl.F_{i,j}$ – the factor load of the dependence of demand (*i*), supply (*j*) on the identified indicators; $a_{i,j}$ – the value of demand indicators Dem_i and supply indicators Sup_j.

The third stage includes the construction of the model of supply and demand monitoring in the market of intellectual labor.

Datadescription

Empirical data for factor analysis of demand for intellectual labor are presented in Table 1.

Empirical data for factor analysis of intellectual labor supply are presented in Table 2.

RESULTS AND DISCUSSION

Factor analysis for variables entering the analysis

The mechanism of supply and demand in the market of intellectual labor is based on competition between employees for the right to apply their abilities in the most advantageous way, and employers - for the right to attract and use the most qualified workers capable of creative, innovative activity. The commodity on this market is intellectual labor, the bearer of which is personally presented by every employee engaged in mental activity. The structure of the market of intellectual labor is more complex in comparison with the structure of the labor market. The owner of human capital gets an opportunity to implement his creative and innovative skills and abilities in the process of investing in a particular business at a particular company (Fig. 1).

The construction of multifactor correlation and regression models of the dependence of supply and demand in the market of intellectual labor of a particular industry on a group of independent factors makes it possible to predict the supply and demand in the industry market of intellectual labor. We have chosen the number of hours spent on the creation of intellectual property objects for a certain period as a dependent index, which reflects the volume of demand for intellectual labor. Calculations were performed by the example of the Ukrainian economy. At the initial stage of the study 35 factors were selected. The volume of demand for intellectual labor is defined as the total amount of time actually spent

Table 1: The system of indicators of factor analysis of demand for intellectual labor

Indicators	Designator
The number of vacancies in the field of engineering and research work	Dem_1
Expenditures on engineering, technical and research work	Dem_2
Share of innovative products (goods, services) in total sales	Dem_3
Number of issued protection documents for inventions	Dem_4
Number of issued protection documents for utility models	Dem_5
Number of issued protection documents for industrial samples	Dem_6
Number of used industrial property objects: inventions	Dem_7
The number of used industrial property objects: utility models	Dem_8
Number of used industrial property objects: utility models	Dem_9
Share of intellectual product in the total value of works performed	Dem_{10}
Share of innovation in the total volume of services rendered	Dem_{11}
The ratio of the number of implemented scientific-innovative developments to the number of works performed	Dem_{12}
Amount of financing of innovation activity at the expense of own funds	Dem_{13}
The number of open venture capital companies in the industry	Dem_{14}
Income from the use of intellectual property	Dem_{15}
Amount of financing of innovation at the expense of the loan	Dem_{16}
Amount of financing of innovation activities at the expense of domestic investors	Dem_{17}
Amount of financing of innovative activity at the expense of foreign investors	Dem_{18}

Table 2: The system of indicators of factor analysis of intellectual labor supply

Indicators	Designator
Number of employees	Sup_1
Planned volume of engineering and research work	Sup_2
Number of companies that are engaged in innovative activities	Sup_3
Share of companies that have departments that perform research and development work	Sup_4
Share of companies that have implemented innovations	Sup_5
Number of employees engaged in engineering and R&D	Sup_6
Number of employees with specialized secondary and higher education	Sup_7
Citation index	Sup_8
Number of employees with Ph.D. degrees, PhDs involved in sectoral scientific and technical activities	Sup_9
Number of employees with Ph.D. degrees, engaged in sectoral scientific and technical activities	Sup_{10}
The share of specialists with scientific degrees among R&D performers	Sup_{11}
Expenditures associated with the protection of intellectual property rights	Sup_{12}
Number of filed applications for the issue of titles of protection	Sup_{13}
Applications for the issue of titles of protection for utility models were filed	Sup_{14}
Number of Nobel Prize winners	Sup_{15}

by industry employees on scientific and inventive activities (Eq. 3):

$$Y_{dem} = Num_1 \bullet Uw_1/100 \bullet Uw_2/100 \bullet F_{int}, \quad (3)$$

Where Num_1 – the number of employees in the industry, thousand people; Uw_1 – the share of engineers and technicians and research workers, %; Uw_2 – the share of companies in the industry, where innovations were implemented, %; F_{int} – the average time per employee of the industry, spent on intellectual work.

