

From Industry 4.0 to Industry 5.0: A Human-Centric Analysis of Azerbaijan's Digital Economic Transformation

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Abstract. *The transition from the technology-centric paradigm of Industry 4.0 to the human-centric, sustainable, and resilient vision of Industry 5.0 represents a critical juncture for global economies. This shift presents both systemic challenges and significant opportunities for national development strategies. This study aims to analyze the alignment of the Republic of Azerbaijan's national digital development strategy with the core principles of Industry 5.0, and to identify the key challenges and opportunities this transition presents for the country's economic future. Employing a qualitative research design, this study integrates a systematic literature review with a content and institutional analysis. The theoretical framework is built upon the concepts of industrial revolutions, and key documents from the European Commission, the World Economic Forum (WEF), the OECD, and the official strategy of the Government of Azerbaijan are critically examined. The findings reveal that while Industry 4.0 focused primarily on technological efficiency, the shift to Industry 5.0 represents a fundamental socio-technical transformation. Globally, this is characterized by the displacement of 92 million jobs by 2030, a significant "compute divide," and pressing ethical concerns. The study finds that the "Strategy for the Development of the Digital Economy of the Republic of Azerbaijan for 2026-2029" demonstrates a strong, though not yet complete, alignment with Industry 5.0 principles, particularly in its focus on human capital development and infrastructural resilience. This research provides a novel, evidence-based assessment of Azerbaijan's readiness for the human-centric industrial era. It offers practical policy recommendations for enhancing the inclusivity and sustainability of the national digital strategy, thereby contributing to the broader discourse on economic development in the context of global technological transformation.*

Keywords: *Industry 5.0, Industry 4.0, human-centricity, digital transformation, sustainable development, economic policy, Azerbaijan*

Introduction

The dawn of the 21st century has been marked by a technological transformation of unprecedented scale and depth. The concept of the Fourth Industrial Revolution, or Industry 4.0, as articulated by Klaus Schwab (2017), laid the groundwork for a new industrial reality predicated on automation, the Internet of Things (IoT), and artificial intelligence (AI). However, by the early 2020s, it became apparent that a profit- and efficiency-driven technological trajectory was insufficient to address escalating social and environmental challenges.

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In response, the European Commission formalized the concept of Industry 5.0 in 2021. This new paradigm recognizes the potential of industry to achieve social goals beyond job creation and growth, positioning it as a sustainable and resilient provider of prosperity that respects our planet's boundaries (European Commission, 2021). While Industry 4.0 places digitalization and efficiency at its core, Industry 5.0 elevates the well-being of workers, sustainability, and social justice as its primary objectives (European Commission, 2021).

This paradigm shift is not a theoretical abstraction. The global labour market is undergoing a radical restructuring. According to the World Economic Forum's "Future of Jobs Report 2025," an estimated 170 million new jobs will be created by 2030, but 92 million existing roles are projected to be displaced, resulting in a net creation of 78 million jobs (WEF, 2025). Furthermore, approximately 80% of the global workforce will require reskilling and upskilling in the near future (WEF, 2025). The OECD (2025) further warns of a severe "compute divide," where AI computing power is heavily concentrated in the US and China, creating a significant risk of "digital colonialism" for developing nations. These global challenges underscore the urgency for nations, particularly those with developing economies, to devise strategies that navigate this new landscape effectively.

Despite the rapidly growing body of research on the conceptual and technological aspects of Industry 5.0 (e.g., Nahavandi, 2019; Xu et al., 2021; Huang et al., 2022), a critical gap remains in assessing the practical alignment of national economic strategies with the paradigm's core tenets. Little is known about how post-Soviet states, with their unique historical and economic contexts, are preparing for this human-centric industrial revolution. This study addresses this gap by conducting an in-depth analysis of Azerbaijan's national digital development strategy. The aim of this research is to assess the degree to which the "Strategy for the Development of the Digital Economy of the Republic of Azerbaijan for 2026-2029" aligns with the core principles of Industry 5.0—human-centricity, sustainability, and resilience—and to identify the systemic challenges and opportunities this transition presents for the country.

