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New EU Industrial Policy Trends as a Basis for Developing a Resilient Industrial Workforce Provision System[1]

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ABSTRACT

The article explores contemporary trends in the development of European Union industrial policy as a conceptual foundation for establishing a resilient industrial workforce provision system. The authors analyze the evolution of EU industrial policy, tracing the transition from the Industry 4.0 paradigm toward the Industry 5.0 model, which is anchored in the principles of human-centricity, sustainability, resilience, and social responsibility. The concept of resilience is examined as a cross-cutting category of EU policy, encompassing the capacity of industrial systems, enterprises, and workers to withstand shocks, adapt to change, and recover under conditions of uncertainty.

Particular emphasis is placed on the enhanced integration of industrial, digital, and socio-labor policies as a strategic response to rising economic turbulence, technological transformations, and labor market imbalances. It is demonstrated that the implementation of the Industry 5.0 concept poses significant challenges to the workforce provision system, as it necessitates a fundamental paradigm shift in approaches to skills development, workforce adaptability, and human capital governance.

Based on the analysis of EU strategic documents, statistical data, and contemporary academic research, the study identifies key constraints to industrial competitiveness: persistent labor shortages, skills mismatches, and the rising importance of employees' digital, cognitive, and social competencies. It is substantiated that the experience of EU Member States provides valuable methodological and practical benchmarks for shaping workforce resilience policies, which are particularly relevant for Ukraine in the context of post-war recovery and European integration.

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The authors propose a conceptual framework in which the industrial workforce provision system is positioned as a subsystem of a resilient economy, delineating governance levels ranging from the national to the enterprise level. The findings underscore the critical role of resilient human capital in ensuring industrial resilience and competitiveness.

Keywords: industrial policy; Industry 5.0; workforce provision system; resilience; human capital; human-centricity; industrial competitiveness; European Union, Ukraine; post-war recovery.

1. Introduction

Since the late 20th century, the manufacturing sector in European Union countries has begun to lose its leading position, which has adversely affected their global competitiveness. The loss of market share in global markets and the establishment of the Single Market necessitated the enhancement of industrial production parameters and product quality to bolster competitiveness (Tsyplytska & Yanenkova, 2018). This, in turn, led to the development of a new industrial policy and its coordination with other areas of state economic regulation, including trade, sustainable development, R&D, regional policy, and employment policy.

An analysis of the content of recent scientific research on European Union industrial policy indicates a shift in emphasis from traditional approaches to supporting industrial development toward multi-level systemic models oriented at resilience, strategic autonomy, and the continuous development of human capital. It is precisely the integration of industrial, digital, and socio-labor policies that creates the foundation for building a resilient industrial workforce provision system in the European Union, directly addressing the contemporary challenges of economic and technological transformation. This aforementioned trend has also been reflected in academic publications. Specifically, the effectiveness of industrial policy is explored through European case studies (Garcia Calvo & Hancké, 2025), and contradictions and balancing issues between the goals of competitiveness, strategic autonomy, and long-term socio-ecological sustainability are analyzed. Building upon this, a post-growth model of industrial policy is proposed, which entails a re-evaluation of the role of labor, employment, and skills in industrial development (Bärnthaler et al., 2025). Significant attention is paid to research into the digital dimension of the new EU industrial policy, where digital tools, innovation hubs, artificial intelligence, and cybersecurity are considered not only as technological priorities but also as a basis for upskilling the workforce and enhancing the adaptability of industrial ecosystems (Ruohonen & Timmers, 2025). One of the most significant areas of scientific research concerns the transformation of workforce skills, particularly the increasing role of human-centric, cognitive, and managerial skills (Carminati et al., 2025). Furthermore, competency models are being developed that focus on integrating the technological, analytical, and social dimensions of labor (Oeij et al., 2024).

The aforementioned transition to the new technological paradigms of Industry 4.0 and Industry 5.0 has brought to the forefront the issue of fundamental transformations in the workforce provision system for the economy as a whole and the industrial sector in particular. This transition has actualized new requirements for the skills and competencies that modern workers must possess; meanwhile, the shortage of qualified personnel remains acute, despite ongoing efforts to address this challenge. The system for developing

a relevant workforce potential for the modern era must address several objectives: ensuring the competitiveness of individual workers, personnel, and enterprises across various economic sectors, which is a necessary prerequisite for the competitiveness of industry and the economy as a whole. This is the focus of the latest EU economic and industrial policy, which is aimed at implementing a range of supranational and national initiatives within EU countries designed to shape appropriate human resource provision for the economy as a whole and industry in particular. This includes cultivating the full spectrum of skills required in the contemporary labour market among workers (professional, cognitive, technological, and other skills).

In the meantime, a significant number of challenges related to cultivating the necessary human resource potential for the transition to Industry 5.0 remain either unresolved or only partially addressed. In our opinion, a consistent analysis of emerging trends in EU industrial policy can help to define the conceptual framework for shaping a modern, resilient industrial workforce provision system.

The purpose of this article is to determine the conceptual foundations for the formation of a resilient industrial human resource provision system based on the latest trends in EU industrial policy.

2. Results.

The evolution of the European Union's industrial policy can be characterized as a progressive transition from a narrow sectoral approach with a hierarchical structure toward the formation of a holistic ecosystem. Within this framework, diverse policy areas—including industrial, digital, socio-labor, trade, and innovation policies—are integrated into a single, coherent mechanism. This shift in coordination logic has followed a distinct trajectory from rigid hierarchy to network-based governance, manifesting in several key transformative stages:

Stage 1 (1950s–1980s) – Siloed Coordination: Trade, innovation, and socio-labor policies were formulated and implemented largely independently of one another, reflecting a fragmented governance structure.