The supply of intellectual labor is defined as the total amount of time employees in the industry which can be engaged in intellectual work (Eq. 4):

$$Y_{sup} = Num_1 \bullet Uw_1/100 \bullet Uw_2/100 \bullet F, \quad (4)$$

Where F– the average working time of one industry employee.

The number of factors to construct a model of demand for intellectual labor was determined by the method of "loosened rock" (Fig. 2).

As shown by Fig. 2, the number of factors is equal to three. Factor analysis was conducted for a more detailed analysis of the degree of influence of individual indicators on the level of demand for intellectual labor (Table 3).

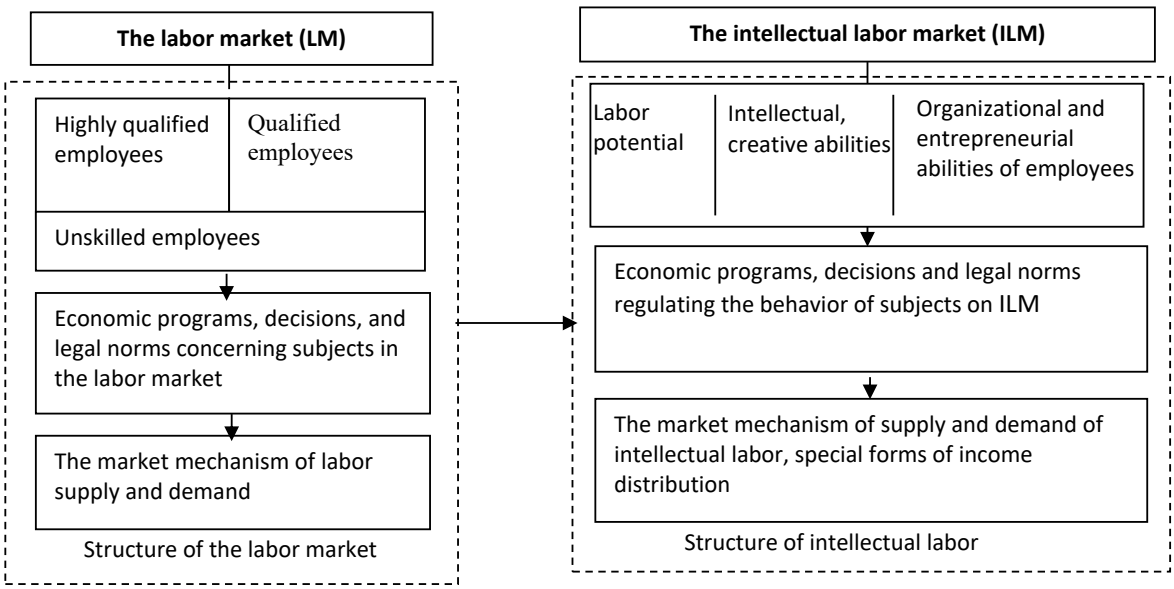

Fig. 1: Transformation of labor markets

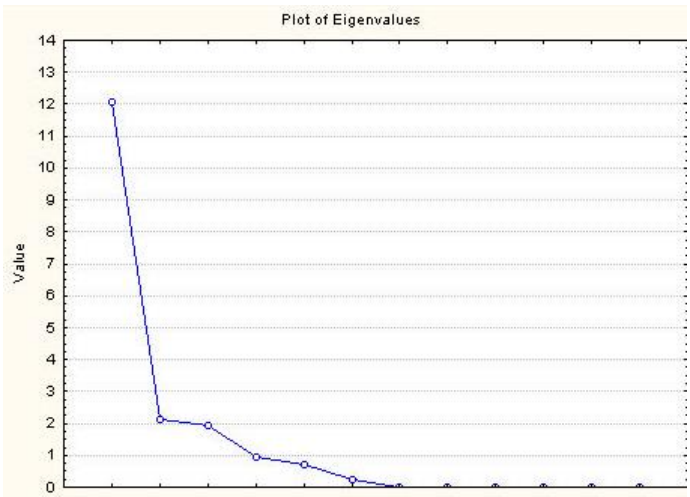

Fig. 2: The "loosened rock" graph for determining the number of factors to construct a model of demand for intellectual labor