This paper is structured as follows. Section 2 presents the theoretical background and the analytical framework. Section 3 details the research methodology. Section 4 discusses the results, including the global challenges and Azerbaijan's strategic alignment. Section 5 provides a discussion of the findings. Finally, Section 6 concludes with policy implications and directions for future research.

2. Theoretical background and analytical framework

2.1. The Evolution of Industrial Paradigms

To understand the significance of Industry 5.0, it is essential to view it within the historical progression of industrial revolutions (Figure 1), as discussed by Zizic et al. (2022). The First Industrial Revolution (Industry 1.0) introduced mechanization through water and steam power. The Second (Industry 2.0) brought mass production through electricity. The Third (Industry 3.0) leveraged electronics and IT to automate production. The Fourth Industrial Revolution (Industry 4.0) is characterized by the fusion of the physical, digital, and biological worlds, creating smart, interconnected systems (Schwab, 2017).

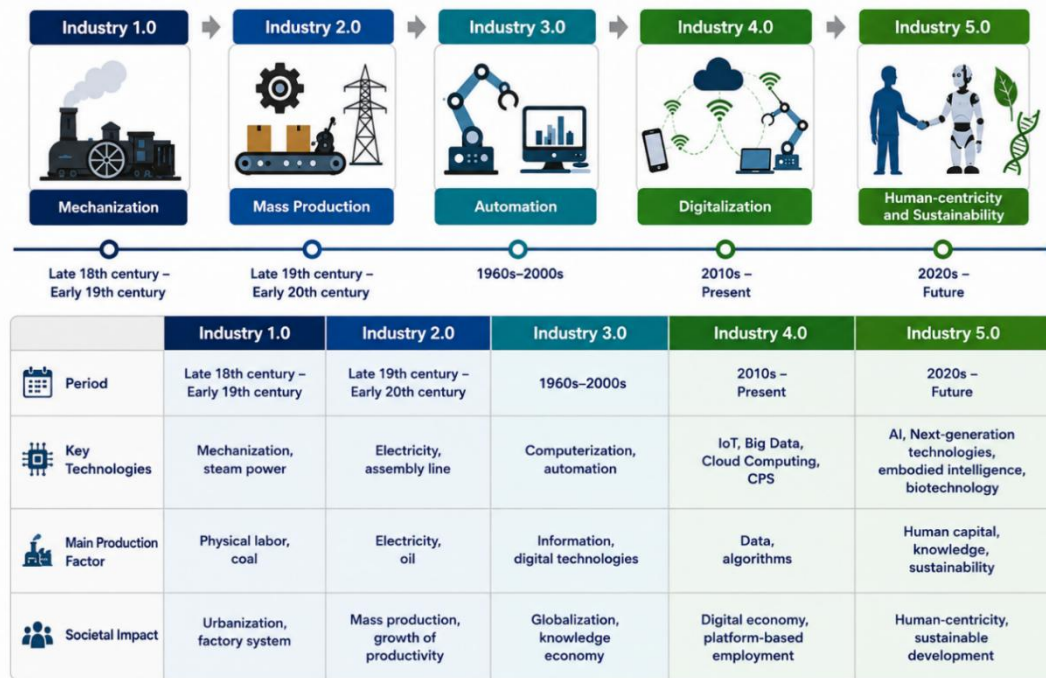


Figure 1
Evolution of industrial revolutions from industry 1.0 to industry 5.0

2.2. Industry 5.0: Core Principles

Industry 5.0 is not a chronological successor but rather a complement and "normative reorientation" of Industry 4.0 (Enang et al., 2023). While Industry 4.0 addressed the question of "what we can do with new technologies?", Industry 5.0 poses a fundamentally different question: "what can technology do for people and society?" (European Commission, 2021). This paradigm is built upon three interconnected pillars (European Commission, 2021; Ivanov, 2023):

