BEYOND TECHNOLOGICAL SUBSTITUTION: AUGMENTATION, SMART WORKING, AND COMPLEMENTARITY IN THE LABOUR MARKET UNDER ARTIFICIAL INTELLIGENCE

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Abstract
This study examines how artificial intelligence is reshaping labour-market structures, while questioning the expectation of large-scale technological unemployment. Drawing on relevant academic literature and institutional data, the analysis shows that AI functions less as a mechanism of total substitution and more as a vector of occupational augmentation. By taking over routine cognitive tasks, the technology acts as a "digital alter ego", enabling human capital to concentrate on activities that require empathy, strategic reasoning, judgement, and creativity. The study also highlights the transition toward smart working and emphasizes that the realization of economic benefits depends critically on workforce adaptability through continuous training, reskilling, and upskilling. In conclusion, the paper argues that the future of work rests on human–machine symbiosis, whose sustainability requires ethical governance and a robust normative architecture — such as Regulation (EU) 2024/1689 — designed to ensure a human-centred integration of technology.

Keywords: *artificial intelligence, future of work, occupational augmentation, smart working, digital alter ego, continuous training, European regulation.*

JEL Classification: A10, D80, O10, O30.

I. INTRODUCTION

Artificial intelligence (AI) is generating profound structural changes across economic and social sectors, marking a fundamental technological transition. Whereas previous innovations were primarily concerned with the automation of manual labour, contemporary AI systems, based on a radically different algorithmic architecture, intervene directly in complex cognitive processing (Acemoglu & Restrepo, 2022). This expansion has led to the recognition of AI as a foundational innovation, with an impact comparable to some of humanity's greatest discoveries, extending the horizons of computer science, the internet, and advanced robotics.

Nevertheless, the rapid diffusion of artificial intelligence has intensified public debate, dividing interpretations between expectations of productivity gains and fears of occupational displacement, prompting a broad spectrum of analyses in the specialized literature. The central concern among workers relates to the risk of occupational displacement through automation (Frey & Osborne, 2017). Although the physical and moral obsolescence of certain professions is inherent in technological progress, the capacity of AI to fully replace the human factor in production processes is contradicted by current empirical evidence (Fruits & Stout, 2026).

Recent research demonstrates that, despite its massive transformative potential, AI operates primarily as a tool for labour augmentation rather than total substitution (Kolko, 2026). Although the technology will take over specific routine tasks, the fundamental creative competencies of human beings will remain irreplaceable. Distinctly human attributes such as curiosity, adaptability, flexibility, and the capacity to solve highly complex problems exceed the statistical limits of algorithms (Rigobon & Loaiza-Saa, 2024). Therefore, AI will redefine and amplify these qualities, but it will not be able to substitute them through any automated system.

It is indisputable that the new tools have reshaped the way we perceive the environment and production processes, yet their influence is predominantly positive (World Economic Forum, 2024). However, the materialization of these macroeconomic benefits is not an automatic process; it depends on active governance and investment in reskilling (Cazzaniga et al., 2024). In the absence of substantial human involvement, concerns regarding economic inequalities are justified; nevertheless, when properly managed, the transformations generated by AI prove to be profoundly beneficial for the evolution of society as a whole.

The global labour market is entering a period of deep structural transformation. According to projections published by the World Economic Forum, the combined impact of artificial intelligence, digital technologies and broader macroeconomic trends is expected to generate approximately 69 million new jobs by 2027 (World Economic Forum, 2023). At the same time, around 83 million occupational positions are expected to be displaced, as they become redundant against the background of functional and technological obsolescence (World Economic Forum, 2023). This dual dynamic — one of creative destruction and occupational reallocation — requires a reassessment of the comparative advantage between human labour and algorithmic capital.

More specifically, although the frontier of performance is becoming increasingly fluid, the specialized literature emphasizes that net added value continues to depend on human–machine complementarity: AI systems enhance the efficiency of execution, while human capital retains its monopoly over strategic reasoning, innovation, and adaptability (Restrepo, 2024; Deloitte, 2023). At present, the distribution of tasks at the organizational level reflects this transitional equilibrium: data show that approximately 34% of economic activities are performed by machines, while the remaining 66% continue to fall within the sphere of human competencies, thereby refuting the thesis of generalized and immediate automation (World Economic Forum, 2023).