The indicators fall within the factor where they are highlighted in red. As can be seen from the listing, the indicators of the first factor can be characterized as the number of implemented scientific and innovative developments in the qualitative section and by the sources of funding. Indicators of the second factor are characterized by the volume of financing of scientific-innovation developments from own and domestic sources. Indicators of the third factor reflect one of the essential parts of the successful application of intellectual labor - the level of their legal protection. The results of the factor analysis showed that the features of the demand for intellectual labor are almost completely characterized by the obtained three factors, which is sufficient to justify the general trends of its use. The first factor has the most significant influence on the level of use of intellectual labor, the value of its variance is 65.93%, the second - 12.19%, the third - 11.13%. Thus, the model of demand for intellectual labor according to Eq.2 looks

Table 3: The degree of influence of individual indicators on the level of demand for intellectual labor (STATISTICA 10 listing)

Variable	Factor Loadings (Unrotated) (data) Extraction: Principal components (Marked loadings are >,700000)		
	Factor 1	Factor 2	Factor 3
Dem_1	0,96601	-0,49501	0,16167
Dem_2	0,91365	-0,27254	-0,35287
Dem_3	0,94506	-0,33878	-0,33878
Dem_4	-0,36833	-0,67658	0,70989
Dem_5	-0,02865	-0,35785	0,84192
Dem_6	-0,60454	0,01664	0,77219
Dem_7	0,96645	0,01364	0,04119
Dem_8	0,85630	0,30984	0,34685
Dem_9	0,86259	-0,16357	-0,34534
Dem_{10}	0,96748	0,25810	0,05206
Dem_{11}	0,82435	0,36357	0,44345
Dem_{12}	0,90963	0,21680	0,09712
Dem_{13}	-0,53681	0,77512	0,15419
Dem_{14}	0,49966	0,15343	0,06878
Dem_{15}	0,96807	0,15773	0,15508
Dem_{16}	0,35123	0,88171	0,35123
Dem_{17}	-0,44745	0,78243	0,13308
Dem_{18}	0,35343	0,71555	0,35343
Expl.Var	12,05827	2,133475	1,956259
Prp.Totl	0,66990	0,118526	0,108681

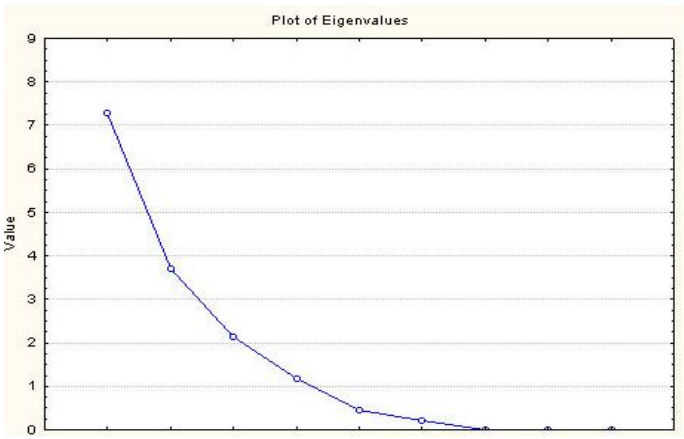

Fig. 3: Graph of the "loosened rock" to determine the number of factors to construct a model of supply of intellectual labor in the economy of Ukraine

as follows (Eq. 5):

$$Y_{dem} = {}^{1}\!/_{12,05827} \times \begin{pmatrix} 0,966Dem_1 + 0,91365Dem_2 + \\ 0,94506Dem_3 + 0,96645Dem_7 + 0,85630Dem_8 + \\ 0,86259Dem_9 + 0,96748Dem_{10} + 0,82435Dem_{11} + \\ 0,90963Dem_{12} + 0,96807Dem_{15} \end{pmatrix} + {}^{1}\!/_{2,133475} \times \begin{pmatrix} 0,77512Dem_{13} + 0,88171Dem_{16} + 0,78243Dem_{17} + \\ 0,71555Dem_{18} \end{pmatrix} + {}^{1}\!/_{1,956259} \times (0,70989Dem_4 + 0,84192Dem_5 + 0,77219Dem_6) \quad (5)$$

Preliminary analysis of the factors number into which all the indicators influencing the level of intellectual labor supply should be divided using the method of "loosened rock" showed that their number is also equal to three (Fig. 3).