Stage 2 (1990s–2010s) – Soft Coordination: Coordination evolved through the implementation of the 'Lisbon Strategy' and the 'Europe 2020' strategy. During this period, cross-sectoral linkages began to emerge and operationalize.

Stage 3 (2020–present) – Integrated Ecosystem: A holistic ecosystem is being established, driven by the European Green Deal (European Commission, 2019; European Commission, 2023c) (aimed at fostering EU economic resilience by transforming climate and environmental challenges into opportunities) and A New Industrial Strategy for Europe (2021). These initiatives facilitate the 'twin transition' (green and digital) and strengthen the EU's strategic autonomy. This ecosystem is designed to ensure the competitiveness of European industry based on clean technologies. The central mechanism—the Green Deal Industrial Plan—aims to create a favorable environment for scaling up the EU's manufacturing capacity for net-zero technologies (European Commission, 2023c).

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The 'Europe 2020' Strategy served as the conceptual framework for this process, outlining a vision for the modernization of the European economy and defining three interconnected priorities for development (European Commission, 2010):
1) smart growth – fostering an economy based on knowledge and innovation;
2) sustainable growth – promoting a transition to a resource-efficient, green, and competitive economy;
3) inclusive growth – ensuring high levels of employment, social cohesion, and balanced territorial development.
During this period, the 'Industry 4.0' concept emerged and gained broad support within the EU. It is aimed at expanding the application of digital technologies, automating production processes, and integrating cyber-physical systems to strengthen the competitive advantages of enterprises across EU Member States (Omelianenko, 2024). Industry 4.0 is based on some key technological innovations, including big data analytics Big Data and Analytics, Autonomous Robots, Simulation, Horizontal and Vertical System Integration, The Industrial Internet of Things, Cybersecurity), The Cloud, Additive Manufacturing, Augmented Reality (Skitsko, 2016).
The European Commission introduced the concept of a 'Sustainable Industrial Policy for the European Union,' which the Council of the EU subsequently evolved into the framework of a 'New European Industrial Competitiveness Policy.' EU strategic documents outline an updated industrial policy framework, the central element of which is an approach centered on 'investing in a smart, innovative, and sustainable industry.' Its key priorities include the international dimension, the Single Market and empowering people, digitalization, the circular and low-carbon economy, investment, and innovation (European Commission, 2017). This approach most closely aligns with the strategy of neo-industrialization through innovation, which is based on strengthening the competitive positions of entrepreneurs and securing a presence in new markets by developing competitive advantages (Deineko, 2016). The strengths of this model of European industrial policy include its synchronization with the social and environmental development priorities of EU member states, the flexibility of its instruments, and the use of the competitive mechanism to modernize the economic structure, thereby enhancing its overall competitiveness (Tsyplytska & Yanenkova, 2018).
Building upon the ideas of the 'Europe 2020' Strategy, the European Commission adopted the 'European Industrial Strategy' in 2020, which was subsequently updated in 2021 to account for the impact of the COVID-19 pandemic (European Commission, 2020a). This new strategy emphasizes the 'green transition,' digital transformation, enhancing competitiveness, and ensuring the strategic autonomy and resilience of the EU economy.
At present, the European Commission is implementing the 'Industrial Ecosystems' framework, comprising 14 distinct subsystems that serve as the foundation for the European Green Deal. This approach effectively integrates both strategies into a unified ecosystem designed to counter global competitive pressures. Within this framework, the European industrial ecosystem extends beyond mere industrial production, enterprises, and firms; it is built upon the interdependence and synergy of several key elements:
1. Integrated Value Chains:

- Suppliers and Subcontractors: Small and medium-sized enterprises (SMEs) that provide essential components to major industry players.

- Logistics and Distribution: Entities responsible for the delivery and commercialization of products.
- Service and Maintenance: Stakeholders ensuring the support and extension of the product life cycle."

2. Science, Innovation, and Education: This serves as the "intellectual core" of the ecosystem, as transformation is unattainable without these foundational elements:

- Research Institutes and Universities: Entities that develop cutting-edge decarbonization technologies.
- Technology Hubs and Accelerators: Platforms that catalyze and scale innovations.

3. Financial Infrastructure: The ecosystem's viability depends fundamentally on access to capital:

Public and Private Investors: This includes EU Funds and venture capital.

The Banking Sector: Financial institutions that align lending conditions with "green" mandates and ESG criteria (Environmental, Social, and Governance).

4. Regulatory and Social Environment:

- Public Authorities and Regulators: Bodies responsible for establishing standards, such as emission limits.
- Trade Unions and Civil Society Organizations: Stakeholders that ensure the Just Transition, focusing on social equity throughout the structural shift.
- End Consumers: Their behavior and demand for sustainable products dictate the trajectory of market development.

In conclusion, the implementation of the ecosystem approach within the EU represents a shift toward the systemic engineering of the European economy's future. The transition from a traditional sectoral division to 'Industrial Ecosystems' constitutes a strategic move by the European Commission to enhance the EU market's resilience, while simultaneously advancing its digital and environmental transformation.

In accordance with the objectives of the New Industrial Strategy, a new industrial paradigm was established — Industry 5.0 (I5.0), as outlined in the 2022 independent expert report of the European Commission titled 'Industry 5.0: A Transformative Vision for Europe' (European Commission, 2022). The emphasis is on the fact that Industry 5.0 does not negate the technological innovations of the previous Industry 4.0 concept, but rather reorients its focus toward addressing social and environmental challenges. It is founded on the principles of human-centricity, sustainability, resilience, and the circular economy, as well as entirely new business goals and performance indicators, where the return and valuation of human and natural capital are central. The objective is to reintegrate human, social, and ecological dimensions into industrial production, enhance corporate responsibility, and improve the ability of businesses to adapt to crisis situations. The European Commission views Industry 5.0 as a tool for strengthening supply chain resilience, increasing strategic autonomy, and fostering a more inclusive model of industrial development.

