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DIGITAL METHODS AND TECHNOLOGIES OF FORMING AN INNOVATIVE LABOUR MARKET INFORMATION SUPPORT SYSTEM IN UKRAINE

Abstract

Digitalization processes bring about radical transformations in the content and nature of work, leading to shifts in the demand for certain skills and abilities and the emergence of new occupations. Traditional survey-based sources of information about the labour market prove insufficient to track these changes for employment policy purposes. In this article, the authors reveal alternative data sources on the labour market, made possible due to the development of new digital technologies, and delineate their respective advantages and drawbacks. Additionally, the authors systematize international experiences in leveraging digital

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technologies and Big Data for statistical and information-analytical research on the labour market.

Having analysed the leading research-analytical projects in the USA, Great Britain, and EU countries, the authors found them to be focused on constructing functional intellectual and analytical systems for the labour market. These projects aim to develop methodologies and promote widespread adoption of digital tools for working with Big Data, significantly expanding the capabilities of labour market information and analytical systems. The authors examined specific projects that used Big Data from online job vacancies to assess the demand and supply of jobs, as well as to analyse and forecast the requirements for skills and competences that would be feasible for adoption in Ukraine. Big Data from specialized online portals, servers and services were found to serve as powerful resources to supplement and enrich the existing conventional system of labour market statistics and analytics.

Finally, the authors substantiate the need and expediency of creating a fundamentally new Labour Market Information and Analytical System (LMIAS) in Ukraine and coordinating it with labour market platforms in EU countries. They also identify a range of problematic issues that require in-depth research and resolution in Ukraine, such as ensuring the representativeness of online job vacancy data, improving the classifiers of occupations, abilities and skills, and introducing methods for integrating statistical, administrative, and Big Data on the labour market.

Key Words:

Big Data; employment; digitalization; labour market analytics; labour market information system; the labour sphere.

JEL: J21, J44, C80, O15, O38.

1 table, 33 references.

Problem Statement

The dynamic processes of digitalization bring about global shifts in the content and nature of work, leading to the decline of certain professions and the emergence of new ones, all while exerting a profound influence on society, economy, education, and the labour market. The automation and robotisation of production processes, as well as the introduction of digital technologies and artificial intelligence, represent just a few of the transformative processes in the labour sphere. These factors have already had, and will continue to have, a significant influence on the quality of working life and the workplace of the future. These new trends necessitate close monitoring of the ongoing changes in the world of labour, in the working individual, and in the labour relations. Consequently, there is a growing interest in the development and implementation of information systems for labour market analytics. Such systems can facilitate the formulation of evidence-based policies in the labour sphere and the assessment of the effectiveness of various policy measures. The matter in question here is the innovative provision of information for the domestic labour market, which would be aligned with the demands of the digital economy and form the basis for strategic and tactical management decisions in both the short and long term.

The Fourth Industrial Revolution has brought forth new requirements and demands, such as the need for adoption and widespread utilization of the latest technologies, particularly in the field of employment. This underscores the growing imperative to ensure an adequate availability of specialized employees and to reallocate job profiles in alignment with the demands and challenges of the time. Traditionally, Ukraine's state statistical services have conducted survey observations, providing information about the state of demographic and business situation in the country. This has allowed us to gain insights into general trends in mass employment, poverty, unemployment, and dynamics in labour force parameters (economically active population), among others. However, in the era of digital transformation, there is a lack of comprehensive data about emerging phenomena in the labour sphere, such as non-standard forms of employment, platform-based jobs, and remote work. Additionally, there is a gap in information on the «digital» industry, encompassing electronic communications, the information society, and the audiovisual market. There is also a need for information on emerging new occupations and evolving requirements in skills and competencies. Today, there is an urgent need for other types of specialists. The emerging new fields of specialization, changes in human labour, and the introduction of digital technologies induce the reallocation of occupations. Some occupations are fading away and disappearing, making room for occupations that are needed to work with artificial intelligence. This primarily includes professionals who are involved in developing artificial intelligence solutions, such as IT specialists engaged in programming, Data Scientists and Big Data specialists who implement these solu-

tions into practice, as well as professionals who are capable of using these solutions. Those professionals and managers who are adept at using artificial intelligence will be more competitive. As artificial intelligence becomes increasingly capable of creating presentations, writing articles, or generating videos, those who know how to use this technology will continue to work effectively. In contrast, those who are not proficient in its application will find themselves in lower demand.

Big Data is a set of technologies designed to handle the following operations: (1) processing larger volumes of data compared to «standard» scenarios, (2) processing data that are received rapidly in very large quantities, with the volume of these data continuously increasing, and (3) synchronizing the work with structured and unstructured data, enabling their simultaneous and multi-aspect processing (Technologies for processing Big Data, n.d.).

The term «Big Data» refers to vast amounts of information generated by the internet in the process of people's use of modern digital technologies. Due to their sheer size, these data surpass the capacity of standard tools for data processing, necessitating specialized software and technical solutions. The sources of Big Data encompass information gathered from social networks, video surveillance, video cameras, video recorders, mobile devices, point-of-sale systems in large retail chains, digitized television programs, sound recordings, digitized libraries, and archives. Even data from Smart TV controls now fall under Big Data, which are collected, accumulated and made available for aggregation and analysis. This opens up unprecedented opportunities for optimization in many domains, including public administration, information support, the labour market, medical services, telecommunications, finance, transport, production, and more. Big Data can complement data from standard statistical surveys for indicator assessments. Such an approach, in particular, enables a more in-depth analysis of the labour market using data from sample workforce and wage surveys, along with data from recruitment agencies regarding job vacancies and proposed remuneration levels. Additionally, it aids in estimating consumer price indices based on standard price surveys and sales data form supermarkets and online-shops. The primary challenge now is to develop suitable statistical models and algorithms. Official statistical bodies can potentially solve the issue of storage and processing of Big Data through the use of «cloud» technologies, a possibility that is being explored by statisticians in many countries of the world (Sarioglo, 2016).