Therefore, the current process represents a stage of strategic reallocation of the factors of production, framed as a new frontier of the Fourth Industrial Revolution. This inflection point promises major macroeconomic benefits, with McKinsey Global Institute estimates suggesting that the combined annual value potential of generative AI, nongenerative AI and advanced analytics could reach approximately USD 17.1 trillion to USD 25.6 trillion globally (McKinsey Global Institute, 2023). However, these projections are strongly qualified in the academic macroeconomic literature. Using a task-based model and Hulten's theorem, Acemoglu (2024) argues that the macroeconomic effects of generative AI are likely to be far more modest, estimating a rise in total factor productivity (TFP)of no more than 0.66% over the next ten years, or approximately 0.064% annually. This analysis warns that such estimates may still be overstated, since early evidence comes mainly from easy-to-learn tasks, whereas future gains would also depend on hard-to-learn, context-dependent tasks that are more difficult to automate (Acemoglu, 2024).

II. LITERATURE REVIEW

The body of specialized literature devoted to artificial intelligence (AI) is vast and multidisciplinary, reflecting the complexity of integrating this technology into the economic and social environment. In order to contextualize the impact of AI on the future of the workforce, it is imperative to examine the current state of knowledge from technical, philosophical, and socio-economic perspectives.

At the level of technological and operational foundations, *Artificial Intelligence Basics* (Taulli, 2019) represents an essential reference point. Taulli provides a clear decoding of core mechanisms among them machine-learning techniques, natural-language processing systems (NLP), and robotic process automation tools (RPA), arguing that an understanding of these functions is a precondition for the effective adoption and integration of AI into organizational strategies.

Beyond technical functionality, a major strand of the literature problematizes the cognitive frontier between human beings and machines, a debate that is fundamental to establishing theoretical limits of automation. In *Artificial Intelligence Versus Natural Intelligence* (Penrose et al., 2022), the authors examine this asymmetry and arrive at a central consensus: despite the remarkable analytical capabilities of algorithms, the reproduction of genuine technological consciousness remains an extremely improbable prospect. This intrinsic limitation supports the thesis that human capital retains an absolute comparative advantage in tasks requiring empathy, moral discernment, and intentionality.

Looking ahead, forecasts concerning the point at which machine capabilities might equal those of human beings — Artificial General Intelligence — bring major structural challenges into focus. Walsh (2018) explores the year 2062 as a possible inflection point at which such equivalence could be reached, warning of the urgent need to recalibrate political and economic institutions in order to prevent technological unemployment. A similar argument is advanced by Kissinger, Schmidt, and Huttenlocher (2021), who emphasize that AI does not merely alter the organization of work, but reshapes the human relationship with reality and raises fundamental questions about identity, agency, and responsibility. For this reason, its development requires a robust framework of value-based governance, capable of preserving meaningful human oversight over technological systems.

Finally, in order to anchor this theoretical debate in the immediate realities of the labour market, the analysis requires the inclusion of recent economic and regulatory perspectives. Current works from Romanian academic scholarship (Dimitriu & Marin, 2024) investigate the ways in which the technology is already perceived and regulated, showing that society must move beyond the myth of the all-powerful machine in order to focus on the challenges and potential benefits arising from the use of AI in professional environments. These conclusions align closely with contemporary microeconomic models (Restrepo, 2024), which demonstrate that the success of the transition toward a new division of labour depends on the strategic decision of organizations to use algorithms for the augmentation of human competencies, thereby transforming AI from a threat into a collaborative partner.

III. TECHNOLOGICAL ANXIETY AND OCCUPATIONAL RECONFIGURATION

As artificial intelligence becomes increasingly embedded in work processes, it is reshaping both occupational structures and the ways in which employees are expected to acquire new competencies. This transition has intensified workers' concerns about technological change, particularly fears related to job displacement and the future relevance of existing professional skills (Wysiński, 2025). Recent studies in psychosocial ergonomics show that this anxiety manifests itself in multiple forms: anxiety toward technology itself, fear of interacting with algorithmic entities, perceived job insecurity, and chronic anxiety about the future (Rizkina, Hidajat, & Farida, 2025). The constant need for adaptation and the pressure to acquire new skills may lead to high levels of psychological exhaustion and occupational stress, turning continuous training into a cognitive burden for vulnerable categories of workers (Rizkina, Hidajat, & Farida, 2025).

