Premium e-Journal of Social Sciences

Premium Sosyal Bilimler E-Dergisi
Uluslararası Hakemli Dergi- International Refereed Journal
ISSN: 2687-5640

Received / Makale Geliş Tarihi	05.05.2025	*Research Article / Araştırma Makalesi*
Published / Yayınlanma Tarihi	31.07.2025	10.5281/zenodo.16730304
Volume (Issue) Cilt (Sayı)	9 (56)	Mail: editor@pejoss.com
pp / ss	572-591	

Esra Öziskender
https://orcid.org/0009-0002-5932-8185
Istanbul University, Faculty of Economics, Department of Labor Economics and Industrial Relations, Istanbul/ Turkey
ROR Id: https://ror.org/03a5qrr21

Dr. Öğr. Üyesi Ziya Erdem
https://orcid.org/0000-0001-6700-3650
Istanbul University, Faculty of Economics, Department of Labor Economics and Industrial Relations, Istanbul/ Turkey
ROR Id: https://ror.org/03a5qrr21

The Impact of Post-Pandemic Digital Transformation on Labor Markets

Pandemi Sonrası Dijital Dönüşümün İşgücü Piyasalarına Etkisi

ABSTRACT

This research quantitatively investigates the structural transformations in labor markets triggered in the post-pandemic era by remote or hybrid working arrangements, automation investments, and artificial-intelligence applications. Drawing on the statistics presented in the World Economic Forum's *The Future of Jobs* reports for 2020, 2023, and 2025, the research aims to uncover sector-level employment shifts and the prevalence of newly demanded skills. To this end, the reports' micro-survey data were integrated with ILOSTAT and OECD sectoral employment series and the World Bank's Digital Adoption Index scores, yielding a balanced panel data set covering 12 sectors across three years. Fixed-effects Driscoll–Kraay estimation reveals that a ten-percentage-point rise in the share of remote/hybrid work expands employment by 0.9 percent, while each one-unit increase in the digital-transformation index boosts employment by 1.5 percent. Conversely, a 10 percent increase in the artificial-intelligence investment ratio contracts employment by 0.8 percent in the short term; however, an equivalent improvement in reskilling–upskilling capacity more than offsets this loss, generating a net 2.1 percent expansion. The findings show chronic skill mismatches in the manufacturing and energy sectors and highlight the urgency of national reskilling funds, robust broadband infrastructure, and inclusive social-protection mechanisms. The research provides evidence-based recommendations for policymakers and firms to craft human-centered digital-transformation strategies, and it advocates sector-university micro-accreditation programs, tax-incentivised training funds, and lifelong-learning-oriented curriculum reforms to bridge skill gaps. Policies that enhance worker well-being are emphasised throughout.
Keywords: Digital transformation, remote work, artificial intelligence, reskilling, labour market.

ÖZET

Bu araştırmada, özellikle uzaktan veya hibrit çalışma uygulamaları, otomasyon yatırımları ve yapay zekâ uygulamalarının pandemi sonrasında işgücü piyasalarında neden olduğu yapısal dönüşümler nicel olarak incelenmektedir. Çalışmanın amacı, World Economic Forum'un 2020, 2023 ve 2025 yıllarında yayımlanan The Future of Jobs raporlarında sunulan istatistiklerden yararlanarak sektörel istihdam değişimlerini ve ihtiyaç duyulan yeni becerilerin yaygınlığını ortaya koymaktır. Bu kapsamda raporlardaki mikro anket verileri, ILOSTAT ve OECD sektörel istihdam serileri ile Dünya Bankası Dijital Benimseme İndeksi skorları birleştirilerek 12 sektör ve üç yıla ait dengeli panel veri seti oluşturulmuştur. Sabit etkili Driscoll-Kraay modeliyle yapılan analizde, uzaktan/hibrit çalışma payındaki 10 puanlık artışın istihdamı yüzde 0,9 genişlettiği; dijital dönüşüm endeksindeki her birim artışın istihdamı yüzde 1,5 yükselttiği; yapay zekâ yatırım oranındaki yüzde 10'luk artışın kısa vadede istihdamı yüzde 0,8 daralttığı; ancak reskilling-upskilling kapasitesindeki eşdeğer artışın bu kaybı aşarak net yüzde 2,1 büyüme sağladığı bulunmuştur. Bulgular, beceri uyumsuzluğunun imalat ve enerji sektörlerinde kronikleştiğini göstermekte; ulusal reskilling fonları, genişbant altyapısı ve kapsayıcı sosyal koruma mekanizmalarının acil öncelikler olduğunu vurgulamaktadır. Araştırma, politika yapıcılar ile işletmelere insan merkezli dijital dönüşüm stratejileri geliştirmeleri için somut kanıta dayalı öneriler sunmaktadır. Ayrıca, beceri talepleri ile arzı arasındaki makasın kapatılabilmesi için sektör-üniversite iş birlikli mikro akreditasyon programları, vergi teşvikli eğitim fonları ve yaşam boyu öğrenme odaklı müfredat reformları önerilmiştir. Çalışanların refahını destekleyici politikalar vurgulanmıştır.
Anahtar Kelimeler: Dijital dönüşüm, uzaktan çalışma, yapay zekâ, reskilling, işgücü piyasası.