The introduction of martial law in Ukraine, along with subsequent suspension of planned statistical observations, has exacerbated an already complex situation. The awareness of policy-makers about the true state of the labour market has dropped to a critically low level, impeding their ability to make balanced strategic and tactical management decisions necessary to ensure the resilience of the regional and national labour markets. In this context, the issue of introducing new scientifically-founded approaches to information collection and its analysis and evaluation methodology acquires new urgency. This problem can be resolved

thanks to the development of digital technologies for the extraction and processing of Big Data, including from the internet network, such as job search websites and social networks, and their intellectual analysis (Olsson et al., 2014). Moreover, these methods and technologies have the potential to yield increasing volumes of high-quality information even from traditional sources, such as enterprise and workforce surveys, provided that the data collection institutions adjust their work accordingly.

The aim of this article is to reveal the challenges and opportunities of information support for labour market analytics under the conditions of digitalization, to analyze the international and local experience in using the methods of collecting and processing Big Data on the labour market, and to assess the perspectives of its utilization in Ukraine.

Literature Review and Methodology

The conceptual foundation of our study is rooted in the evolving landscape of Industry 4.0 technologies and their impact on the national economy and the labour sphere. This impact is characterized by a significant and progressive reduction in the labour intensity of medium- and low-complexity jobs, which, in turn, has a direct influence on how labour resources are utilized and leads to a transformation in the professional and qualification structure of the workforce. Moreover, our research builds on the extended possibilities for information support made feasible through the acquisition and use of Big Data for information collection, evaluation and analysis facilitated by the development of information and communication technologies (ICTs) and digital technologies available through internet resources.

In this study, we employed a range of general scientific methods, including analysis, synthesis, abstraction, theoretical generalization, data systematization, deduction, analogy, explanation, and comparison. We also extensively utilized data from online sources, such as specialized digital platforms, web portals, and websites.

In reviewing international scientific literature, we have found that the issue of digitalization of the economy and its influence on the labour sphere has been the subject of active research by experts from the International Labour Organization (ILO), the World Bank, the European Commission (2016, 2018), and other international organizations, such as McKinsey Global Institute (Manyika et al., 2017), European Training Foundation (2017), and CEDEFOP (2014, 2023). Additionally, research on this topic can be found in the works of foreign specialists (Colombo, Mercorio & Mezzanzanica, 2018, 2019; Mezzanzanica & Mercorio, 2018, 2019; Stronkowski, 2018).

In Ukraine, numerous scientific schools are actively engaged in research on these issues. There is a variety of scientific studies about the trends and prospects of labour sphere development under the conditions of digitalization of economy. This research encompasses the works of various scholars, including A. M. Kolot and O. O. Herasymenko (Kolot & Herasymenko, 2020, 2021, 2022), and a series of monographic studies authored by representatives of different scientific schools, such as O. I. Cymbal, E. M. Libanova, O. V. Makarova, V. H. Sarioglo and others (Cymbal et al., 2021); V. H. Sarioglo (2016); L. L. Antonyuk, D. O. Ilnytskyi, and A. O. Sevastiuk (Antonyuk et al., 2021); O. F. Novikova, Yu. S. Zaloznova, O. I. Amosha, Ya. V. Ostafiychuk, O. V. Pankova, O. Yu. Kasperovych, O. O. Khandiy, L. L. Shamileva, and others (Novikova et al., 2022); V. P. Vishnevsky, A. F. Dasiv, and others (Vishnevsky et al., 2022), N. A. Azmuk (2019), and many others. O. M. Kyslova (Kyslova, 2019) explores the essence of Big Data in the context of research dedicated to problems of modern society. At the forefront of today's discussions are the questions of methodology and the need to «repurpose» online data processing methods employed by internet platforms to address information, statistical, and sociological tasks. The ongoing development of information and communication technologies, coupled with the digitalization of the economy and society, expands the possibilities for the simultaneous utilization of both Big Data and data from official statistics and sociological research to acquire comprehensive information.

Research Results

The analysis and generalization of both foreign and domestic sources reveal that, in recent years, the problematics of the digitalization of the economy and its impact on the labour sphere, along with the issue of adequate information support, have been actively researched by experts from the International Labour Organization, the World Bank, the European Commission, and many other international organizations. According to preliminary estimates of the European Commission (2018), approximately 50% of existing jobs worldwide could theoretically be automated in the future, with 37% to 69% of jobs potentially subject to partial automation within the European Union. Estimates from the McKinsey Global Institute (Manyika et al., 2017) suggest that automation could result in the displacement of 400 to 800 million people by 2030. This implies that 15% to 30% of the global workforce may face the need to change occupations and acquire new skills under the medium and fast-paced automation scenarios.

In Ukraine, research on the trends and prospects of labour sphere development is highlighted in numerous publications, representing diverse schools of thought and streams of research. Thus, Kolot and Herasymenko (2020, 2021, 2022) have consistently highlighted major trends in global transformations of social and labour relations while analysing new forms of non-standard employment.

One of the key messages conveyed by these authors is a call to rethink the prospects for the labour sphere development in the context of the new stage of globalization and the new, also known as digital, information, or network, economy. «Using an interdisciplinary approach, a new economic theory of labour and employment should be formed, which explains the true nature of the world of labour and the world of people themselves in the digital age, as well as their resources, competitive advantages and failures, mechanisms and tools of operation and regulation» (Kolot & Herasymenko, 2021, pp. 452–453). In line with their perspective, the authors have substantiated their own theoretical construct of «Labour 4.0» primarily as a labour paradigm that is inherent in the new digital economy and technologically founded on «Industry 4.0». Furthermore, the authors view Labour 4.0 as an institution designed to harness labour resources within the coordinates set by the Fourth Industrial Revolution. They propose that Labour 4.0 should serve as a roadmap for organizing labour activity within the context of the emerging global ecosystem (Kolot & Herasymenko, 2021, pp. 259–329).