- 1. Human-Centricity:** This principle places the well-being, needs, and capabilities of workers at the center of the production process. Rather than asking what can be done with technology, it asks what technology can do for people (European Commission, 2021). This involves augmenting human skills through human-machine collaboration (cobots, digital twins) rather than replacing them (Grosse et al., 2023). From an economic perspective, this implies a shift from a "labor-saving" model to a "human capital investment" model as the primary driver of productivity growth.
- 2. Sustainability:** This pillar emphasizes the necessity for industrial systems to operate within planetary boundaries. It entails a transition towards a circular economy, waste reduction, and the adoption of environmentally friendly technologies, thereby enabling the decoupling of economic growth from environmental degradation (Ghobakhloo et al., 2022). For national economies, this implies the formation of a new competitiveness model predicated on resource efficiency and environmental responsibility.
- 3. Resilience:** This principle focuses on the ability of industrial systems to withstand and adapt to external shocks—whether economic crises, pandemics, or geopolitical instability. Resilience requires the creation of adaptive, flexible production networks and value chains with built-in mechanisms for redundancy and duplication of critically important functions (Ivanov, 2023; Enang et al., 2023). In the context of growing volatility in the global economy, this characteristic acquires strategic significance for developing countries.

2.3. Analytical Framework

To achieve the stated objective, this study employs a three-dimensional analytical framework that operationalizes the key pillars of Industry 5.0—human-centricity, sustainability, and resilience—as

evaluative dimensions. The assessment of the alignment of Azerbaijan's national digital development strategy with these dimensions is conducted by addressing the following key questions:

- (Human-Centricity): To what extent does the strategy prioritize investments in human capital, education, workforce reskilling, and the creation of decent working conditions within the digital economy?
 - (Sustainability): Does the strategy provide for measures to enhance resource efficiency, adopt "green" technologies, and achieve long-term economic and social stability?
 - (Resilience): Is the strategy aimed at building the adaptive capacity of the economy, diversifying production, and establishing reliable protection systems against internal and external shocks?
- This analytical framework enables not only the identification of the presence or absence of certain elements within the strategy but also an assessment of the depth and systemic nature of their integration into national digital development policy.

Methodology

To achieve the stated research objectives, this study employs a qualitative research design of an exploratory nature. The choice of qualitative methodology is determined by the nature of the research question, which requires interpretation and assessment of the content of policy documents rather than statistical measurement of quantitative dependencies. The methodological toolkit comprises three complementary components:

1. **Systematic Literature Review.** An extensive analysis of academic and policy-oriented publications on Industry 4.0, Industry 5.0, digital transformation, and sustainable development was conducted. Primary attention was devoted to peer-reviewed articles in journals ranked in the first and second quartiles (Q1–Q2) according to the Scopus and Web of Science classifications, as well as to authoritative reports from international organizations—the European Commission, the World Economic Forum, and the OECD. This stage enabled the formation of the study's theoretical foundation, the verification of key concepts, and the identification of global trends and systemic challenges associated with the transition to the new industrial paradigm.
2. **Content Analysis and Institutional Analysis of Strategic Documents.** At this stage, a qualitative content analysis of official strategic documents is carried out. The primary object of the study is the "Strategy for the Development of the Digital Economy of the Republic of Azerbaijan for 2026–2029." The analysis is focused on identifying explicit and implicit references pertaining to human capital development, environmental and economic sustainability, as well as the resilience of the economic system. To provide a broader context, the national priorities enshrined in the "Azerbaijan 2030" program are also examined. The application of this method enables a systematic assessment of policy documents based on predefined criteria corresponding to the three pillars of Industry 5.0.
3. **Comparative and Systemic Analysis.** The final stage involves juxtaposing the findings obtained from the systematic literature review with the conclusions drawn from the content analysis of strategic documents. This approach allows for the identification of points of convergence and divergence between global benchmarks (the principles of Industry 5.0) and Azerbaijan's national strategic priorities. Furthermore, the comparative analysis facilitates the identification of systemic challenges and specific opportunities conditioned by the country's unique economic and institutional context, which collectively ensures the validity and robustness of the final conclusions and recommendations.

4. Results

4.1. Global Challenges and Opportunities of the Industry 5.0 Transition

The analysis of the literature reveals several systemic challenges that characterize the global transition to Industry 5.0 (Table 1).