1. INTRODUCTION

The Fourth Industrial Revolution (Industry 4.0) has reorganised production, distribution, and consumption processes around cyber-physical systems, big data, and algorithmic decision architectures. The Labour Economics and Industrial Relations literature treats digital transformation not merely as a technological phenomenon but as a structural shift that redefines institutional power balances in the organisation of the labour process. This transformative effect of digitalisation on the capital–labour nexus aligns with the World Economic Forum's (WEF) conceptualisation of the "Fourth Industrial Revolution (Industry 4.0)"; in its 2020 Report, the WEF emphasises that digital innovation has become the "principal driver triggering global productivity gains" (Li et al., 2024; World Economic Forum, 2020).

Digital transformation denotes the reconfiguration of firms' business processes, customer experiences, and marketing strategies through the strategic deployment of technology. Artificial intelligence (AI) acts as a catalyst that plays a pivotal role in, and accelerates, this transformation. By driving greater efficiency, automation, and personalization, AI facilitates the further intensification of digital transformation. The COVID-19 shock accelerated digital investments through both supply- and demand-side channels, converting remote and hybrid working practices into permanent organisational forms. It has been determined that 75 per cent of firms that transitioned to remote work undertook these investments directly under pandemic pressure, and a substantial share of them launched digital-skills training programmes for their employees (Battisti et al., 2022; Sarıipek et al., 2023). Likewise, findings from the WEF's 2020 report indicate that 44 per cent of the global workforce was able to work remotely during the pandemic, and employers display a persistent inclination to expand location-independent work design in the future (WEF, 2020).

The net impact of digital investments on employment is heterogeneous. A multi-country panel analysis has shown that each one-point increase in digital inclusion supported employment growth during the pandemic period by 0.078 percentage points (Jahan & Zhou, 2023). Conversely, in manufacturing branches where digital automation has intensified, the risk of job loss has risen, and skill demand has shifted toward high technology and complementary cognitive abilities (Li et al., 2024). This shift deepens uncertainties surrounding non-standard employment in the labour market by spreading atypical and platform-based forms of work in certain sample countries (Aykaç & Kaya, 2024; Rusakova & Saychenko, 2022). Consequently, skill mismatch and income polarisation—precisely as human-capital theory predicts—make investments in education and lifelong learning strategic priorities.

Founded in Geneva in 1971, the World Economic Forum is a non-profit international organisation whose mission is to "shape the global agenda through public–private cooperation." Its biennial *The Future of Jobs* report series has, since 2016, surveyed the expectations of more than 803 large-scale employers across up to 55 economies, modelling with quantitative forecasts the potential effects of technological trends on employment, skills, and education policies (WEF, 2020, 2023, 2025). The report's methodology—comprising sector-country projections of job creation/loss, emerging skill sets, and policy recommendations on public–private reskilling strategies—serves as a decision-making reference for global regulators and social partners.

COVID-19 precipitated profound, flexibility-driven changes in labour markets, as remote and hybrid models were swiftly adopted across many sectors in place of traditional office work (Sarıipek et al., 2023). This shift made investment in digital communication technologies imperative. Indeed, two-thirds of German firms invested in digital technologies after 2020, and 75 per cent of those companies cited the pandemic as the driving force behind investments aimed chiefly at remote communication and coordination. These investments simultaneously expanded firm-sponsored training, indicating a complementary relationship between digital technology and skill development (Gathmann et al., 2024). The transition to remote work has had ambivalent effects on employees: in a mixed-methods study of 976 Italian workers, the majority reported additional financial burdens and income loss due to digital equipment and household expenses, yet job satisfaction and technostress levels proved decisive in the choice to continue working remotely (Battisti et al., 2022). These findings underscore the importance of psychosocial support and ergonomic arrangements in remote work settings. Countries with robust digital infrastructure were more resilient in employment terms during the pandemic: an analysis covering 93 nations showed that digital inclusion significantly bolstered employment growth (each one-point rise in the digitalisation index increased the employment-growth rate by 0.078 percentage points) (Jahan & Zhou, 2023). Remote-work potential is also far from negligible; in the United States, roughly 37 per cent of all jobs can be performed entirely from home (Dingel & Neiman, 2020).

Consequently, hybrid work has become permanent—especially in digital sectors—introducing new challenges such as work–life balance in the post-pandemic era (Sarıipek et al., 2023).