The fear of displacement does not derive exclusively from the nature of technology, but from the speed with which algorithmic systems and machine-learning models are penetrating the economic ecosystem. Although the hypothesis of human-factor substitution has an empirical basis, the possibility of its definitive exclusion from production processes remains contradicted by labour-market realities (Fruits & Stout, 2026). Current data confirm that AI operates primarily as a vector of task reallocation, automating above all repetitive and monitoring activities.

This dynamic releases human resources, allowing workers to concentrate on higher-order analytical activities such as strategic planning and optimization (Fruits & Stout, 2026; Chen et. al., 2024). Moreover, algorithms display severe structural limitations in replicating divergent cognitive processes; for example, in innovation and brainstorming sessions, generative models tend toward repetitiveness, being unable to substitute the intuition, free association, and spontaneity specific to human consciousness (Rigobon & Loaiza-Saa, 2024).

Within this new architecture of work, exclusively human capabilities—such as ethical discernment, curiosity, creativity, and vision—become not only visible, but fundamental and non-automatable (Aoun, 2017). Consequently, as the macroeconomic landscape shifts, maintaining relevance in the labour market imposes an absolute imperative of continuous adaptability and active reskilling (Cazzaniga et al., 2024). The modern workforce can no longer rely on the limitations of a singular, traditional qualification to achieve optimal performance. To effectively navigate the complexities and inertia of emerging production environments, human capital must cultivate hybrid competencies that fuse technical acumen with advanced interpersonal and transdisciplinary capabilities (Aoun, 2017). The continuous assimilation of these complementary skills is essential for sustained adaptability. As artificial intelligence becomes embedded in production and organizational processes, labour markets are being reshaped by new forms of uncertainty, task redistribution, and occupational adaptation. Although the historical and quantitative literature highlights the emergence of numerous new jobs rich in human expertise, designed to compensate for the displacement of traditional industries (Autor et al., 2024), the distribution of these opportunities is often uneven. Recent research draws attention to the fact that generative AI disproportionately affects "gateway occupations" in administrative and support sectors (Heck, et. al., 2026). By restricting these traditional routes of skill formation and upward mobility for workers without higher education, AI risks amplifying the structural polarization of the workforce (Heck, et. al., 2026). This phenomenon is corroborated by analyses from the International Monetary Fund, which warn that demand for new technological skills will generate major wage benefits for highly skilled workers, while potentially contributing at the same time to a contraction of the middle class (Cazzaniga et al., 2024).

Current academic literature supports a mixed perspective on this complex phenomenon (Carbonara & Santarelli, 2025, pp. 1–30); however, economic models centred on task-based automation demonstrate that, under certain specific conditions, AI generates a net expansion in labour demand through the creation of new activities, thereby managing to outweigh the initial displacement effect (Acemoglu & Restrepo, 2018). According to

estimates published by the World Economic Forum (2023), structural disruption driven by macrotrends will significantly affect formal employment by 2027. More precisely, the data forecast the emergence of around 69 million new jobs, while 83 million existing roles are expected to be displaced. This dynamic underscores a period of profound occupational reallocation rather than purely net positive growth (World Economic Forum, 2023).

This net positive trend is supported by massive capital investment in the emerging infrastructure of AI (World Economic Forum, 2023) and is supported by the International Labour Organization, which estimates that only 3.3% of global employment falls into the highest category of exposure to generative AI (Gradient 4), while the broader labour-market impact is expected to take the form of task transformation and augmentation rather than generalized job disappearance (ILO, 2025). The large-scale implementation of AI is, however, conditioned by persistent vulnerabilities, particularly inflationary pressures, the imperatives of the "green transition", and the challenges posed by major demographic changes (OECD, 2025; World Economic Forum, 2023).

In this decision-making context, the dynamics of professional training are governed by the theory of skill-biased technological change (Autor & Katz, 2020). Thus, technology does not function as an absolute substitute for human beings, but as a "digital alter ego" that rewards complementary human skills (McKinsey Global Institute, 2025). The human–machine relationship is shifting from a conflictual stage to an ecosystem of mutual support, in which creativity is exponentially enhanced, demonstrating that automation protects the creative force and generates entirely new professions.