The coordination of industrial, digital, innovation, and socio-labor policies is executed within the framework of the EU's economic governance system (Council of the European Union, 2025a), underpinned by ecosystem-based, integrated, and synergistic approaches. Policy coherence is ensured through the following mechanisms:

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1. Better Regulation Mechanism: This mechanism is based on specific guidelines followed by the European Commission during the preparation of new initiatives and proposals, as well as during the management and evaluation of existing legislation. It includes (European Commission, 2023b):

- Impact Assessment: A decision-making filter for coordination that employs an integrated approach to simultaneously evaluate economic (industrial), digital, and socio-labor consequences.
- Regulatory Scrutiny Board: A central "quality controller" within the EU policy-making system that analyzes and monitors the balance and alignment of various policies.
- Public Consultations ("Have Your Say"): A formal public discussion period lasting 8–12 weeks, allowing for stakeholder feedback and subsequent legislative amendments.
- Ex-post Evaluation: A performance check of EU legislation after its implementation, based on the 'Evaluate First' principle, which mandates assessment prior to proposing new regulatory actions.

2. The European Semester: Serving as the 'command center' of European integration, this mechanism acts as the coordinating pillar of the European Union's economic governance system. Through this framework, Member States align their diverse policy areas—including fiscal, economic, digital, and labor policies—with collectively agreed-upon EU rules (Federal Ministry of Labour and Economy of Austria, 2025). It functions as a coordination instrument for socio-economic policy components, ensuring the long-term sustainability and resilience of public finances across all Member States while preventing excessive sovereign debt. Furthermore, the European Semester promotes sustainable economic growth and convergence, fosters job creation (including through the Micro-credentials system), and aims to mitigate macroeconomic imbalances within the Union. It is reinforced by reforms and investments designed to bolster growth and resilience, alongside the monitoring of structural reforms and social policy implementation at the national level. The operational mechanism of the European Semester consists of an annual coordination cycle, during which the European Commission reviews national budgets. In instances where a Member State prioritizes industrial investment while neglecting digital education or social protection, the Commission issues 'Country-Specific Recommendations' (CSRs). Compliance with these recommendations is mandatory for accessing EU structural and investment funds.

3. Recovery and Resilience Facility (RRF) (European Commission, 2025c): This instrument is implemented to provide financial support for reforms and investments across Member States, ensuring greater resilience, sustainability, and productive readiness for the challenges and opportunities presented by the green and digital transitions. Specifically, coordination is achieved through the structural integration of industrial, digital, innovation, and socio-labor policies within 'Transition Pathways,' which encompass the following components:

- Technological Component: Identifying the necessary innovations (Innovation Policy).
- Infrastructural Component: Determining the required digital networks and connectivity (Digital Policy).

- Human Capital: Assessing the emergence of new professions and skill requirements (Socio-Labor Policy).
- Financial Component: Identifying investment sources and capital allocation (Industrial Policy).

4. Social Scoreboard: Operating within the framework of the European Pillar of Social Rights (EPSR), this monitoring system tracks the social implications of economic structural changes. The European Commission has proposed a set of social principles, initiatives, and targets for 2030, which serve as a "social compass" for the EU's recovery and its adaptation to the green and digital transitions.

5. Pact for Skills and Skills for Industry: This mechanism establishes a critical nexus between industrial and socio-labor policies (European Commission, 2020d; European Commission, 2020e; European Commission, 2020f). To this end, the EU facilitates the creation of retraining hubs tailored specifically to the requirements of emerging digital ecosystems. As digital policy drives automation, social policy—channeled through the Pact—ensures the reskilling of the workforce, preventing structural unemployment by enabling transitions into high-growth sectors. Concurrently, the establishment and operation of European Digital Innovation Hubs (EDIHs) serve as an 'on-the-ground' mechanism to ensure policy coherence and implementation at the regional level (Council of the European Union, 2025b).

6. Social Dimension 4.0: Digital Rights of Workers: As digitalization reshapes the nature of work—specifically through platform-based employment and telecommuting—the EU is integrating a 'social pillar of digital rights' directly into its industrial policy. This integration aims to preserve human capital, which remains the primary resource of European industry.

7. Just Transition Mechanism (JTM): This mechanism integrates regional, industrial, and social policies to mitigate the structural impact of decarbonization. For instance, coal-dependent regions (such as those in Poland or Germany) are allocated funds to establish new innovative enterprises, while simultaneously providing social guarantees and comprehensive retraining programs for the local workforce, particularly miners (European Commission, 2023b; Council of the European Union, 2025b).

8. Public-Private Partnerships (PPP): The primary instruments for operationalizing such partnerships include:

- EU Industrial Alliances: These serve as collaborative platforms where the state, industry, and academia coordinate their strategic actions. As a cornerstone of the EU's modern industrial strategy, these alliances aim to address market failures, ensure European technological sovereignty, and accelerate the 'twin transition' (green and digital). They are designed to scale innovations from laboratory research to mass production, eliminate strategic dependencies on third countries, and adapt the workforce to emerging digital and environmental standards. Key examples include the European Battery Alliance (EBA), the European Clean Hydrogen Alliance, and the Alliance on Processors and Semiconductor Technologies.
- The Quadruple Helix Model: The promotion of a collaborative framework involving universities, research centers, enterprises, and the public sector to foster a cohesive innovation ecosystem (European Parliament, 2022).

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The competitiveness of the European economy is substantially contingent upon the quality of human capital and the capacity to attract and retain skilled professionals. The supranational policy framework which is typical for the European Union necessitates the identification of adaptive experiences and best practices for prioritizing, establishing, and further developing vocational education in the industrial sector (Omelianenko, 2024). Furthermore, the relevance of workforce provision challenges is determined, on one hand, by their direct impact on productivity, competitiveness, and industrial development, and on the other, by the shortage of qualified specialists – particularly in vocational trades and high-demand fields – which presents a significant challenge for many companies. This results in diminished production efficiency and complicates the resolution of economic issues due to labor shortages and limited professional mobility.