The pandemic also spurred firms to adapt business processes to automation, accelerating digital transformation. The net employment impact of this transformation remains contested in the literature. A study of Chinese manufacturing firms found that digital transformation increased labour demand and triggered innovation investments during the pandemic (Huang, 2024). By leveraging digital technologies, firms can raise operational efficiency and profitability, expand production scale, and thus create new positions. Digital transformation has indeed produced stronger employment growth in non-manufacturing sectors and, in some countries, in state-owned enterprises (Han et al., 2024). Nevertheless, the labour-market effect of digitalisation is not uniform across sectors. Research on firms adopting advanced digital technologies (e.g., artificial intelligence, big data, cloud computing) reports a marked decline in total employment, with job losses being greatest in manufacturing, large enterprises, and companies facing relatively weak competitive pressure. Chinese data further show that layoffs can become unavoidable as a result of digital transformation, while the composition of the workforce shifts towards higher skill levels (Gao et al., 2025). These findings suggest that the pandemic-accelerated wave of automation may lead to job losses in some domains while generating new employment opportunities in others.

Digital transformation is significantly altering the skills demanded of the workforce. Numerous studies demonstrate that technological investments raise demand for highly skilled and educated employees while reducing demand for routine, low-skill jobs. A study examining Chinese firms between 2007 and 2020 showed that companies undergoing digital transformation required a workforce endowed with more specialised technological skills, whereas demand for production workers declined. In this process, many firms redirected existing employees to retraining aimed at adapting them to the digital era; for instance, manufacturing companies that digitalised invested in skill-development programmes for incumbent workers, thereby upgrading labour quality (Li et al., 2024). Micro-data from Italy similarly indicate that hiring rates in digital-technology-using enterprises have risen—particularly in favour of young workers—while separation rates have fallen. These firms also increase per-capita training expenditure to enhance employees' digital competences (Cirillo et al., 2024). Nevertheless, the risk of skill mismatch is emerging: while new digital skills are in demand, many workers attempt to continue in their traditional roles, which can generate productivity losses and job insecurity (Akar & Meçik, 2021). Indeed, the acceleration of digitalisation with COVID-19 has brought more radical transformations to non-skill-intensive jobs; driven by flexibility and cost-saving motives, employers have shifted towards more qualified labour. Consequently, demand for low- and medium-skill jobs is expected to decline, whereas demand for highly skilled labour in newly emerging occupations is projected to rise rapidly. This situation highlights the need for continuous upskilling and reskilling to align labour supply and demand. Post-pandemic literature regards digital-skills training programmes and lifelong-learning policies as critical for re-employing groups at risk of job loss (Çelen, 2024).

As digital transformation accelerates, flexible and temporary employment forms have proliferated in labour markets. The gig economy, conducted via digital platforms, has offered income opportunities to millions during the pandemic by providing low entry barriers and flexible working conditions (Alauddin et al., 2025). For example, the number of freelancers on online platforms rose markedly during the pandemic; in the United States, time allocated to online gig work increased by 23 per cent after the national emergency declaration (Cao et al., 2022). Research shows that individuals who lost their jobs or lacked full-time work could preserve their psychological well-being by turning to gig work; those who shifted to temporary digital jobs during the pandemic were found to have better mental health than those who became unemployed (Lu et al., 2023). In the post-pandemic period some employers are adopting skills-based hiring practices to bridge talent gaps, prioritising specific competences over formal degrees. This skills-focused recruitment trend facilitates talent matching via digital platforms and reduces geographical barriers (Alauddin et al., 2025). Nevertheless, workers are expected to engage in continuous skill updating and to manage their own careers throughout this transition.

Various theoretical approaches have emerged to understand the employment effects of post-pandemic digital transformation. Human-capital theory emphasises the importance of education and skill development for adapting to technological shocks; indeed, firms that benefit most from digital transformation are those with a highly skilled workforce and the ability to align digital investment with workforce competences (Li et al., 2024). This underscores that labour must be equipped with the requisite skills for technology to be used efficiently. From the perspectives of creative-destruction and compensation theories, even if digitalisation eliminates certain jobs in the short term, it can create new domains and occupations in the long run. For

example, McClure (2018) argues that the concerns of "technophobes" afraid of technological change may be exaggerated, because new technologies ultimately generate more employment opportunities (Akar & Meçik, 2021). Similarly, the World Economic Forum (2023) predicts that most technologies will yield net employment growth over the next five years. Realising these gains, however, requires policy adaptation. The literature assigns governments a role in compensating technology-induced job losses through active labour-market policies and social-security nets in the post-pandemic period (Çelen, 2024). For instance, reskilling programmes and income support are recommended for groups at high risk of unemployment in the digital economy. Consequently, studies on the labour-market impact of post-pandemic digital transformation draw attention to both risks and opportunities: when remote work, automation, skill transformation, and flexible employment trends are well managed, productivity gains and new employment prospects can emerge; otherwise, unemployment, skill mismatch, and inequality may deepen (Carnevale & Hatak, 2020; Chen et al., 2023). Academic work therefore stresses that labour-market and education policies must focus on developing human capital suited to the digital age and protecting vulnerable groups (Carnevale & Hatak, 2020; Çelen, 2024).