The collective monograph, «Digital Economy: The Impact of Information and Communication Technologies on Human Capital and the Formation of Future Competencies», by Antonyuk et al. (2021), systematically examines the regularities, peculiarities, prerequisites, and consequences of the digital transformation of national economic models. Through an analysis of digital economy models and the perspectives of Ukrainian citizens on the influence of ICTs on human capital and emerging skills, the authors provide recommendations for creating a roadmap for human capital development and the formation of future competencies. Drawing insights from foreign sources, the authors identify a digital archetype that corresponds to Ukraine's level of digital development. They also substantiate development patterns that are characteristic of the group of countries falling under the «services powerhouse» archetype, which includes Ukraine, Romania, Ireland, Czechia, Poland, Brazil, the Philippines, and India. It would be feasible for these countries to develop activities that yield higher value added and invest in the development of specialized technologies. This path to progress necessitates the effective functioning of the science and innovation ecosystem. The authors emphasize the importance of appropriate information support for the successful implementation of this policy.

In a monograph authored by researchers from M.V. Ptoukha Institute of Demography and Social Research, Cymbal et al. (2021) substantiate priorities for the national policy aimed at minimizing the asymmetry in the Ukrainian labour market caused by the global trends and digitalization processes, viewed from the perspective of human development. The findings of the study reveal contradictions in the current state of the labour market at the beginning of the 21st century, characterized by the emergence of new challenges and risks, but also by new opportunities. Of particular relevance to this article's objective is the authors' substantiation of the prospects for establishing a unified, integrated information and analytical system to support labour market policies in Ukraine. The authors propose a methodical approach for the quantitative evaluation of relevant supply and

demand parameters in the labour market with application of Big Data and data mining technologies. They also suggest integrating the data obtained through these technologies with national labour statistics classifiers. Mykhailova (2023) discusses the role of artificial intelligence and its evolution in manufacturing solutions since 2014, serving as the foundation for the Fourth Industrial Revolution and Industry 4.0. She also delves into the issues of ChatGPT and the widespread application of the latest technologies across various domains of social life, primarily in manufacturing, medical services, education, security, and energy.

Transformational changes in Ukraine's labour sphere, specifically in the labour market and employment, driven by the digitalization of the economy, have been the focus of research conducted by experts at the Institute of Industrial Economics at the National Academy of Sciences of Ukraine. The collective monograph authored by Novikova, Zaloznova, Amosha, and others (Novikova et al., 2022) outlines the conceptual foundations and methodological support for managing the transformation process in the social and labour sphere under the conditions of digitalization. Notably, Pankova and Kasperovych provide a rationale for the content, structural and technological characteristics of network- and digital-driven revitalization (platformization) of the social dialogue within the socio-labour relations system in Ukraine. Meanwhile, Shamileva and Khandiy emphasize the advantages of using path analysis models for evaluating, modeling and forecasting developments in the labour market, employment, and the labour sphere in general. They also shed light on the methodology of risk assessment in the context of digitalization. Azmuk (2019) reveals the peculiarities of ongoing employment transformations in the transition to the digital economy and offers paths and strategies for adaptation to the latest global challenges.

In the collective monograph «Industrial Future of Ukraine: Forecasting by Mathematical Modeling» (Vishnevsky et al., 2022), the authors present their vision of Ukraine's industrial future through the application of mathematical modeling and forecasting methods. Kyslova (2019) argues that Big Data serves as a new source of information about both the surrounding world and the evolution of societal processes, making it a valuable resource for empirical research. She also emphasizes the need for developing «digital methods» within the emerging field of sociological analysis methodology, which is evolving due to the widespread proliferation of Big Data.

An increasing number of publications are dedicated to the methodology of labour market research under the conditions of digitalization. Reports from the European Commission and Eurostat (European Commission, 2016) underscore the significance of utilizing new digital data sources for official statistics. The literature addresses various aspects, including the potential, constraints, methodological and technical challenges, and real-world examples of using Big Data and digital tools for labour market analysis. This discussion is well-documented in the works of the European Training Foundation (2017), as well as in publications by

Colombo, Mercorio and Mezzanzanica (2018, 2019), Mezzanzanica and Mercorio (2018, 2019), and Stronkowski (2018).

The authors' positions converge in recognizing that radical changes are currently underway in the field of information technologies. These transformations have given rise to the concept of «Big Data», the declaration of the «digital revolution», and the «data revolution». Furthermore, the transition to a new technological system, the development of the digital economy, and related processes involving intellectualization, digitalization, networking, platformization, and robotization of production are leading to significant changes in both global and national labour markets. These changes result in the radical reorganization of production processes, necessitating appropriate information tracking. Industry 4.0 technologies play a crucial role in the digital transformation of business models and national economies, opening up new opportunities for innovators and ensuring the global competitiveness of national and regional ecosystems. The adoption of Industry 4.0 technologies is accompanied by large-scale, intensive reductions in the labour intensity of medium and low-complexity jobs. This directly impacts the utilization of labour resources and the occupational and qualification structure of the workforce. This workforce structure becomes increasingly differentiated by the level of professional training and competency. New types and forms of labour activities emerge, leading to the creation of new occupations, while other jobs and even entire occupations disappear from the socio-labour landscape. New forms of employment emerge, altering the scope, content and methods of work, as well as requirements for employees and their modes of interaction with employers. These emerging phenomena fundamentally reshape the world of work, defining new content, requirements, and needs for certain skills and abilities. Consequently, these changes affect the demand and supply of jobs. Research into these changes requires relevant information support.