As an intrinsically technological factor of production, artificial intelligence (AI) fundamentally reconfigures the nature of work, facilitating the transition toward the paradigm of "smart working" (Bednar & Welch, 2020, pp. 281–298). This concept goes beyond the mere elimination of redundant tasks, radically altering competitive mechanisms. Consequently, advanced economies are facing an acute shortage of highly skilled labour. Integration into the orbit of digitalization presupposes the assimilation of a new organizational culture in which human capital becomes difficult to replace, while being simultaneously challenged to delegate part of its attributes to algorithmic systems.

The systemic impact of AI has demonstrated that traditional professional experience risks becoming insufficient in the absence of continuous training and lifelong learning. This dynamic explains the exponential demand for specialists not only in AI architecture, but also in cybersecurity (World Economic Forum, 2023). At the same time, the flexibilization of work provides greater mobility, prompting companies to abandon strictly procedural requirements in favour of the achievement of strategic objectives, thereby retaining talent. Viewed as a driver of the Fourth Industrial Revolution, AI facilitates the transnational transfer of skills, with the professions of the future being deeply anchored in the management of the ecological transition, the circular economy, and renewable energy resources (Organisation for Economic Co-operation and Development, 2025).

Although AI has an unparalleled capacity to process massive volumes of data, it lacks human flexibility, intuition, and empathy — attributes grounded in a form of creativity refined across generations. According to the task-based automation model (Acemoglu & Restrepo, 2018), AI can successfully substitute intensive manual labour and cognitively repetitive work, while also achieving fluent communication. Nevertheless, value judgements invariably involve an ethical and moral component that remains inaccessible to machines. In analysing this ascent, Kaplan (2024) advances the hypothesis of a transition toward a form of "non-biological life". In a future marked by human–machine symbiosis, individuals will interact with AI as a digital alter ego, assuming the vital role of supervising, synchronizing, and correcting algorithms (McKinsey Global Institute, 2025).

The vulnerabilities associated with AI extend beyond the sphere of occupational displacement. The central concern lies in the hypothesis that autonomous systems could evade human control, thereby becoming a potential existential threat. This anxiety is amplified by the absence of a universal and exhaustive definition of artificial intelligence, which obstructs long-term projections. The lack of trust in non-human technology and the probability of risk scenarios has been consistently highlighted by the World Economic Forum (2023). The dilemma of the "machine with a heart" represents the ethical core of the current revolution. In order to ensure efficiency and social sustainability, human beings remain the ultimate source of created value. The fundamental principle of this era must remain firm: technology must be placed exclusively at the service of human beings, and not the other way around (International Labour Organization [ILO], 2025).

From an economic perspective, the adoption of AI entails a profound reorganization of productive processes and a redistribution of tasks between technological capital and human labour, a phenomenon rigorously explained by the theory of task-based automation (Acemoglu & Restrepo, 2018). From a sociological perspective, this transition alters the nature of the competencies that are valued. Recent analyses indicate that, although approximately 40% of occupations are highly exposed to the automation of certain component tasks, this process

leads primarily to the redesign of workflows rather than to the elimination of jobs as a whole (McKinsey Global Institute, 2025).

From this perspective, AI does not operate as a mechanical mechanism for replacing human labour, but facilitates a hybrid human–machine reconfiguration, often defined as "superagency", in which technology simply amplifies human capabilities (McKinsey Global Institute, 2025). The major challenge for contemporary policy does not lie in managing a reduction in the aggregate volume of work, but in the capacity of institutional systems to support an equitable transition toward competencies compatible with the new paradigm (International Labour Organization [ILO], 2025).

From conception to implementation, AI systems function as a form of augmented intelligence, being entirely dependent on a continuous flow of human input and validation (Jarrahi, 2018). Excessive delegation of decision-making responsibility to machines may generate systemic risks in modern data-driven environments. While AI excels at pattern detection and the processing of massive volumes of data, fundamentally, it lacks the capacity to independently formulate the framework of a problem and possesses no intentionality of its own (Boden, 1988). Therefore, human oversight remains indispensable. Complementarity becomes imperative: while machines dominate the analytical sphere and routine processing, the relevance of the human factor remains decisive in areas governed by uncertainty, ambiguity, and social complexity, preserving the human being as the final arbiter of overarching decisions (Jarrahi, 2018; Organisation for Economic Co-operation and Development, 2025).