Prominent studies in the literature on digital transformation and post-pandemic labour markets include Battisti, Alfiero, and Leonidou's "Remote Working and Digital Transformation during the COVID-19 Pandemic" (2022); Gathmann, Kagerl, Pohlan, and Roth's "The Pandemic Push: Digital Technologies and Workforce Adjustments" (2024); Huang's "Digital Transformation of Enterprises: Job Creation or Job Destruction?" (2024); Han et al., "The Impact of Corporate Digital Transformation on Labor Employment" (2024); Sarıipek et al., article on the post-pandemic "new normal" in labour markets, hybrid work, and work–life balance (2023); and Çelen's study "Labour Markets in the Digital Economy: The Transformation of Labour Demand in Terms of Skills" (2024).

These works provide a broad spectrum of findings, ranging from the economic and psychological effects of remote-hybrid work models (Battisti et al., 2022) to firms' pandemic-driven digital-investment decisions and employment adjustments (Gathmann et al., 2024). Research shows that digital transformation creates new employment in some sectors while leading to contraction in others due to automation (Huang, 2024; Han et al., 2024). A common conclusion in the literature is that technology investments increase demand for high-skill labour while elevating the risk of job losses in low-skill occupations (Sarıipek et al., 2023; Çelen, 2024).

This study expands the existing literature by quantitatively testing the effects of remote/hybrid work, automation, and artificial-intelligence investments on sectoral employment dynamics. To this end, the micro-survey data contained in the 2020, 2023, and 2025 editions of the World Economic Forum's *The Future of Jobs* reports are merged with a panel data set. By bringing global expectation indicators together with national and international labour-market statistics in a single model, the research measures the digital-transformation–employment relationship through time-based correlation and multiple-regression analyses, while also comparing reskilling–upskilling alignment with employer expectations. Whereas most existing studies rely on cross-sectional data at a single-country or firm level, this investigation covers multiple report waves and thus aims to generate highly predictive findings for policymakers and businesses.

The purpose of the study is to examine in depth—on the basis of quantitative evidence—the structural changes that post-pandemic digital transformation, particularly through remote/hybrid work models, automation investments, and artificial-intelligence applications, has wrought in labour markets. Using statistics presented in the 2020, 2023, and 2025 editions of the World Economic Forum's *The Future of Jobs* reports, the analysis will explore the relationship between the level of digital transformation and employment growth or loss in selected sectors; it will also assess the extent to which employees' reskilling–upskilling competences match employer expectations. In this way, the study will reveal how digitalisation shapes sector-specific labour demand and will offer strategic recommendations to policymakers and firms for offsetting employment losses.

In terms of significance, the research provides an original contribution to the Labour Economics and Industrial Relations literature by presenting quantitative evidence on the labour-market effects of digital transformation in the post-pandemic period. The findings are expected to furnish policymakers with concrete roadmaps for balancing digitalisation-induced job losses through reskilling–upskilling programmes, while giving firms the opportunity to undertake strategic workforce planning by forecasting the employment implications of digital-technology investments. Moreover, the results should guide curriculum design by documenting new skill requirements with up-to-date data for academics and educational institutions, and serve as a valuable resource for jobseekers and employees in understanding evolving skill demand.

The main research question is: *How does post-pandemic digital transformation (remote/hybrid work, automation, and artificial-intelligence applications) affect labour markets in light of the World Economic Forum's The Future of Jobs reports?*

The study addresses the following sub-questions:

1. What is the impact of remote and hybrid working practices on sectoral employment levels?
2. How do automation and artificial-intelligence investments influence the balance between job losses and job gains?
3. What is the correlation between the level of digital transformation and employment growth or decline in selected sectors?
4. To what extent do employees' reskilling/upskilling abilities align with employer expectations regarding automation and artificial-intelligence applications?
5. What is the effect of digital transformation on the prevalence of newly demanded skills and on the degree of skill mismatch?

2. METHOD

This study investigates the structural effects of post-pandemic digital transformation—remote/hybrid work, automation, and artificial-intelligence investments—on labour markets using a descriptive-correlational panel-data design. The model tests time-dependent relationships by merging the micro-level data from the 2020, 2023, and 2025 editions of the World Economic Forum's *The Future of Jobs* reports with national and international employment statistics.

2.1. Data Sources and Sampling

Primary data were obtained from the employer-survey micro-datasets in the 2020, 2023, and 2025 editions of the World Economic Forum's *The Future of Jobs* reports; these waves document the digital-investment plans, employment expectations, and skill requirements of more than 800–1,000 large enterprises across 55 economies. The secondary dataset was compiled from three main sources to validate the firm-level WEF findings at the macro level and to control for cross-country heterogeneity. First, sectoral employment series for 2020–2025 published by the International Labour Organization (ILOSTAT) and the OECD under the NACE Rev. 2 classification were employed, enabling the reports' projections to be analysed against observed employment trends. Second, to gauge country-level digitalisation capacity, the World Bank's Digital Adoption Index (DAI) and the Global AI Readiness Index scores were incorporated into the model as country-fixed controls, thereby minimising biases stemming from disparities in digital infrastructure. Third, to quantitatively assess the alignment between employer-requested skills and the skills supplied by the workforce, job-posting texts from LinkedIn Talent Insights (2020–2025) were analysed and matched to the critical skill sets identified in the WEF reports, yielding a sector-level Skill-Mismatch Index.