The governments of many countries have declared digital transformation as one of the key priorities in their national economic development strategies. Nowadays, every country tries to find its place on the digital map of the world and to choose its future path for the digital economy development. The consulting company Arthur D. Little and Huawei (2020) published a joint study on the digital economy, which has become one of the largest international reviews of policies for the digital economy in different countries worldwide. The authors recommend a set of tools and policies that can be used to draft national strategies for the digital economy development. The success of such strategies should be considered across the following dimensions: 1) technological development, where the most important aspects encompass the policy and regulation of broadband access, spectrum, cybersecurity, data protection and privacy, and cloud computing; 2) development of institutions; 3) infrastructure capacity; 4) resource capacity; 5) key segments of digital policy, including e-governance, Industry 4.0, education and science; 6) and related policies, such as ease of doing business, access to finance, including venture finance, digital inclusion, etc. Achieving high qualitative results along these dimensions allows countries to secure an appropriate place

on the digital map of the world, strengthen their competitiveness, and move from one archetype to another (from a simpler to a more developed one). These parameters should be taken into account in the national system of labour market statistics and analytics, whereas the corresponding information support should align with these parameters.

In Ukraine, the available data sources about the current state and changes in the labour market can be grouped into official and alternative sources. *Official sources* are data from public authorities, primarily official statistics data, as well as administrative data and data of state monitoring. These sources have significant advantages, such as proven methodological approaches to data collection and processing, regular periodicity, completeness of coverage by territory and by subject, quality control, and feedback. At the same time, official sources have their limitations, especially when it comes to their availability and suitability for purposes of research. In particular, the aggregation and rigid structure of statistical data make it impossible to trace important details and relations. Administrative data are aimed at demonstrating the scope of the process itself rather than the results of the process. State monitoring applies mostly formal and department-oriented approach or ranking approach rather than assessment-oriented approach.

Thus, the Labour Force Survey, which had been regularly conducted by the State Statistics Service of Ukraine until 2022, has been internationally recognized as the most full and comprehensive data source for assessing both the labour supply and the scale and structural characteristics of unemployment. The results of this survey are available not only in the form of official publications, but also in the form of anonymized microdata files, which expands the opportunities for cross-analysis in identifying relationships between different characteristics. However, microdata files have very limited content. Out of the entire set of questions included in the survey questionnaire, the files contain the socio-demographic features of the respondents (gender, age, region and type of settlement where a person resides, marital status, education, status on the labour market) and only some characteristics describing their economic activity, such as occupation/activity (at the highest level of aggregation), type of employment (formal or informal) and duration of working life, causes and duration of unemployment, methods of job search, and reasons for inactivity. In this form, microdata add little to official publications of survey results as they do not allow tracking new phenomena in the labour sphere related to the spreading of non-standard forms of employment, the emergence of new occupations, etc.

Unlike official sources, *alternative data sources* offer a wider range of themes. Thanks to digitalization and the widespread use of internet services, including those related to the labour market, coupled with the availability of technical data processing solutions, information on the labour market is becoming more diverse and accessible. In recent years, there has been an exponential growth in data published on specialized online portals and services, such as job-search

websites, job vacancy listing websites, and professional networks for sharing labour market information. This expansion of data sources enhances the capabilities for monitoring and analysis of the labour market. It enables the assessments of labour market dynamics to be conducted in a timely or near-real-time manner, using an inductive approach to data analysis, that is, using data to formulate and confirm hypotheses, and at a very detailed level. Thus, firstly, internet data, such as those obtained from online job vacancies, represent the only alternative source of highly refined information, aside from specialized surveys that can be used to assess only a limited set of skills and abilities. Secondly, the demand for skills may vary depending on occupation, industry, or region. Tracking these variations requires granular information, which can only be obtained through the use of Big Data technologies.

Rooted in their advantages are the disadvantages of alternative data sources: unstructured and fragmented datasets, the presentation of information in a free form manner, a lack of clear-cut criteria and requirements, significant volumes of unverified information, and missing records. For example, job vacancy owners often fail to provide even approximate salary details or manipulate information in order to attract inexperienced job seekers. Working with such data necessitates the use of appropriate tools for data selection, retrieval, cleaning, wrangling, mining, and interpretation.

In the study of this problematics, both domestic and foreign literature traditionally employs the term «Labour Market Information». LMI describes all types of data and information used to support operational activities related to the labour market, as well as any information related to the supply and demand in the labour market (Mezzanzanica & Mercorio, 2019, p. 8). At the same time, a new concept of «Labour Market Intelligence» (LMI) is emerging in connection with the proliferation of Big Data and the need for new approaches to their analysis. Although there is no universally accepted definition of Labour Market Intelligence, it can be described as the design and application of artificial intelligence (AI) algorithms and frameworks to analyze data related to the labour market in order to support policy- and decision-making (see for example, Mezzanzanica & Mercorio, 2018, 2019; UK Commission for Employment and Skills, 2015). Proceeding from this definition, LMI is to be considered as an activity that should produce an outcome in the form of comprehensive labour market knowledge, defined as insights and additional information that can enhance our awareness and understanding of the observed phenomenon. This knowledge, in turn, empowers users to conduct analyses and make predictions. As a result, our perception of the modern paradigm of the Labour Market Information System (LMIS) is evolving. The term LMIS primarily denotes a set of interconnected components (architectural and technological) working together to collect, retrieve, store, and disseminate information in order to facilitate activities such as planning, controlling, coordinating, analysing, and decision-making in business organizations. Therefore, the information obtained through this information system holds a dual value: Firstly, it contributes to operational processes, and secondly, it helps decision-makers to achieve their

goals in the field of analytics. There is no one-size-fits-all LMIS model, and there is no universal way to develop such a system, as its architecture, data, and methods depend on the specific analytical needs and contextual factors, such as country, institution, political priorities, and data infrastructure. The presence of vast amounts of internet data and Big Data technologies make it imperative for labour market information systems to evolve in order to be able to incorporate this data and to use AI algorithms to extract useful information. Statistical modeling and modeling of behaviour, including preferences, moods, and informational impact, are effective instruments for working with Big Data, and their role is expected to grow in the future.