The results of factor analysis of the supply on the market of intellectual labor in Ukraine are shown in Table 4.

The first factor characterizes the potential

Table 4: Results of factor analysis. Determining the level of supply for intellectual labor (STATISTICA 10 listing)

Variable	Factor Loadings (Unrotated) (data) Extraction: Principal components (Marked loadings are >,700000)		
	Factor 1	Factor 2	Factor 3
Sup_1	0,74669	0,65501	-0,03102
Sup_2	0,85336	-0,02721	-0,30345
Sup_3	-0,32981	0,89587	-0,02001
Sup_4	0,87238	-0,24118	-0,40314
Sup_5	0,95609	0,19341	-0,01943
Sup_6	0,96079	-0,12794	0,04119
Sup_7	-0,16133	0,48819	0,86159
Sup_8	-0,23466	0,39093	0,76974
Sup_9	-0,57542	0,46837	0,67171
Sup_{10}	0,53381	0,13251	0,79729
Sup_{11}	-0,29862	-0,58548	0,77038
Sup_{12}	-0,42396	0,79131	0,21613
Sup_{13}	-0,26925	0,75716	-0,18631
Sup_{14}	-0,43378	0,81397	0,20833
Sup_{15}	-0,43045	0,69741	-0,01963
Expl.Var	7,291981	3,718119	2,134396
Prp.Totl	0,486132	0,247875	0,142293

volume of scientific developments in the economy of Ukraine: the number of companies, organizations and potential performers of scientific research. The value of its dispersion is 48.61%, which indicates a weighty influence on the achieved level of intellectual labor supply. If the first factor reflects the potential supply of intellectual labor, the second factor is reasonable to interpret as the actual supply. The value of its variance is 24.79%. The third factor, by its load takes the third place among the factors that have a significant impact on the value of the supply of intellectual labor. It characterizes the achieved level of qualitative support of scientific and innovation developments by the executors. It is reasonable to consider this factor as an assessment of compliance of the actual level of qualification of various groups of executors to the successful implementation of innovative developments. The value of its dispersion is 14.23%. Thus, the supply model for intellectual labor according to Eq. 2 looks as follows (Eq. 6):

$$Y_{sup} = 1/7,291981 \times \left(0,74669Sup_1 + 0,85336Sup_2 + 0,87238Sup_4 + 0,95609Sup_5 + 0,96079Sup_6\right) + 1/3,718119 \times \left(0,89587Sup_3 + 0,79131Sup_{12} + 0,75716Sup_{13} + 0,81397Sup_{14}\right) + 1/2,134396 \times \left(0,86159Sup_7 + 0,76974Sup_8 + 0,67171Sup_9 + 0,79729Sup_{10} + 0,77038Sup_{11}\right) \quad (6)$$

Creating a model for monitoring supply and demand in the intellectual labor market

The third stage involves the construction of a model for monitoring supply and demand in the market of intellectual labor (Fig. 4).

Discussion of the current situation in the intellectual labor market

The monitoring made it possible to: 1) determine the current supply and demand ratio in the market of intellectual labor; 2) develop appropriate measures to eliminate the identified imbalance. Calculations in 2019 and 2021 showed that before the pandemic COVID-19 there was an excess of supply over demand (by 13%), then there was an excess of demand (by 20%). This situation is explained by the fact that the majority of employees in the intellectual sphere have an opportunity to organize their workplace and algorithmize intellectual processes in an optimal way in view of the forced remote or distancework. The current situation in the intellectual labor market shows that before the pandemic, the excess of supply over demand was justified and confirmed by studies (Chitsaz *et al.*, 2019; Ganotakis, 2010; Hasbullah, 2006). This is due to the first two supply factors: the number of companies, organizations, and R&D performers who worked permanently in a business environment (offices) (Chitsaz *et al.*, 2019; Ganotakis, 2010; Hasbullah, 2006). Indeed, before the pandemic, only a small part of employees