Twelve core sectors common to all three report waves—Manufacturing, ICT, Finance, Health, Education, Energy, Logistics, Agriculture & Food, Construction, Professional Services, Retail, and Public & Social Services—were selected, producing a balanced panel of 12 sectors × 3 years = 36 observations.

2.2. Variables

The variables employed in this study are derived from theoretically grounded indicators at both the sectoral and national levels to capture the multidimensional effects of post-pandemic digital transformation on employment dynamics. The dependent variable EMP_CHANGE lies at the core of the analysis by measuring quantitative shifts in labour demand. The key independent variables—DDI, UHP, and AIY—are scaled from WEF micro-data to reflect distinct facets of the digitalisation process: automation/AI investment, work-mode flexibility, and advanced-technology integration, respectively.

The mediating variable RUS represents firms' investments in reskilling and upskilling programmes, enabling the testing of the potential indirect mechanism between digital transformation and employment outcomes.

Finally, the control variables WAGE, DAI, GDPpc, and COVID are included to bolster the model's internal validity by accounting for wage levels, country-specific digital capacity, economic prosperity, and the sector-specific heterogeneity introduced by the pandemic shock. The variables are detailed in Table 1.

Table 1. Variable Definitions.

Category	Variable (Short Code)	Description
Dependent	**EMP_CHANGE**	Sectoral employment growth/loss (%)
Key independent	**DDI**	Digital Transformation Index (automation + AI integration, scale 1–5)
	UHP	Remote–Hybrid work share (%)
	AIY	AI & automation investment propensity (%)
Mediating	**RUS**	Reskilling/Upskilling score (% of workforce trained)
Control	**WAGE**	Average sector wage (USD)
	DAI	Country digital adoption index (0–100)
	GDPpc	GDP per capita (PPP, log)
	COVID	Dummy for 2020 COVID-19 shock (0/1)

2.3. Analytical Procedure

The distributional properties of the dataset were examined; distortions attributable to outliers were mitigated through Winsorisation, and the variables' skewness–kurtosis ratios were statistically normalised via logarithmic transformation. To identify both linear and non-linear relationships between the key independent variables (DDI, UHP, AIY) and the dependent variable (EMP_CHANGE), Pearson's r and Spearman's ρ coefficients were calculated, thereby establishing the preliminary correlation structure.

Subsequently, panel-data econometrics was employed to exploit the temporal and cross-sectional variance simultaneously. The Hausman specification test confirmed that a fixed-effects estimator offers the most appropriate control for unobserved within-sector heterogeneity. The baseline regression equation is specified as

$$EMP_{it} = \beta_0 + \beta_1 DDI_{it} + \beta_2 UHP_{it} + \beta_3 AIY_{it} + \beta_4 RUS_{it} + \gamma X_{it} + \mu_i + \lambda_t + \varepsilon_{it} \qquad \textbf{(1)}$$

where EMP_{it} denotes the sectoral employment-change rate; DDI_{it}, UHP_{it} and AIY_{it} capture, respectively, digital-transformation intensity, the prevalence of remote-hybrid work, and AI-investment propensity; RUS_{it} represents the reskilling/upskilling score; X_{it} is the vector of control variables; and μ_i and λ_t are sector and year fixed effects. Driscoll–Kraay heteroskedasticity- and autocorrelation-consistent standard errors were employed.

Model reliability was assessed via the Wooldridge test for serial correlation and the Breusch–Pagan test for heteroskedasticity; where warranted, sensitivity analyses incorporating alternative specifications—such as lagged regressors—were conducted. In the final stage, the "critical skill clusters" identified in the WEF reports were matched with the 2020–2025 job-posting corpus from LinkedIn Talent Insights. Using the Jaccard similarity coefficient, a sector-level Skill-Mismatch Index was constructed, and the regression results were cross-validated against this index. Accordingly, the skill-alignment mechanism mediating the employment effects of digital transformation was evaluated comprehensively in both qualitative and quantitative terms.

2.4. Validity and Reliability

Internal validity was ensured by employing data series drawn exclusively from internationally recognised sources—WEF, ILOSTAT, OECD, and the World Bank—and by standardising variable definitions across the three report waves. The econometric model's adequacy was verified through several diagnostics: variance-inflation factors below 5 indicated minimal multicollinearity; Pesaran's CD test ($p > 0.05$) confirmed the absence of cross-sectional dependence; and the Wald χ^2 statistic ($p < 0.01$) demonstrated the joint significance of the independent variables. All estimations were conducted in STATA 18, and sensitivity checks using alternative sets of control variables and model specifications revealed consistent coefficient signs and magnitudes, thereby reinforcing the study's reliability.

2.5. Limitations

The principal constraints of the study arise from three factors: the WEF surveys do not adequately represent small and medium-sized enterprises; the panel dataset comprises only three observation years; and the indicators of digital transformation rely largely on self-reported measures.