Table 1*Global challenges of digital transformation in the context of the transition to industry 5.0*

Challenge	Characteristics	Quantitative Estimates	Source
Labour Market Transformation	Mass displacement of jobs due to automation and AI	170 million new jobs created, 92 million existing jobs replaced, net increase of 78 million jobs by 2030	WEF, 2025 (European Commission, 2021; Huang, Wang, Li, Zheng, Mourtzis, & Wang, 2022)
Skills Gap (Reskilling Imperative)	Mismatch between workforce skills and the requirements of the new economy	Approximately 80% of the workforce will require reskilling and upskilling	WEF, 2025 (European Commission, 2021; Huang, Wang, Li, Zheng, Mourtzis, & Wang, 2022)
"Compute Divide"	Uneven distribution of AI computing power globally	USA — ~75%, China — 15%, Europe — 5% of global AI compute	OECD, 2025 (European Commission, 2025; Ivanov, 2023; Nahavandi, 2019)
Digital Colonialism	Risk of developing countries' dependency on technological monopolies	Half of all cloud regions ready for AI computing are concentrated in the USA and China	OECD, 2025 (Ivanov, 2023)
Ethical Challenges of AI	Lack of global safety standards, data privacy concerns, algorithmic discrimination	Different countries adopt varying approaches to regulating large language models	European Commission, 2025 (Grosse, Sgarbossa, Berlin, & Neumann, 2023)
Cybersecurity	Growing vulnerabilities of digital systems	Increasing number of cyberattacks on critical infrastructure	OECD, 2025 (European Commission, 2025)

Source. Compiled by the author based on (WEF, 2025; OECD, 2025; European Commission, 2025).

The most prominent challenge is the radical restructuring of the labour market. The WEF (2025) data indicates a massive job displacement (92 million jobs) and creation (170 million jobs) scenario. This is accompanied by a significant skills gap, with a vast majority of the workforce requiring reskilling. Another critical challenge is the "compute divide" (OECD, 2025), where the vast majority of AI processing power is concentrated in the US and China, posing a strategic risk to developing nations and potentially leading to "digital colonialism." Finally, the rapid proliferation of AI technologies brings ethical challenges related to data privacy, algorithmic bias, and a lack of global governance standards (European Commission, 2025). Conversely, the transition also presents significant opportunities, including the development of more robust and adaptable production systems, the creation of high-value "green" jobs, and the potential for a better quality of life for workers through human-machine collaboration.

4.2. Alignment of Azerbaijan's National Strategy with Industry 5.0

Azerbaijan has demonstrated a proactive stance towards the global digital transformation. In December 2025, President Ilham Aliyev approved the "Strategy for the Development of the Digital Economy of the Republic of Azerbaijan for 2026–2029" (Government of Azerbaijan, 2025). An analysis of the strategy (Table 2) reveals its strong correlation with Industry 5.0 principles.

Table 2*Alignment of Azerbaijan's digital development strategy with industry 5.0 principles*

Industry 5.0 Principle	Direction of Azerbaijan's Strategy for 2026–2029	Degree of Alignment
Human-Centricity	Investments in human capital, preparation of highly qualified personnel, expansion of innovation activity	High
Resilience	Creation of high-speed networks and data centers, strengthening coordination with the private sector	High
Sustainability	Support for sustainable economic growth, development of data-driven governance	High
Social Equity	Coverage of digital transformation across all segments of the population (projects such as ASAN xidmət, "Smart Village")	Medium
Inclusiveness	Involvement of over 300 local companies and SMEs in digital transformation programs	Medium

Source. Compiled by the author based on (Government of Azerbaijan, 2025).

- **Human-Centricity:** The strategy explicitly states that investing in human capital and preparing "highly qualified personnel" are key priorities, recognizing the crucial role of a skilled workforce in the digital economy (Government of Azerbaijan, 2025, p. 5). This constitutes a direct acknowledgment of the human-centricity principle.
- **Sustainability and Resilience:** The strategy aims to support "sustainable economic growth" and "development of data-driven governance" (Government of Azerbaijan, 2025). Furthermore, its focus on "creating high-speed networks and data centers" (Government of Azerbaijan, 2025, p. 7) directly contributes to building economic resilience. This is particularly crucial given the geopolitical and economic instabilities that can affect the region.
- **Social Equity and Inclusivity:** While the strategy's focus on human capital and economic growth is a key element, its stated goal of "covering digital transformation across all segments of the population" (Government of Azerbaijan, 2025, p. 9) constitutes evidence of its inclusive ambition. Existing projects such as ASAN xidmət and "Smart Village" are cited as concrete examples of this inclusivity, demonstrating a pre-existing infrastructure for social welfare in the digital era.