Recent research into the current state and key trends of the European Union labor market indicates a deepening of structural imbalances, with the shortage of high-skilled personnel possessing advanced competencies evolving into a systemic, long-term challenge. An analysis of these disparities and their dynamics suggests that labor shortages across EU Member States exhibit distinct sectoral and regional characteristics. According to Eurostat data, the highest job vacancy rate (8.4%) is observed in managerial roles, marketing, and the IT sector, confirming the EU economy's critical reliance on digital competencies (Eurostat, 2025). Data from 2023 further reveal that labor shortages in STEM fields (including ICT), construction, healthcare, and hospitality have become persistent and are projected to intensify amidst the green and digital transitions (European Commission, 2023a). Notably, labor deficits in industry and construction have nearly tripled compared to figures from a decade ago, indicating that the demand for these professions and specific skill sets is significantly outstripping the current capacity of vocational and academic training systems. The human resource challenge is particularly acute in the realm of Information and Communication Technologies (ICT), both regarding specialized ICT professionals and the digital literacy required across other disciplines. In 2023, 57.5% of European enterprises that recruited or attempted to recruit ICT specialists reported difficulties in filling vacancies. The primary cause cited was an insufficient number of applicants (reported by 43.2% of enterprises), followed by other issues such as a lack of required qualifications, inflated wage expectations, and a deficiency of professional experience.

Furthermore, to ensure the efficacy of relevant policy formulation, it is fundamentally important to clearly delineate the factors driving the aforementioned labor shortages, accounting for their heterogeneity and uneven regional distribution. On the supply side, significant labor constraints have emerged, driven by demographic aging and the misalignment of educational curricula with market requirements (skill mismatch). According to Cedefop estimates, approximately 45% of workers in the EU believe their skills could be utilized more effectively if they acquired additional competencies in advanced digital technologies (CEDEFOP, 2022). Moreover, qualification mismatches result in an estimated 2% loss in labor productivity across the entire economy. On the demand side, there is a rapid surge in requirements stimulated by the 'Twin Transition'—the simultaneous digital transformation and implementation of green technologies. This dual transition generates an escalating demand for novel occupational roles to which

traditional education and vocational training systems are struggling to adapt in a timely manner.

Within the EU, there is a pronounced regional differentiation, manifested in a notable contrast between Member States. While Northern and Western European countries (e.g., the Netherlands and Germany), characterized by high employment rates, suffer from an absolute labor shortage (European Labour Authority, 2024), countries in Southern and Eastern Europe (e.g., Italy, Greece, and Spain) face the challenge of low labor market participation among youth and women, compounded by a deficit of highly specialized professionals (Eurostat, 2024).

To address these multifaceted challenges, comprehensive measures and mechanisms are being implemented at the EU level, including:

- Vocational Training and Education: The implementation of micro-credentials and Upskilling/Reskilling programs—particularly in the fields of Artificial Intelligence (AI) and renewable energy—which facilitate the rapid adaptation of the workforce to accelerating technological shifts.
- Migration Policy: The revision of the EU Blue Card Directive, which streamlines the attraction of highly qualified talent from third countries by lowering salary thresholds and simplifying the recognition of professional experience.
- Retention Strategies: The promotion of inclusive practices and the improvement of working conditions in critical sectors (such as healthcare and transport), which serve as essential factors in preserving existing human capital amidst intensifying global competition for talent.

Consequently, addressing the labor shortage within the EU is pursued not only by expanding the scale of professional training for specialists with modern competencies but also through the regulation of migration flows, the development of flexible lifelong learning ecosystems, and the implementation of inclusive practices aimed at personnel retention.

It is equally important to note that the private sector plays an active role in mitigating human resource deficits. Specifically, enterprises are implementing internal training programs designed to enhance or provide employees with new ICT-related skills. In 2023, 22.4% of EU enterprises provided training to their entire workforce specifically intended to upgrade their digital and ICT competencies (Eurostat, 2023).

In response to the growing demand for modern skills, the European Commission introduced the 'European Skills Agenda for Sustainable Competitiveness, Social Fairness and Resilience' (European Commission, 2020b). The agenda was formulated within the context of two fundamental transformations—the green and digital transitions—as well as the necessity to overcome the consequences of the COVID-19 pandemic. The document outlined a new framework for skills development in the EU, aimed at enhancing workforce resilience, modernizing education and training systems, and ensuring the long-term competitiveness of the economy. In particular, the agenda provides for:

1) strengthening sustainable competitiveness. Skills and lifelong learning are decisive factors for long-term sustainable growth, productivity, and innovative development; consequently, they determine the capacity of enterprises of all sizes – particularly small and