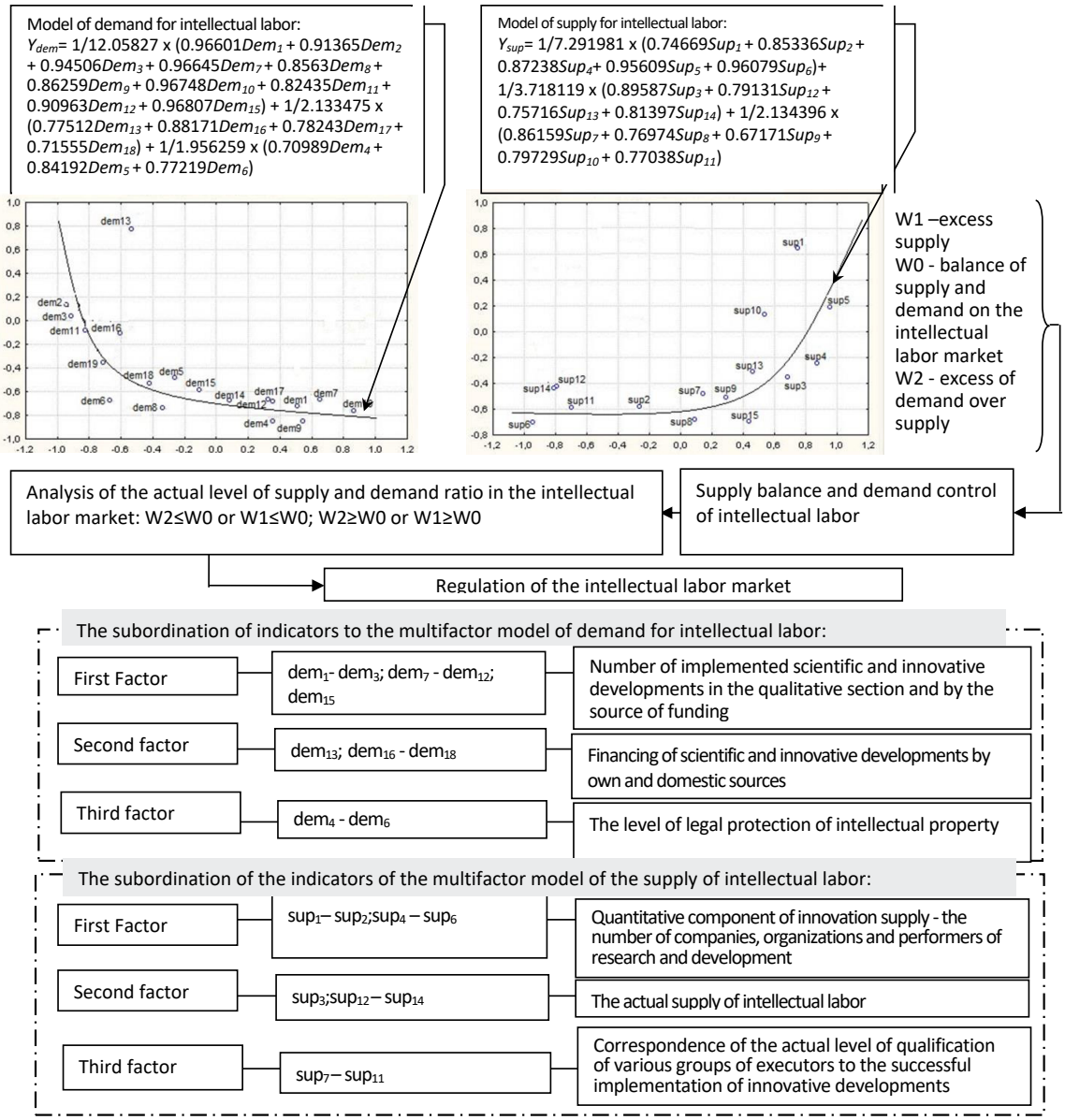

Fig. 4: Model for monitoring supply and demand in the intellectual labor market

worked remotely from time to time (Intarakumnerd *et al.*, 2002; Mayo, 2002). After the pandemic (2021), most intellectual work is done remotely (in the remote mode) (Gupta *et al.*, 2020). This, at a fundamental level, have an impact on the level of demand for this type of work and makes it possible to turn the economy around. This situation makes it possible to implement efficient differentiation of labor, optimizing transaction costs. Digital platforms "facilitate the division of tasks" by means of "efficient allocation of resources and consistent reduction of transaction costs.

CONCLUSION

The current situation forces organizations of all forms of ownership to pursue an active personnel

policy, i.e. the accumulated intellectual capital becomes one of the main factors of business competitive ability. Particularly development of intellectual labor market will make it possible to increase the level of innovative applicationof own labor potential, because the field of application ofhuman labor having knowledge and work experience in various directions is much broader, than the sphere of application of human labor when people do not have necessary qualification level. Analysis of the development of situation in the field of application of achievements of STP before and after pandemic made it possible to come to the conclusion that at the present moment the situation in the market of intellectual labor is influenced by several key factors:

- Imbalance between the supply and demand of intellectual labor and the use of funds to pursue an active policy of attracting creatively thinking and innovative employees;

- Preservation of low competitive ability of certain categories of citizens on the intellectual labor market due to limited opportunities to implement their individual intellectual abilities: young people without work experience, women with underage children, able-bodied people with disabilities, difficulties related to find jobs for graduates completing the course of professional educational institutions of all levels;

- Inter- sectorial reallocation of the labor force as a result of the realization of organizational and entrepreneurial capital, the complexity of small business development, the complexity of solving the problems of employment and, consequently, of increasing the efficiency of the use of intellectual capital;