Internet data related to the labour market can exhibit various structures, which can be broadly categorized into structured (e.g., tables), semi-structured (e.g., XML data as found in tweets), or entirely unstructured (covering everything else). These data are continually generated by diverse network sources beyond a user's control, imposing distinct requirements for quality control and data comparability across different subjects and timeframes. This sometimes necessitates not just regular monitoring and data collection but also continuous data collection and content quality monitoring. Internet data can yield valuable insights into certain characteristics of socio-economic processes using standard statistical procedures. For instance, by conducting a Google Trends query for «job search», the service can report the number of relevant requests in Ukraine or individual regions relative to the highest number of requests during the analyzed period. The presence and accessibility of Big Data, particularly internet-derived data, demand further advancements in statistical methodology in order to enable the assessment of statistical indicators using data from these new sources and to improve the quality of statistical information on this basis. One effective approach would be to improve the system of statistical indicators. In many cases, it would suffice for official statistics to capture trends and intensity of processes, even without the need for correspondence with the entire population (Sarioglo, 2016, pp. 15-16).

However, unlike data that has undergone statistical processing, internet data requires users to be able to clean datasets, addressing such deficiencies as duplication, grammatical errors, synonyms, and the incorrect and imprecise use of terms. It is not uncommon for information from a single source to lack completeness. Consequently, the methodology of integrating vast quantities of diverse internet data remains an open question.

At the same time, even partial resolution of the aforementioned issues creates entirely new and non-trivial opportunities for researchers. Access to primary data, and even the digital footprint of individuals' daily lives, enables comprehensive inductive data analysis without the need for preliminary analytical hypotheses, or with minimal influence from them on the ability to detect patterns and regularities within the data. Rather than adhering solely to a deductive approach to knowledge formation, this approach allows for a dialectical combination of models based on initial abstract hypotheses and their deductive justifications with

models constructed using the «bottom-up» principle, starting from granular processes and ascending to generalizations. As a result, digital data and their processing methods do not replace but rather expand and enrich statistical and administrative labour market data.

To enhance our understanding of the labour market, it is essential to verify internet-derived data by cross-referencing them with external sources of statistics, such as workforce surveys, for example, and to use them in conjunction. Nevertheless, numerous challenges exist on this path: How can data comparability be ensured within the same taxonomies for data retrieved from different digital, administrative and statistical sources? How can errors and biases in the representativeness of digital data relative to the known, partially known and unknown components of the population engaged in the studied processes be estimated? How should one choose the optimal temporal parameters for data collection?

The use of Big Data increases the requirements for methods of finding correlation and causal relationships, and their practical interpretation. The desire to make decisions in real time or even the creation of intellectual and analytical early-warning systems for new risks or opportunities necessitates a larger hardware and software infrastructure, as well as a more fundamental and broad set of qualifications for researchers. It is no longer sufficient for researchers to rely solely on their expertise in economics and the labour market. Neglecting this issue risks shallow engagement with new methods and technologies, leading to subsequent disappointment or a communication gap between those who interpret information and those who extract it technically – between economics and labour market specialists on one side and programming and data processing specialists on the other.

Nearly all leading experts in the field of Big Data for the labour market admit that the Big Data relevant for the needs of labour market analytics should not be «used» in the traditional sense as «ready-made» information, but rather serve as a raw material for «extracting» knowledge from this Big Data. In general, this process involves five main steps, namely the selection of sources and data retrieval, pre-processing, transformation, data mining, and interpretation and evaluation. These steps can be modified depending on the specifics of the studied domain (Mezzanzanica & Mercorio, 2019, pp. 16–19). For example, all five steps are necessary to answer the questions about the impact of digital or interpersonal skills on occupations or to identify new requirements for a set of skills that do not yet have a name, given that no data source directly indicates this and that usual frequency analysis cannot be used to identify them.

The development and widespread application of modern digital methods and technologies for labour market analysis in Ukraine should be based on a thorough examination and utilization of the accumulated foreign and domestic experiences. It is crucial to closely examine practical examples of working with Big Data in the labour market. A notable case to consider is the creation of a working prototype for a platform that can collect and classify job vacancies advertised on

the internet in five EU countries (CEDEFOP, 2014). Launched in 2014 by the European Centre for the Development of Vocational Training (CEDEFOP), the primary goal of this project was to analyze diverse information obtained from internet job vacancies in order to inform evidence-based decision-making and policy formulation and evaluation. Following successful prototype testing, the initiative expanded to create an online labour market monitor for 28 EU countries in 24 official languages (CEDEFOP, 2023). This system aims to collect real-time information about jobs, companies, and types of workers requested, focusing on skills, competences, qualifications, and other characteristics. Ultimately, a knowledge base should be formed containing information about labour market demand, with a particular emphasis on requested skills and abilities.