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medium-sized enterprises (SMEs)—to remain competitive amidst technological and structural changes;
2) ensuring social fairness. The recovery of Europe will be successful only with social cohesion and by preventing anyone from being excluded from this process. The possession of relevant skills ensures greater employment resilience and the ability to successfully navigate career transitions. This requires expanding equal opportunities for upskilling and reskilling – regardless of sex, racial or ethnic origin, religion or belief, disability, age, or sexual orientation – including adults with low levels of education or qualifications, as well as persons with a migrant background;
3) building our resilience. Skills development enhances individuals' ability to successfully adapt to life and career changes and reduces their dependence on market fluctuations. Digitalization has revealed the need to strengthen human potential in the field of cybersecurity, specifically preparedness for cyber threats and the capacity to respond effectively to them.
The concept of 'resilience' is gradually becoming a cornerstone in strategic documents and academic research concerning the sustainable functioning of socio-economic systems at various levels. Resilience is understood as the capacity of diverse systems to withstand shock impacts (which are often unpredictable), maintain critical functions, and recover by adapting to altered conditions. While resilience emphasizes a system's ability to bounce back and adapt following shocks, stability primarily denotes resistance to external pressures.
In this context, it is indicative that the strategic foresight report on the EU's development toward 2040 is titled 'Resilience 2.0: Empowering the EU to Thrive Amidst Turbulence and Uncertainty' (European Commission, 2025a). 'Resilience 2.0' represents an approach aimed at ensuring the EU's prosperity under turbulent conditions up to 2040 and beyond. It is based on the recent European Preparedness Strategy ('The European Union Strategy on Preparedness to Prevent and Respond to Emerging Threats and Crises') (European Commission, 2025b) and emphasizes the necessity of proactively analyzing not only emerging risks but also opportunities, while accounting for highly unpredictable scenarios. The report highlights that the scale, complexity, diversity, and duration of future challenges—ranging from geopolitical and geo-economic shocks, conflicts, and security threats to the triple planetary crisis (climate change, pollution, and biodiversity loss), as well as technological and demographic shifts and threats to democracy and values – demand a new level of resilience. Consequently, the magnitude and complexity of current and future challenges necessitate a proactive and forward-looking approach to their prevention and resolution (European Commission, 2025a).
In the strategic documents of international organizations, specifically the OECD, the EU, and the UN, the concept of 'resilience' is interpreted as a defining characteristic of security in times of upheaval. It is further defined as the capacity of a system to reconfigure its elements and key resources in a mobile manner to achieve dynamic stability at a new level of development in response to sudden internal or external disturbances (MacLeman, Miller & Marty, 2017; OECD, 2020).
Due to the proliferation of the concept of resilience as a cross-cutting category, tools for assessing the vulnerability and adaptive capacity of the economy are being actively developed. The assessment of resilience involves determining exactly how a system creates,

maintains, or loses its restorative capacity. In this context, the primary criteria for economic resilience include adaptability, reliability, recovery speed, redundancy, flexibility, and diversity (Kyzym et al., 2024).

The EU has developed a comprehensive set of indicators to monitor progress in achieving resilience. These include the Resilience Dashboards (integrated into the EU Semester), the Social Scoreboard, the Recovery and Resilience Scoreboard, and the information portal for the UN Sustainable Development Goals (SDGs). The European Commission proposes using the Resilience Dashboards for EU Member States (European Commission, 2020c) as a 'primary compass' for building a resilient economy. These dashboards comprise a system of indicators that reflect: capabilities – the means that facilitate development and/or the potential to counter future threats (shocks); and vulnerabilities – obstacles or factors that may amplify the negative impact of various risks and shocks, particularly those associated with the green and digital transitions. The selection of indicators is based on strategic foresight and accounts for long-term development drivers that are most likely to determine the trajectory of future transformations in European countries (Kyzym et al., 2024).

The operationalization of resilience criteria within the evaluation of labor supply policies remains a complex methodological challenge. On one hand, indicators must ensure cross-country comparability, including granular analysis across various economic sectors. On the other hand, for the purposes of monitoring and formulating evidence-based policy at the national and subnational levels, these indicators must be sufficiently detailed to identify 'bottlenecks' in the recruitment, retraining, and retention of the workforce. In this regard, a two-tier approach is considered most appropriate: (1) a core of harmonized indicators for international comparisons, and (2) a national decomposition of this core to the level required to justify evidence-led management decisions.

To ensure international comparability, the indicators established within the aforementioned EU instruments can serve as a foundation. These include the EU Resilience Dashboards (within the European Semester framework) and the Social Scoreboard, which functions as a benchmarking system for the socio-labor performance of Member States. Within the evaluation of labor supply policies, these indicators can be mapped to specific labor market resilience criteria. For instance:

- Adaptability can be assessed through adult participation in lifelong learning and the overall level of digital proficiency;
- Agility (Flexibility) can be measured by the intensity of cross-sectoral and occupational transitions, as well as the prevalence of diverse forms of employment;
- Recovery Speed can be evaluated through the dynamics and rates at which employment and vacancy indicators return to pre-crisis levels.

At the national level, it is appropriate to decompose these indicators by sectors (NACE), occupational groups (ISCO), qualification levels, and territories, integrating harmonized statistical sources with administrative data, employer surveys, and job vacancy data. Within this framework, national and sectoral indicators function as a diagnostic layer, enabling the precise targeting of policy instruments – such as skills development, employment incentives, mobility support, and personnel retention – without compromising the international comparability of the 'core' set of indicators.

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The concept of resilience, with its emphasis on maintaining stability under volatile conditions, aligns closely with the key trends that will define industrial development in the coming decades. These encompass transformations associated with Industry 4.0 and Industry 5.0, such as the integration of cyber-physical systems into production, the advancement of additive manufacturing, artificial intelligence, and augmented reality, as well as the deepening customization and personalization of processes (Omelianenko, 2024). Concurrently, the industrial sector operates amidst broader socio-economic shifts – including geo-economic fragmentation, economic uncertainty, and demographic transformations – which are significantly altering labor market parameters in both the short and long term.

In the context of the development of Industry 4.0 and, particularly, Industry 5.0, human capital is becoming a decisive factor in industrial resilience—alongside technological, environmental, and security factors. The formation of a modern resilient industry entails a reorientation of production processes and labor models, as well as an increased role for the worker within these transformations. This leads to the emergence of new requirements for knowledge, digital and technological skills, adaptability, and continuous professional development.

Based on the aforementioned, we propose a conceptual framework for the workforce provision system, which demonstrates its interconnections and governance levels. This framework allows for a systemic approach to examining the essence of external and internal conditions (prerequisites) for ensuring industrial resilience (Fig. 1).