- Insufficient adaptation of the education system, structures of social and cultural sphere to the current situation on the market of intellectual labor: low level of retraining, advanced training of personnel on the basis of intra productive training of employees, lower level of use of knowledge, loss of skills and abilities;

- Insufficient level of cultural and moral performance of enterprise employees, growth of psychological tension in the society as a result of the COVID-19 pandemic, degradation of the social sphere as a consequence of insufficient financing of education, science.

Therefore, here are the major lines of action in this market in the medium-term perspective:

- Preservation at the national and regional levels of funding of measures to promote the development of vocational education; development of intra-company training system of company personnel, organizations, advanced vocational training of employees, increasing their competitiveness and professional mobility in the market of intellectual labor;

- Equalization of the general education level of the workforce, development of their intellectual and creative-innovative abilities, and the development of mechanisms to meet the needs of organizations for graduates of all levels of vocational education institutions;

- Encouraging citizens to start their own businesses through the active use of digital forms of employment, expanding measures and ways of supporting venture business.

AUTHOR CONTRIBUTIONS

V. Scherbak generated the general idea, analyzed and interpreted the data, prepared the manuscript text and manuscript edition. L. Ganushchak-Efimenko organized the fieldwork, summarized the data, and prepared the manuscript. O. Nifatova conducted a sectoral analysis of the labor market and performed a literature review. V. Yatsenko conducted experiments.

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CONFLICT OF INTEREST

The authors declare no potential conflict of interest regarding the publication of this work. Besides, the ethical issues including plagiarism, informed consent, misconduct, data fabrication and, or falsification, double publication and, or submission, and redundancy have been completely witnessed by the authors.

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ABBREVIATIONS (NOMENCLATURE)

%	Percentage
COVID-19	CoronaVirus Disease 2019, coronavirus infection 2019-nCoV
Eq.	Equation
EU	European Union
Expl.Var	Explanatory Variable
Fig.	Figures
ILM	Intellectual labor market
LM	Labor market
Prp.Totl	Percentage of the total variance explained
STATSTICA	Statistical analysis software package
Var	Variable
WHO	World Health Organization

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