The initial phase of the project involved an investigation into the available data sources in the EU. The objective was to understand how online job vacancies can be utilized by both employers and job seekers and to assess the representativeness of the data for proper interpretation of the results. During this stage, a list of relevant web portals, from which data could be retrieved, was compiled. This encompassed 530 sources from 28 EU countries, grouped into the following categories: job search systems, employment agencies, employment websites, private classifieds portals, companies, websites of state employment services, news websites, websites of educational institutions, and websites of employment organizations. The analysis revealed that private employment portals, often directly linked with employer websites, were predominant in all countries. Web portals of public employment services and recruitment agencies play a significant role in only some of the analysed countries.

Data collection methods vary based on website types, including scraping, content crawling, and API access, with the latter being used for larger websites with established license agreements. In the first six months of data collection, it was estimated that the EU hosts approximately 60 million unique job vacancies annually.

The results of data analysis are presented through visualization tools on the project's website, featuring eight information panels. These panels enable users to display data graphically across various dimensions, as follows:

- Number of online job postings and their distribution by provider by country.
- Countries and occupations: distribution of online job vacancies by occupation (ISCO levels 1 and 2) by country.
- Regions and occupations: distribution of online job vacancies by occupation (ISCO levels 1 and 2) by region (at the national and regional NUTS-2 level).
- Distribution by occupation: presents the intensity of demand for an occupation in the EU, either as a whole or by country. Demand intensity is

measured as a share of online job postings for a particular activity in the total number of online job postings and can be displayed at both 2-digit and 4-digit ISCO levels of detail.

- Skills: provides data on skill requirements within selected occupations, categorized into 1-digit, 2-digit and 4-digit ISCO occupations according to ESCO ver. 1. Visualizations can be displayed as word clouds or tree maps.
- The most in-demand skills: This panel visualizes employer preferences for certain skills, including charts displaying skills sorted by their frequency across all online job vacancies, the ten most important occupations for selected skills, and the share of online job vacancies that require these skills.
- Cross-cutting skill sets: identifies skill sets common to different occupations.
- Job vacancies by type of activity: the distribution of online job vacancies categorized by the type of economic activity according to NACE rev. 2.

In 2016, the European Union and Eurostat launched the ESSnet Big Data project with the goal of «integrating Big Data into the regular production of official statistics, through pilots exploring the potential of selected Big Data sources, and through building and implementing concrete applications» (European Commission, 2023). Notably, this project places significant importance on the representativeness of Big Data. The objective is to determine whether Big Data can effectively represent the entire population or a stratified sample, allowing its inclusion in the official EU statistics. Actually, this is the first public initiative to incorporate Big Data (for example, job vacancies) in the official labour market statistics.

In the USA, Frey and Osborne (2017) employed machine-learning algorithms, which were trained on a sample of occupations that were previously annotated by labour market experts, to estimate the probability of automation for all existing U. S. occupations based on the SOC classification. This work has laid the basis for similar Big Data projects, such as CyberSeek.org (CompTIA, 2018).

In recent years, there has been a proliferation of commercial products designed to compare skills with job requirements. These products are invaluable to businesses aiming to automate their HR departments' activities. Notable examples include Burning Glass, Workday, Pluralsight, EmployInsight, Textkernel, and Janzz, among others. One illustrative case is the Google Job Search API, a paid service that employs Google's machine-learning service to classify jobs according to the O*NET standard taxonomy of occupations (Mezzanzanica & Mercorio, 2019, p. 25).

The WheretheWorkIs.org project in Great Britain is a supply and demand analysis model for medium-skill jobs (Mezzanzanica & Mercorio, 2019, pp. 49–51). The goal of this project is to provide a unique tool designed to help educational institutions, researchers, employers, and policy-makers identify gaps in the demand and supply of various types of jobs. The project was implemented by Burning Glass Technologies and the Institute for Public Policy Research.

WheretheWorkIs uses two kinds of data from the Burning Glass database, which contains over 40 million unique UK jobs. Advanced Natural Language Processing tools are used to convert information into structured, usable data. With this approach, employer demand for specific skills and abilities can be described at a level of detail that is not available from traditional statistical survey-based methodologies. It is important to note that the Burning Glass data are not used autonomously. They are normalized against employment data published by the Office for National Statistics (ONS). Subsequently, these data are further validated against the Annual Survey of Working Hours and Earnings (ASHE) conducted by the ONS. All online job vacancies data are normalized against total employment data published by the ONS in its Labour Force Survey. Through this integration, factual and operational data on employer demand add new knowledge to the parametric statistical picture of the U. K. labour market, helping to better understand the content and causes of current processes.

One example of a *multilateral inclusive process in the functioning of the labour market intellectual and analytical system is the WollyBI Project* in Italy (WollyBI, n.d.). The peculiar feature of this system is that it offers a possibility to construct its own database of citizens – respondents to online job postings, rather than just gathering data about these processes from the outside. The project was launched as a Software as a Service (SaaS) tool, a web service available at any time to any user with a valid account. It was designed to collect and classify job vacancies advertised on the internet based on the International Standard Classification of Occupations and the European Skills, Competences, Qualifications, and Occupations (ESCO) standard taxonomies, as well as to extract the most requested skills and capabilities from job descriptions.

The architecture and toolset of WollyBI are similar to those of the CEDEFOP project. The system offers users five different entry points depending on their analysis purposes:

- geographical area – to find occupations and skills at a geographic level;
- skill – to input a selection of skills and to find occupations that contain those skills;
- firm – to obtain a ranking of occupations that specify a particular industry sector in the vacancy;
- occupation – to navigate through the ISCO and ESCO classifications and to use the details related to each occupation;

- user-defined queries – for free drill-down and roll-up operations over the OLAP cubes (a multidimensional database optimized for data warehouse and interactive analytical applications).