The scale of digital transformation helps explain why the functioning of the contemporary economy has become increasingly dependent on data-intensive and intelligent systems. At the global level, the volume of data created and replicated was forecast to reach 181 zettabytes by 2025, placing unprecedented pressure on storage and processing architectures (International Data Corporation, 2021). In this environment, high-performance computing infrastructures no longer represent a mere technological advantage, but a critical enabling layer of the digital economy, since HPC is essential for processing and analysing growing volumes of data and supports data-intensive applications, AI and cloud technologies (European Commission, 2025). Their productivity effects, however, depend not only on computational capacity itself, but also on complementary investments in software, organizational redesign, skills and data-intensive processes (Brynjolfsson, Rock, & Syverson, 2021).

A relevant pillar of this transition is the European JUPITER initiative. Designed as Europe's first exascale-class supercomputer, the system has reached operational maturity, becoming a central core of the future "AI factories" (EuroHPC Joint Undertaking, 2025). This empirical trajectory confirms that the exponential expansion of artificial intelligence requires a corresponding expansion of the underlying computational power. On the other hand, this densification of infrastructure raises critical sustainability issues. The expansion of data centres requires a massive supply of electricity, which is why international institutions such as the IMF emphasize that abundant energy provision and the adaptation of power grids to alternative sources are mandatory conditions for continued growth (Bogmans, C. et. al. / IMF, 2025). Moreover, the dynamics of automation have direct implications for global emissions, closely linking the technological future to climate-change policies (Abeliansky, Prettner, & Rodríguez Crespo, 2024).

In response to these structural challenges, global governance has initiated the legal regulation of artificial intelligence. A major inflection point is represented by Regulation (EU) 2024/1689 — the Artificial Intelligence Act — whose Article 1 stipulates the imperative of developing "human-centric and trustworthy" artificial intelligence. The legislative act seeks to safeguard health, safety, and fundamental rights, while also preserving conditions for technological innovation. Its legislative architecture prohibits unacceptable practices and imposes strict transparency requirements on high-risk systems used in the labour market. Beyond the macro-legislative level, the implementation of algorithmic ethics imposes stringent requirements on human resources departments, which are required to provide enhanced protection for workers' data, prevent unjustified emotional inferences in the workplace, and ensure permanent human oversight in order to counter decision-making bias.

Within this regulated context, the future of work transcends ephemeral conjunctural analyses. Once integrated into decision-making flows, AI redefines the distribution of tasks and the architecture of organizational responsibility, imposing a symbiosis in which algorithms manage analytical complexity, while the human factor resolves uncertainty and ambiguity (Jarrahi, 2018).

IV. SOME CONCLUSIONS

As artificial intelligence becomes increasingly embedded in economic activity, it generates a structural challenge that goes beyond productivity gains, requiring a reorganization of production processes, managerial practices, and institutional responsibilities. The evolution of the labour market will be characterized by an inherent duality between emerging opportunities and dislocative tensions, redefining the occupational profile and the hierarchy of competencies, with considerable pressure on the middle class and on occupations that have traditionally provided pathways for social mobility.

The academic literature rejects the simplistic dichotomy between technological enthusiasm and alarmist determinism, supporting instead the paradigm of complementarity (Jarrahi, 2018). According to the task-based automation model (Acemoglu & Restrepo, 2018), although algorithmic systems excel at data processing and pattern recognition, they cannot substitute inherently human attributes such as intuition, ethical discernment, and the management of ambiguity. The materialization of these benefits is, however, conditioned by the productivity J-curve (Brynjolfsson, Rock, & Syverson, 2021), which shows that technological efficiency emerges only after substantial adaptive investment in intangible assets and professional reconversion.

In parallel, the expansion of AI depends on an energy and computational infrastructure of unprecedented scale, requiring the alignment of digital innovation with international strategies for combating climate change and with the imperative need to regulate algorithmic systems in the labour market in accordance with robust ethical standards (Regulation (EU) 2024/1689). Therefore, the future of the workforce will not be determined solely by the performance of machines, but by the capacity of institutions to manage the interdependence between innovation, environmental responsibility, inclusive education, and regulation. Far from eliminating human relevance, artificial intelligence reinforces the need for decision-making responsibility, transforming the human–technology relationship into a necessary form of collaboration oriented toward the support of equity and social progress.

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