The expediency of delineating governance levels within the proposed model is grounded, on one hand, in the specificity of instruments and methods for addressing labor supply challenges inherent to each level. On the other hand, this differentiation is corroborated by the findings of various empirical studies. The central premise of this multi-level governance approach is that the resilience of the industrial labor supply system is a derivative of the hierarchical synchronization and mutual alignment of personnel management levels. Empirical data further substantiate that the shortage of a skilled workforce in the EU acts not merely as a social challenge but as a systemic risk to economic security and industrial resilience.

Regarding the macro-level, it has been established that the recovery capacity of EU regions correlates directly with the degree of workforce digitalization, proficiency in advanced skill sets, and the flexibility of labor market institutional frameworks. Specifically, the resilience of the EU economy during the COVID-19 pandemic was contingent not only on the scale of financial support but also on the population's proficiency in remote work capabilities and digital literacy. Empirical evidence indicates that under force majeure conditions—exemplified by the COVID-19 pandemic—sectors with a higher share of skilled labor capable of remote operations based on advanced competencies demonstrated significantly lower vulnerability to lockdowns. This underscores the role of human capital as a vital economic stabilizer within the framework of the resilience concept (Fana, M., Tolan, S., Torrejón, S., Urzi Brancati, M. C., & Fernández-Macías, E., 2020).

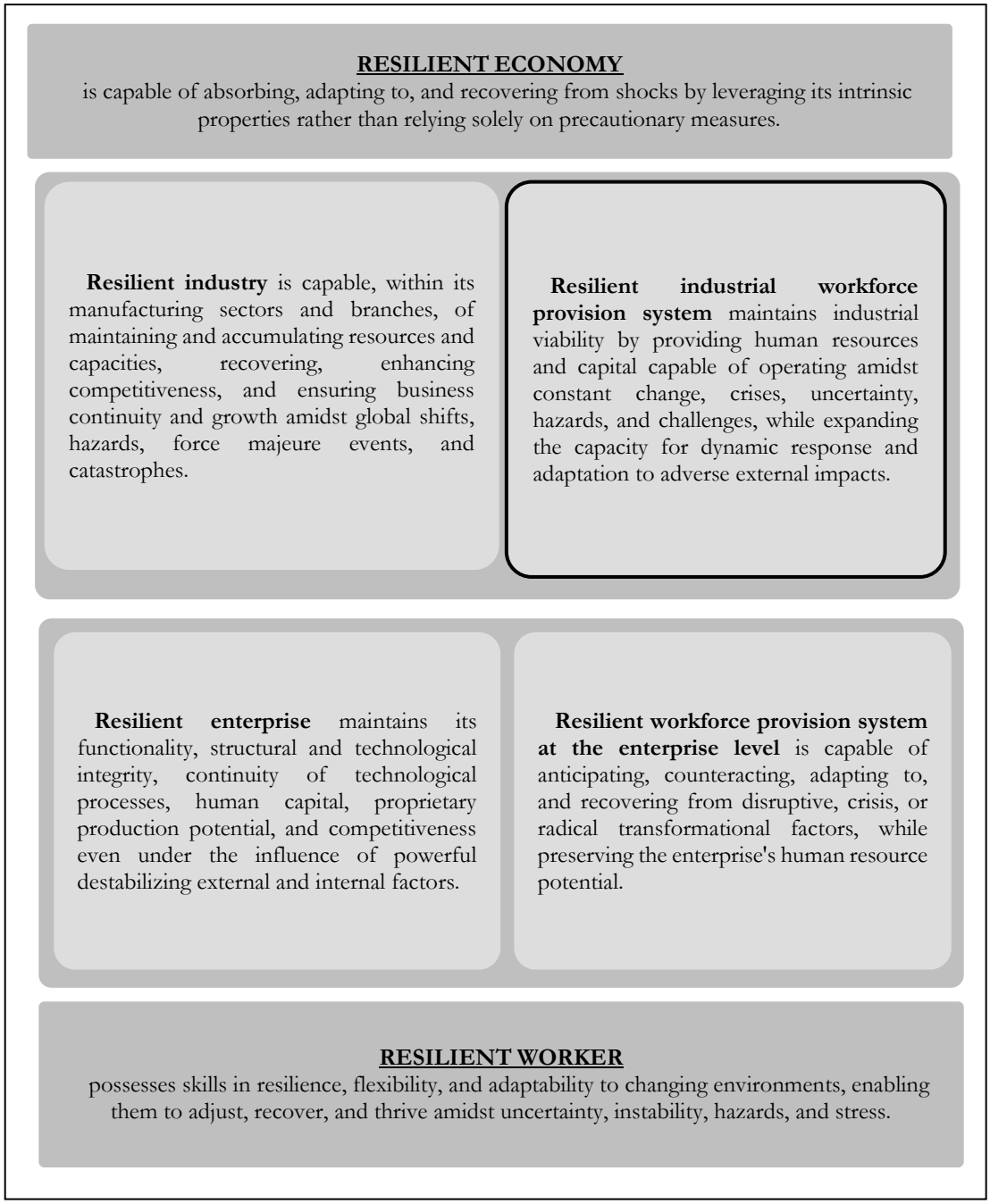

Fig. 1. *The industrial workforce provision system as a subsystem of a resilient economy (by governance levels)*

The validity of delineating the meso-level is well-illustrated by the transformation experiences of industrial clusters in Germany and the Nordic countries. Empirical research

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on skills for the 'green transition' demonstrates that sectoral resilience in high-tech industries – such as electric vehicle manufacturing – is fundamentally dependent on proactive human capital management (CEDEFOP, 2021). At the micro-level (the enterprise level), empirical findings further substantiate the critical importance of developing advanced competencies and investing in personnel training to ensure corporate resilience and competitiveness. Companies that have actively invested in the upskilling of their workforce demonstrate a strong correlation with higher labor productivity rates and more stable post-crisis profitability recovery following external shocks (OECD, 2023).