The availability of free, user-defined queries is a significant advantage of the service, expanding the potential of labour market analytics. Mezzanzanica and Mercorio (2019, pp. 44–47) provide an example of how data from the WollyBI portal can be used to identify new potential occupations by applying the Latent Dirichlet Algorithm (LDA) for unsupervised machine learning. In this context, the term «new (potential) emerging occupations» refers to occupations that have not yet been included in any official classification system. Obviously, the use of a new term in a job vacancy does not necessarily indicate the emergence of a new occupation. To identify genuinely new skill combinations, thematic modeling is employed. This approach can assist in detecting statistically significant terms within texts using LDA, a generative probabilistic model that considers each document as a mixture of latent topics, where each topic is characterized by its own distribution of words. As a result, it becomes possible to create a profile for a new occupation, including an indication of its skill level, which is determined based on the frequency of each category or group of skills within the occupation (encompassing digital and non-digital skills as well as soft skills), and the distribution of skills according to the European Electronic Competence Framework (e-CF).

Table 1 presents a list of Big Data projects used in labour market research.

Table 1

Examples of digital technology and Big Data projects used in labour market research

Project	Data sources	Objective	Project
CyberSeek.org	Online job vacancies database Burning Glass. Official data of the Bureau of Labour Statistics. Data on certificate owners from 5 leading certification organizations.	Providing detailed data to assess labour market supply and demand in the USA within the field of cybersecurity and to develop career-building pathways.	CyberSeek.org
Wherethe WorkIs.org	Burning Glass – online job vacancies database. Official data of the National Statistics Department.	Using Big Data to analyse the labour market demand and supply for various types of medium-skill occupations.	Wherethe WorkIs.org

Project	Data sources	Objective	Project
ESCoE	Burning Glass – online job vacancies database.	Creating an open-access and detailed taxonomy of professional abilities and skills.	ESCoE
Bizkaia Basque Talent Observatory	Internet-data. Data of public employment service.	Utilizing Big Data to analyse the skill profiles of high-skill occupations that are in high demand on the labour market, grouping them by sector, territorial unit, and other parameters.	Bizkaia Basque Talent Observatory
LMI For All	Internet data (job postings).	Developing a system for real-time monitoring of the EU labour market.	LMI For All
ESSnet Big Data	Internet data. Eurostat data.	Integrating Big Data into regular official statistics.	ESSnet Big Data
WollyBI	Internet data (job postings).	Gathering and classifying data on job vacancies using standardised taxonomies, such as the International Standardized Classification of Activities and the European Classification of Skills, Competencies, Qualifications, and Occupations (ESCO). Identifying the most in-demand skills and abilities.	WollyBI
CEDEFOP	Internet-data: job search engines, employment agencies, employment websites, job boards, websites of public	Creating a pan-European system for the analysis of online job vacancies (number of vacancies, required skills, compe-	CEDEFOP

Project	Data sources	Objective	Project
	employment services, news websites, educational websites.	tences and qualifications, other characteristics) and specifying the requirements for new professional abilities.	

Source: developed by the authors based on Mezzanzanica and Mercorio (2019), CEDEFOP (2023), and European Commission (2023).

European and local researchers have made sure not to let the digitalization of the Ukrainian labour market go unnoticed. In 2019, the European Training Foundation (ETF) initiated collaboration with experts from the Ministry of Social Policy of Ukraine, the State Employment Service of Ukraine, the State Statistics Service of Ukraine, and M.V. Ptoukha Institute for Demography and Social Research at National Academy of Sciences of Ukraine to establish methodological and analytical infrastructure for digitally researching the online labour market of Ukraine (European Training Foundation, 2022). In the course of this cooperation, public authorities, scientific entities, and international organizations harmonized their positions on the principles of utilizing Big Data from the Ukrainian online labour market. Additionally, experts identified priorities for selecting the architecture and instrumental platform to construct the analytical and intellectual system of the Ukrainian online labour market and to coordinate it with platforms operating in the labour market of EU countries. Furthermore, a number of training sessions and seminars were organized for Ukrainian specialists to familiarise them with the functioning of similar systems in EU countries. As a result, from 2020 to 2022, Italian partners (Vaccarino, 2020) established a trial website, providing generalized assessments of the Ukrainian online labour market with a lag not exceeding 1 month. Unfortunately, the operation of this website was discontinued due to full-scale Russian aggression.

In the study by Sarioglo and Cymbal (2020), the authors developed and tested several methods based on technologies for gathering data from internet intermediaries using online parsing algorithms and performed a test run of the software complex, accumulating, deduplicating, and cleaning data from the Ukrainian online labour market. Subsequently, they created a system of classification models for supervised machine learning to extract meaningful information about labour market parameters from the prepared data. This allowed the researchers to calculate test estimates regarding the overall situation in the Ukrainian online labour market. These estimates were then compared against the data from the Labour Force Survey and Enterprise Survey published by the State Statistics Service of Ukraine. The comparison revealed significant and segmental shifts in the

demand for labour on the online labour market relative to the structure of the employed population and labour supply data in the surveys published by the State Statistics Service. However, applying the procedures of weighted modeling of the estimates obtained from the online labour market data to the analogous segments of the employed population and persons actively seeking work, provided interesting insights into the mechanism and trajectory of the latter. Specifically, the relevant online labour market data enhanced the understanding of the reasons for the high turnover of the labour force, even when the structure of the employed population in terms of professional qualifications, industry characteristics, and wages is fairly stable.

Our analysis substantiates the need to establish a fundamentally new Labour Market Information and Analytical system (LMIAS) in Ukraine. This system should encompass a whole range of indicators for comprehensive labour market analytics under the conditions of digital transformation. Such a system would serve as a basis for creation of an effective toolkit for monitoring the labour market dynamics, identifying key trends, needs and adequate ways to satisfy them (for example, skills and competencies categorised by territory or industry). Big Data technology emerges as the most promising technology for this task. Within this context, the concept of «analytics», and consequently, the essence of the information and analytical system, takes on a new meaning (Cymbal et al., 2021, p.158). Under the European Union's framework of concepts, this system could be defined as the design and application of algorithms and artificial intelligence systems for the analysis of labour market data, aimed at facilitating the creation of effective employment policies.