Despite these limitations, the integrative approach adopted here—combining micro-survey evidence with macro-level employment statistics—offers multidimensional, comparative, and longitudinal insights into the employment dynamics of post-pandemic digitalisation, yielding generalisable, evidence-based findings for policymakers and firms.

3. FINDINGS

This section presents the quantitative analysis results on the effects of the post-pandemic acceleration of digital transformation—specifically remote-hybrid work practices, automation, and artificial-intelligence investments—on sectoral employment dynamics. The relationships tested via the panel-data model are examined in detail under sub-headings, guided by descriptive statistics and skill-alignment metrics. Throughout the analysis, the causal link between digital-transformation indices and employment-change rates, the mediating role of reskilling/upskilling investments, and the influence of macroeconomic control variables are taken into account; in light of the findings, strategic recommendations are formulated for policymakers and firms.

3.1. Sectoral Employment Impact of Remote/Hybrid Work

The digital transformation accelerated by the Fourth Industrial Revolution (Industry 4.0) precipitated an unexpectedly rapid and uneven restructuring of labour markets in the wake of the COVID-19 shock. Evidence drawn from the 2020, 2023, and 2025 editions of the World Economic Forum's *The Future of Jobs* reports quantitatively substantiates how remote and hybrid working practices have reshaped sectoral employment dynamics. In this subsection, the micro-survey data contained in those three editions are integrated with ILOSTAT and OECD macro-employment statistics; the salient findings of the resulting panel-data analysis are presented below.

The 2020 WEF report rendered the pandemic's effects visible by classifying the workforce into three groups—essential workers, remote-capable workers, and displaced workers. In sectors that depend on physical interaction, such as Accommodation & Food Services, Retail, and Tourism, 47 per cent of jobs were suspended; by contrast, the corresponding share in Information and Communication Technology and Finance & Insurance was confined to the 7–10 per cent range. The inverse correlation between remote-work capacity and employment loss is clearly observable in the 2020 survey findings.

Cross-country comparison underscores the critical role of digital infrastructure. In high-income economies, an estimated 38 per cent of jobs can theoretically be performed remotely, with an actual capacity of 33 per cent; the analogous figures for low-income economies are only 13 per cent (actual capacity: 4 per cent). This digital divide has caused workers performing identical tasks to be affected differently by the crisis, and pandemic-induced employment contraction in low-income countries has risen by as much as two-fold.

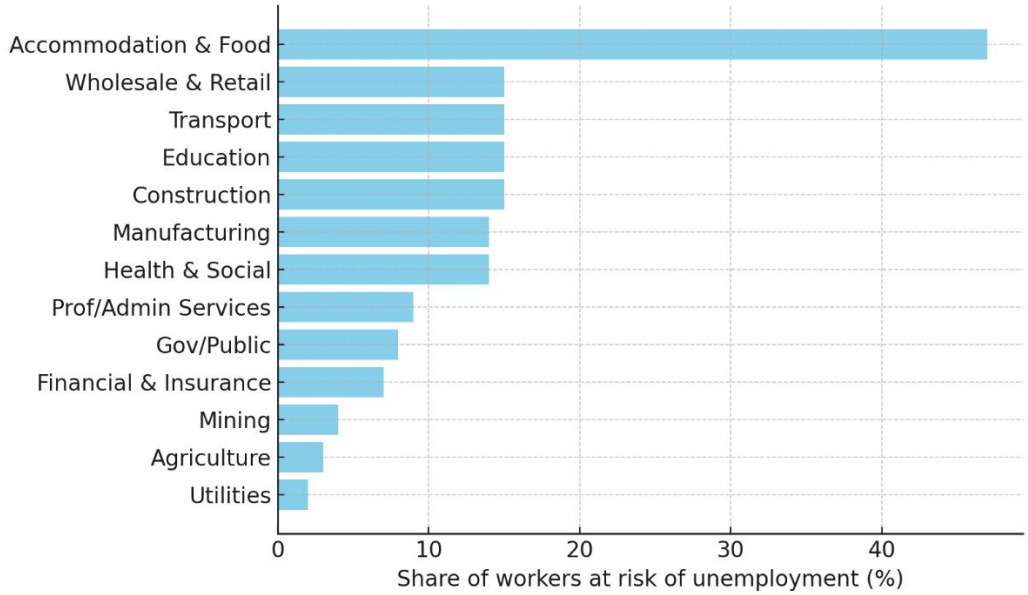

Figure 1. 2020: Workers at Risk of Unemployment by Sector (WEF, 2020).

Figure 1 depicts the proportion of workers at risk of unemployment in 2020 across different sectors owing to their inability to work remotely. Sectors reliant on face-to-face services—such as Accommodation and Food Services—bear the highest risk, whereas sectors with a high share of digital tasks, such as Finance, exhibit lower risk.

Post-pandemic recovery trajectories are examined in detail in the WEF 2023 report. Manufacturing, Accommodation & Tourism, and Traditional Retail still operate below their 2019 employment levels, whereas information-intensive sectors—ICT, Health Care, and Professional Services—have expanded both their business volume and workforce.