Based on the content of Figure 1, we further present our vision and definitions of the fundamental categories that ensure the sustainable competitiveness of the economy and industry under modern conditions.

The concept of a resilient economy has emerged as a response to the increasing turbulence within the functioning of socio-economic systems at various levels, triggered by military conflicts, climate change, ecocide, pandemics, and force majeure events. According to the authors, a resilient economy is a model characterized by the economic system's capacity to absorb, adapt to, and recover from shocks by leveraging its intrinsic properties rather than relying solely on precautionary measures. It is established upon the integration of ESG (Environmental, Social, and Corporate Governance) principles into the functioning of socio-economic systems at different levels and depends on the economic structure, resource potential, and the ability to substitute lost components.

The resilience of human resource potential can be interpreted as a margin of safety and adaptability that ensures the workforce security of the national economy in general and industry in particular. The resilience of human resource potential is becoming a key factor in economic competitiveness amidst uncertainty and instability. It is particularly noteworthy that this resilience should serve as one of the decisive factors in the post-war recovery of Ukraine (Azmuk, 2024).

Resilient industry is understood as the capacity of enterprises and manufacturing sectors to maintain and accumulate resources and capabilities, recover, enhance competitiveness, and ensure business continuity and growth even amidst significant destabilizing impacts, such as force majeure events or catastrophes (both natural and man-made, including armed conflicts). Industrial resilience is directly linked to techno-technological paradigmatic shifts—the transition toward Industry 4.0 and Industry 5.0—where the characteristic of economic resilience is paramount, and industry itself is assigned the role of a driver for the necessary transformations (Cherevatskyi, 2023).

Resilient industrial workforce provision system (at the national level) is a comprehensive, dynamic, flexible, adaptive, and stable system of managerial decisions and instruments aimed at attracting, developing, and supporting the human resource potential of industrial enterprises in alignment with strategic objectives. Its purpose is to provide the industrial sector with human resources capable of operating effectively amidst rapid change, crises, uncertainty, and external challenges. Such a system must ensure the forecasting and synchronization of workforce training with labor market demands, focusing on key strategic priorities for the modernization of the country's industrial sector.

Resilient enterprise is defined by the capacity of the entity and its workforce to act proactively under volatile and adverse conditions, to develop and implement mechanisms for foresight, adaptation, and recovery (including those based on technological upgrades),

and thereby maintain functionality, structural and technological integrity, continuity of production processes, human capital, proprietary production potential, and competitiveness even when subjected to powerful destabilizing external and internal factors.

Workforce resilience at the enterprise level denotes the capacity of the human resource management system to withstand shocks, recover rapidly, and adapt to changes while maintaining or even enhancing personnel productivity. A key feature of a resilient HR management system is its ability to anticipate, counteract, adapt to, and recover from disruptive, crisis, or radical transformational factors, thereby preserving the enterprise's human resource potential. Such a system:

- ensures the recruitment, development, motivation, social protection, and retention of employees necessary for achieving established production objectives;
- strengthens the enterprise's adaptability through effective human resource management as a stabilizing subsystem;
- establishes an internal strategic foundation for resilience, which bolsters the overall potential of the enterprise, allowing it to adapt rapidly to the shifting conditions of the external environment (Torbych, 2024).

Resilient worker is defined in the modern context by the possession of a complex of soft skills—including cognitive, social, and psychological competencies necessary for effective professional activity in the contemporary world—in addition to purely professional and technological hard skills. Both types of skills must exist in a harmonious synthesis. The development of skills related to resilience, flexibility, and an employee's adaptive capacity is highly valuable amidst social uncertainty, instability, hazards, and stress, as it enables individuals to adjust, recover, and thrive when facing challenges. Cultivating a mindset oriented toward embracing change and interpreting obstacles as learning opportunities allows resilient individuals to maintain focus and productivity under unpredictable circumstances (Skillsoft, 2025).

In our view, particular attention must be paid to the category of the 'resilient worker.' This is necessitated by the fact that the new socio-labor reality engendered by Industry 4.0 and Industry 5.0 – the foundation of which is a system of interconnected networks – is characterized by dynamism, the capacity for flexible response to problems and crises, and the ability to adjust production processes promptly. Within 'smart factories,' requirements for personnel and their subsequent roles are undergoing significant changes, while the organization of labor is assuming new forms. Enterprises increasingly organize their activities based on distributed teams and dynamically composed collectives, whose members continuously exchange data and recalibrate current tasks. A relocation of workplaces and production sites is occurring, facilitated by the possibilities of remote coordination, video communication, and digitalized administrative and operational control. The technologies of Industry 4.0 and Industry 5.0 are modifying and transforming the business environment, and consequently, the entire network of socio-economic relations. In this process, the cost, time, and subjective benchmarks of business conduct and interpersonal interaction are shifting, alongside the requirements for the professional-qualificational attributes and competencies of the worker (Kolot, 2024).

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Accordingly, Industry 4.0 and Industry 5.0 introduce radical changes to the requirements for industrial workforce provision. The accelerated implementation of digital tools, remote work solutions, and advanced technologies—specifically machine learning and generative artificial intelligence—has provided enterprises with vital practical experience, enabling a deeper understanding of the critical competencies necessary for effective response to rapid technological shifts (World Economic Forum, 2025).

The aforementioned author's vision regarding the structural elements of the industrial workforce provision system as a subsystem of a resilient economy, combined with the core trends in the formation and implementation of industrial policy in EU countries, establishes a foundation for further, more detailed research into potential practical instruments for ensuring industrial workforce resilience in both the EU and Ukraine (considering its European integration vector).