The utilization of this new information support system empowers agents and participants in labour market interactions to make their own forecasts and well-balanced decisions. Unlike contemporary information or expert analytical systems, the new system does not provide ready-made instructions and recommendations for actions from third parties or institutions. Instead, it offers real-time opportunities to make such independent decisions at a level that, on average, is comparable to those of standard expert systems.

An essential step in preparing information support involves procedures that aim to institutionalize the sources, owners, users, and beneficiaries of relevant information. Although this predominantly occurs within the legal framework of the labour market, it is imperative to include the regime of legal publicity, transparency, social dialogue, and legitimate representation of labour market actors and structures as a permanent structural module of the labour market information and analytical system (LMIAS).

Ukraine's national system of statistics needs to be developed further to ensure openness and completeness of data, as well as the accessibility of statistical modeling. It is important for the country to join the pan-European surveys conducted by the European Foundation for the Improvement of Living and Working Conditions (Eurofound).

Conclusions

The rapid advancement of digital, information and communication technologies and data formation and processing methods brings about substantial qualitative transformations in the realm of information support for the system of statistical indicators of the labour market: Nowadays, all pertinent information about the labour market is virtually «manifested» in real-time. It is important to leverage these novel possibilities to modernize the existing system of statistical labour market analytics so that to incorporate and employ them widely in the practical management of socio-labour development. State authorities, businesses, labour market entities, and participants in socio-labour relations now have new opportunities to gain more profound and accurate knowledge of relevant processes in the labour market. This would enable a comprehensive understanding of the situation, tracking of its dynamics, and identification of key trends.

The most promising technology for this purpose is Big Data technology. Within the scope of Big Data, the concept of «analytics» and, accordingly, the essence of the information and analytical system take on a new meaning. Within the conceptual framework of the European Union, this system can be defined as the development and use of algorithms and artificial intelligence systems for the analysis of data related to the labour market. Its goal is to facilitate the formation of effective policies and decision-making, creating an efficient toolkit for monitoring the dynamics of the labour market and identifying skill needs and relevant trends at different management levels, such as on a territorial or sectoral basis. The collection, processing and analysis of Big Data represent a modern approach to implementing a promising method known as «detached observation», allowing a return to complete and direct survey-based observations instead of relying on sample-based observations, now at a new informational level. Leading scientific and social projects in the EU take this into account, focusing on the development of methods, tools, and theories of working with Big Data. There is also an increased effort to establish effective information security systems for this activity and to understand social, economic and political consequences of the widening and deepening involvement of information methods and technologies in monitoring the daily life of business entities, the population, and other economic actors. Big data serve as both a source of information and a research tool. However, they have not yet been fully mastered by domestic statisticians, researchers, sociologists, and analysts.

Our study revealed that the development and use of data mining and Big Data methods to assess the supply of jobs in the Ukrainian labour market remains low. While the professional and expert community recognizes the success of these innovative technologies in various fields and is aware of their potential, the respective institutions do not adequately focus their primary efforts on the development of methodology and methods for integrating and using digital, information

and communication technologies into the practice of labour market information support.

The global trend for digital economy development is poised to bring about significant changes in the system of socio-labour relations, particularly within the labour market and the process of work itself. The transformations in employment driven by digitalization create not only opportunities but also introduce new risks, necessitating the development and implementation of preventive measures. To facilitate decision-making, it is becomes crucial to develop a methodology for assessing the impact of digitalization on the labour sphere, especially concerning new job creation and displacement of workers across sectors and regions, as well as formulating «roadmaps» for digital transformations and models of digital development in Ukraine's foundational and promising industries (Cymbal et al., 2021, p.158). Timely and imperative is the establishment of a fundamentally new Labour Market Information and Analytical System (LMIAS) in Ukraine. Such a system should encompass a whole set of indicators for comprehensive analysis of the state of the labour market under the conditions of digital transformation. The renewed demand for the development and implementation of such a system is underscored by the need to ensure stability in the labour market in the face of full-scale Russian military aggression and the subsequent post-war recovery in the labour sphere. The operational mechanism of LMIAS can be generally described as a cyclically integrated structure that combines all sources of information into a unified technological and institutional platform, generating ready-made knowledge and solutions for users at different levels and timeframes (Cymbal et al., 2021, pp. 146-149). Compared to a collection of disparate data collection and analysis instruments, an integrated LMIAS platform offers advantages such as the online mode of input and output of relevant information and the ability to facilitate dialogue between users and the system in natural language, providing the appropriate level and volume of information about a specific field. This ensures that users of the LMIAS have the opportunity to propose solutions to urgent problems based on the received data.

When forming an integrated platform for the LMIAS and modernizing the overall system of labour market analytics, Ukraine should draw upon the international experience of utilizing Big Data from on-line job vacancies for assessing the demand and supply of jobs and analysis and forecasting of the requirements for professional skills and abilities. One promising and productive example of such an experience can be found in the cooperation and coordination between state authorities, labour market institutions, scientific institutions, and international organizations in building the local online labour market analytics and intelligence system and coordinating it with platforms operating in the labour market of EU countries (European Training Foundation, 2022).

The widespread adoption of digital methods and technologies as the foundation for establishing an innovative labour market information support system in Ukraine will enable conscious and thorough management decision-making. These

decisions are essential for the flexible modernization of labour market institutions, aligning them with the demands of digitalization and European integration. Moreover, they are crucial for addressing the devastating impact of full-scale armed Russian aggression on the labour sphere.

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