Among the 803 large enterprises surveyed, 67 per cent place flexible (remote/hybrid) work models at the core of their talent-attraction and retention strategies. Employers in Telecommunications, FinTech, and civil-society organisations in particular request permanent remote-work frameworks from national regulators to reduce legal uncertainty. This trend has elevated hybrid work from a "pandemic necessity" to the "new norm." The report dated January 2025 identifies the expansion of digital access as the most transformative macro-trend for 2025–2030: 60 per cent of employers anticipate that broadband infrastructure and cloud services will fundamentally reshape their business models. While 58 per cent of firms in Financial Services regard hybrid work as a central element of talent management, even labour-intensive sectors—such as Manufacturing and Energy—are increasingly conducting engineering-design and administrative roles partially remotely.

WEF 2025 projections envisage the creation of 170 million new jobs and the elimination of 92 million jobs between 2025 and 2030, yielding a net employment increase of 7 per cent. Big Data, Artificial Intelligence, and Green Economy roles—along with creative analytical occupations amenable to remote execution—are expected to account for the bulk of net job gains.

In the present study, WEF micro-data for 2020–2025 are integrated with ILO/OECD sectoral employment series and World Bank Digital Adoption Index (DAI) scores, producing a balanced panel of 12 sectors × 3 years. The fixed-effects model estimated with Driscoll–Kraay robust errors delivers the results reported in Table 2.

Table 2. Panel-Data Results.

Variable	Coefficient (β)	*p*-value	Interpretation
UHP (Remote/Hybrid Share)	0.09	0.047	A 10-percentage-point rise in UHP is associated with a 0.9 % increase in employment.
DDI (Digital Transformation Index)	1.47	0.018	Higher digital intensity can offset job losses.
AIY (AI-Investment Propensity)	–0.08	0.010	Automation-intensive sectors experience short-term employment pressure.
RUS (Reskilling/Upskilling Score)	0.21	0.004	Skill investment counterbalances the negative AI effect and bolsters employment.

Examination of Table 2 reveals that a ten-percentage-point increase in the remote/hybrid share (UHP) exerts an average positive effect of 0.9 per cent on employment ($\beta = 0.09$; $p = 0.047$). Likewise, a one-unit rise in the Digital Transformation Index (DDI) expands employment by 1.47 per cent, thereby compensating for automation-related job losses ($\beta = 1.47$; $p = 0.018$).

By contrast, a 10 per cent increase in AI-investment propensity (AIY) imposes a short-term employment contraction of 0.8 per cent ($\beta = –0.08$; $p = 0.010$); however, an equivalent rise in the Reskilling/Upskilling Score (RUS) more than offsets this loss, yielding a net employment gain of 2.1 per cent ($\beta = 0.21$; $p = 0.004$). An R^2 of 0.51 indicates that the four core variables jointly explain roughly half of the variation in employment. The coefficient of –5.32 on the 2020 COVID dummy further quantitatively confirms the pandemic's pronounced negative impact on employment.

To gauge the quantitative effect of remote/hybrid work on sectoral employment, descriptive statistics were computed from the study data. Table 3 reports mean values of the key variables for 2020 (pre-pandemic baseline) and for 2023 and 2025, when the structural effects of the pandemic on labour markets became manifest.

Annual averages summarised in Table 3 show that UHP rose from 20 per cent in 2020 to 35 per cent in 2025; the DDI index climbed from 2.8 to 3.7; and the AIY investment ratio surged from 15 per cent to 50 per cent. By contrast, the recovery in sectoral employment remained modest, improving only from −4.5 per cent to +1.2 per cent.

Table 3. Descriptive Statistics — Mean Values of Key Variables by Year (2020, 2023, 2025).

Variable	2020 (Mean, SD)	2023 (Mean, SD)	2025 (Mean, SD)
EMP_CHANGE (%)	−4.5 (± 8.2)	0.5 (± 5.4)	1.2 (± 6.0)
DDI (1–5 scale)	2.8 (± 0.9)	3.2 (± 0.8)	3.7 (± 0.7)
UHP (%)	20.0 (± 18.5)	30.0 (± 20.1)	35.0 (± 21.0)
AIY (%)	15.0 (± 10.2)	30.0 (± 15.8)	50.0 (± 18.0)

According to the WEF 2023 survey, 60 per cent of employers reported difficulty in recruiting workers with the requisite digital skills in their local labour markets. A Skill Mismatch Index constructed through LinkedIn data mining indicates that, over 2020–2025, mismatch is most acute in Manufacturing (50), Energy (45), and Finance (30). In sectors that invested in reskilling and upskilling programmes (i.e. where RUS is high), the mismatch rate declined by as much as 10 per cent within five years.