Discussion

The findings of this study provide several important insights. First, they confirm that the transition from Industry 4.0 to Industry 5.0 is not a linear technological progression but a fundamental shift in socio-technical paradigms (Enang et al., 2023; Xu et al., 2021). The global evidence of a "compute divide" and massive job displacement underscores that the transition is fraught with risk and opportunity, especially for nations like Azerbaijan with developing economies.

Second, the analysis of Azerbaijan's strategy shows a commendable strategic vision that is significantly aligned with the "human-centric" and "resilient" pillars of Industry 5.0. The country's focus on developing its domestic digital infrastructure is a clear strategy for building resilience against external shocks. Similarly, its explicit emphasis on "investments in human capital" (Government of Azerbaijan, 2025) and an inclusive approach to digitalization (through projects like ASAN xidmət) are positive steps toward human-centricity.

However, a potential gap exists in the explicit integration of environmental sustainability and circular economy principles within the core of the digital strategy. While the strategy mentions "sustainable economic growth," a more explicit link to green technologies and eco-friendly digitalization—a core element of Industry 5.0—would strengthen its alignment. The focus on human capital appears to be predominantly skills-oriented for economic growth, rather than focused on broader worker well-being

and autonomy. The study's findings resonate with the "phantom profits" theory discussed by Neumann et al. (2021), which posits that technological investments that ignore human factors are likely to underperform. Azerbaijan's strategic focus on human capital and inclusive digital access can be seen as a safeguard against such a risk. This focus aligns with the conclusion of Grabowska et al. (2022) that the humanization of the built technological environment was a primary driver in the evolution from Industry 4.0 to Industry 5.0. The national strategy can be viewed as a direct policy response to this driver.

Conclusion

6.1. Key Findings and Contributions

This study has investigated the transition from Industry 4.0 to Industry 5.0, examining its global challenges and national implications for Azerbaijan. The key findings are as follows:

- 1. Industry 5.0 represents a paradigm shift:** The move from Industry 4.0's efficiency focus to Industry 5.0's human-centricity is a fundamental redefinition of the purpose of industrial development.
- 2. Global challenges are systemic:** The transition is characterized by major challenges such as labour displacement, a significant "compute divide," and new ethical dilemmas associated with AI.
- 3. Azerbaijan's strategy shows significant alignment:** The national digital strategy demonstrates a strong focus on human capital and resilience. It also reflects an inclusive ethos, evident in its existing social programs.
- 4. Room for further development exists:** To fully embrace the Industry 5.0 vision, Azerbaijan could strengthen the environmental sustainability dimension of its digital transformation and broaden its concept of human capital development from pure skills to encompass a more holistic view of worker well-being and agency.

6.2. Policy Implications

Based on the findings, the following policy recommendations are proposed:

- **Maintain and Accelerate Human Capital Investment:** The government should continue to invest in education and training, with a focus on reskilling and upskilling programs targeted at the specific needs of the new economy. The "80% of the workforce" challenge (WEF, 2025) is a call for a national, strategic, and urgent effort.
- **Explicitly Integrate Sustainability:** The digital strategy should be updated to include explicit metrics and targets for environmental sustainability. This includes promoting "green ICT," supporting the circular economy, and incentivizing energy-efficient digital solutions.
- **Enhance Resilience:** The strategy's focus on digital infrastructure should be complemented by policies that promote economic diversification and reduce dependencies on single industries, creating a more robust and adaptable economic structure.
- **Address the Digital Divide:** The government should develop targeted programs for the most vulnerable groups to ensure the benefits of the digital economy are shared equitably, preventing the creation of a new form of social exclusion.

6.3. Limitations and Future Research

The primary limitation of this research is its qualitative and conceptual nature. It relies on the analysis of policy documents and existing literature without empirical data collection. Future research could empirically validate these findings by conducting surveys and interviews with policymakers, industry leaders, and workers. Comparative studies analyzing the digital strategies of other post-Soviet or Caspian Sea region countries would also provide a broader perspective.

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