3. Conclusion.

EU countries have faced a series of formidable challenges in the formulation and implementation of industrial policy, a significant portion of which is directly linked to the emergence of Industry 4.0 and 5.0. An additional challenge is the sharp increase in uncertainty and instability within the external and internal environments, as well as the conditions under which this policy is executed. At the conceptual level, a definitive response has been the transition to the concept of 'resilience,' defined as the capacity of systems to maintain viability and functionality under adverse and volatile conditions. The concept of 'resilience' is gradually becoming cross-cutting in both academic research and EU policy documents, effectively superseding the previous focus on 'sustainability.' A vital feature of this concept is its universality, allowing for its application across systems and their subsystems (ranging from a 'resilient economy' to a 'resilient worker'). It is noteworthy that this concept aligns with the specific challenges and trends of the modern era during the transition to new technological paradigms; it is applicable to the economies of both developed and transition (developing) countries operating amidst hazards, uncertainty, instability, and catastrophes.

The European Commission is developing the 'Industrial Ecosystems' framework, comprising 14 distinct subsystems that serve as the structural foundation for the implementation of the European Green Deal. As a candidate for EU membership, Ukraine is progressively integrating into these ecosystems. Consequently, Ukrainian industrial policy must align with these 14 subsystems to gain access to European value chains and strategic financing.

A pivotal aspect of Ukraine's integration into the European industrial ecosystem is the transition to advanced technological paradigms, specifically Industry 4.0 and Industry 5.0. This transition facilitates the development of a resilient labor supply system (for both the broader economy and the industrial sector specifically) capable of fostering the essential skills and competencies required of the modern workforce. The establishment of such a system is recognized as a primary objective of contemporary EU economic and industrial policy, both at the pan-European level and within individual Member States.

One of the key aspects of the transition to new technological paradigms (Industry 4.0 and Industry 5.0) is addressing the challenge of developing a resilient workforce provision

system (for the economy as a whole and the industrial sector in particular), capable of fostering the essential skills and competencies required of modern employees. The establishment of such a system is recognized as a primary objective of contemporary EU economic and industrial policy, both at the pan-European level and within individual EU Member States. European Union countries are continuously refining mechanisms to ensure the resilience and competitiveness of their industries by creating the appropriate institutional, managerial, human resource, financial, regulatory, and technological foundations, including those aimed at cultivating the necessary human resource potential. For Ukraine, the experience of EU member states in establishing a resilient workforce provision system at various levels (from the national to the enterprise level) is of paramount importance, both in the context of European integration and for meeting the needs of post-war industrial recovery. This should be reflected in the development of relevant strategic documents (programs and recovery strategies for Ukraine) and the instruments for their practical implementation. In this regard, the strategic documents of the EU must serve as a definitive benchmark. For Ukraine, the key objectives in establishing a resilient industrial workforce provision system should include the following:
1) changes in the vocational education system primarily aimed at fostering essential new skills and expanding opportunities for professional labor mobility;
2) modernization of the vocational guidance system, accounting for the shifts in workforce requirements driven by the emergence of Industry 4.0 and Industry 5.0;
3) development of a system of incentives to facilitate the transition of labor into the industrial sector from other fields of activity;
4) enhancement of mechanisms for the employment of foreign nationals, tailored to the needs of Ukrainian industrial recovery based on modern, advanced principles;
5) development and implementation of regulatory instruments for labor relations and employment stimulation under emergency conditions;
6) formulation and introduction of policies and practices to enhance labor market inclusivity, alongside programs to integrate civilian and military populations (including older adults, women, internally displaced persons, combat veterans, and persons with disabilities) into the labor market and employment within Ukrainian industrial enterprises (Novikova, Ostafiichuk & Pankova, 2024).
7) Intensifying Ukraine's participation in a series of programs directly related to stimulating economic growth, job creation, and the development of advanced digital competencies. This specifically includes the Digital Europe Programme (2021–2027) and the Connecting Europe Facility (CEF), as well as the strategic borrowing and adaptation of key elements from pan-European initiatives. These efforts are aimed at fostering the cutting-edge skill sets essential for ensuring the resilience of the industrial labor supply.
The EU's experience in securing an industrial labor supply serves as a strategic framework and benchmark for Ukraine. At the same time, the implementation of specific instruments necessitates a differentiated approach that accounts for the structure of national industry, sectoral specialization, the technological sophistication of manufacturing, and the loss of labor potential resulting from the war.
Certain instruments can be directly applied—notably, mechanisms for skills forecasting, the development of dual and modular vocational education, and continuous learning systems for industrial personnel. Other elements—primarily financial models for

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incentivizing workforce training, mechanisms for inter-agency coordination, and labor mobility regulations—require institutional adaptation in light of Ukrainian realities and the specificities of the wartime and post-war periods. Concurrently, objectives related to the restoration of manufacturing capacities in frontline and de-occupied regions, the reintegration of veterans into industrial production, and the formation of human resource reserves for the defense-industrial complex demand the development of indigenous, context-sensitive solutions.

In light of the aforementioned, two key areas for further research emerge as particularly relevant: the adaptation of the European experience in developing a resilient industrial labor supply system to the institutional and structural specificities of Ukraine; and the development of instruments to facilitate the integration of specific groups—primarily veterans and internally displaced persons (IDPs)—into industrial employment, areas where European experience remains limited. The escalating labor shortage in Ukraine further underscores the practical significance of these research trajectories.

The experience and advancements of EU countries in enhancing mechanisms for industrial resilience and competitiveness are evolving dynamically; therefore, Ukraine's top economic governing bodies must monitor these processes and adopt targeted strategic management decisions to restore domestic industry within the framework of European integration requirements, incorporating this experience into the formulation and implementation of a national industrial policy based on the principles of resilience.

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