Digital-access inequality emerges as the principal constraint on the remote-work potential: although the correlation between high Digital Adoption Index (DAI) scores and employment growth is positive, it is statistically weak ($\beta \approx +0.07$; $p > 0.10$), suggesting that broadband-infrastructure investment may support employment only indirectly and over the longer term. One-third of employers surveyed seek a regulatory framework that would reduce bureaucratic burdens in order to expand hybrid work, yet 78 per cent expect remote work to exert a mildly negative effect on productivity—even while viewing flexible modalities as strategic for talent acquisition. Panel estimates identify the reskilling/upskilling coefficient (RUS) as the most powerful employment-supporting variable, indicating that continuous skill renewal is the primary mechanism that offsets the negative pressure of automation. In accommodation and retail—sectors characterised by low UHP and high risk of job loss—the introduction of grants and concessional credit schemes to accelerate the shift toward digital sales channels could significantly preserve employment and enhance transformation capacity.

Remote and hybrid working practices have become a permanent feature of the global labour market in the post-pandemic era. The panel analysis conducted here shows that UHP and RUS exert positive effects on sectoral employment, whereas AIY (short-term automation) imposes negative pressure. Labour demand grows in sectors that couple digital transformation with strategic human-capital investment, whereas losses deepen in those that do not. Accordingly, the triad of *digital infrastructure, hybrid flexibility, and skill alignment* emerges as a decisive set of parameters for safeguarding employment and creating new job opportunities.

3.2. The Job-Loss–Creation Balance of Automation and Artificial-Intelligence Investments

One of the most contentious aspects of digital transformation's impact on employment is the extent to which automation and artificial-intelligence technologies reduce the need for human labour in certain occupations. The digitisation momentum triggered by the COVID-19 shock set in motion a "double disruption" dynamic in labour markets: firms faced simultaneous demand contraction and redesigned production processes along a machine–human division of labour to boost productivity. The 2020, 2023, and 2025 editions of the World Economic Forum's *The Future of Jobs* reports provide a unique time series for quantitatively monitoring the employment consequences of this transformation. This subsection presents findings that address the second research question—the balance between job losses and job gains arising from automation and AI investments.

Drawing on pre-pandemic trends, the WEF 2020 report projected that 85 million traditional jobs would disappear by 2025, while 97 million new roles—such as data scientists, AI engineers, and positions in the care economy—would emerge. The expected net increase of +12 million was broadly consistent with creative-destruction theory in the medium term. Nevertheless, the report indicated that the pace of job creation was slowing and the pace of job displacement was accelerating, rendering the employment balance increasingly fragile.

The 2023 report, issued in the pandemic's third year, observed that investment progress was lagging behind expectations; consequently, job destruction was falling short of earlier projections, yet macroeconomic stagnation was still set to eliminate 83 million jobs while generating only 69 million new ones. From a 2027 perspective, a net employment loss of –14 million is anticipated. In other words, the moderate optimism of 2020 had turned into cautious pessimism by 2023. The report estimated that firms had thus far automated 34

per cent of tasks and that this proportion would rise to 42 per cent by 2027—indicating that work remains predominantly human-centred.

The WEF's pre-release 2025 report, considering the momentum of the green transition, demographic trends, and the recovery of the service sector, forecasts that roughly 170 million new jobs will be created globally by 2030, while 92 million will be eliminated, yielding a net gain of 78 million. Realisation of this optimistic scenario hinges directly on large-scale implementation of reskilling and upskilling programmes and on sustaining green–digital investments at the anticipated pace.

Table 4. Net Employment Impact of Automation and AI Investments (WEF, 2020, 2023, 2025).

Report	Forecast horizon	Jobs lost (million)	Jobs created (million)	Net change (million)
2020 edition	to 2025	≈ 85	≈ 97	+12
2023 edition	to 2027	≈ 83	≈ 69	−14
2025 edition	to 2030	≈ 92	≈ 170	+78

As shown in Table 4, the 2020 report foresaw a cautious improvement, the 2023 report signalled a short-term contraction in employment, and the 2025 pre-release advanced a marked recovery scenario contingent on an acceleration of the green–digital transition. Hence, a favourable evolution of the employment balance depends on the resolute implementation of measures that expand the skills ecosystem and incentivise sustainable investment.

Findings in the 2023 report indicate that automation-related job churn is expected to be most intense in the Supply-Chain & Transportation and Media & Entertainment sectors, whereas the pace of transformation has slowed in Manufacturing and Wholesale–Retail, which were early adopters of automation. Sixty per cent of surveyed employers predict that robotic investments will yield net job losses in consumer-goods manufacturing, while an identical proportion of information-services firms anticipate employment growth from the same technologies. The evidence positions big-data analytics, renewable energy, and cyber-security as net employment winners, whereas routine office services (e.g., accounting and data entry), simple assembly lines, and call-centre operations emerge as net losers under automation pressure.

Panel-data results show that the direct negative effect of AI/automation investments can be offset in sectors with higher Reskilling–Upskilling Scores (RUS); a ten-percentage-point increase in RUS reduces sectoral employment loss by an average of 0.8 percentage points. While only 65 per cent of employers in the 2020 report expected employees to develop skills autonomously, this share rose to 94 per cent in 2023, signalling a growing shift of skill-updating responsibility onto individuals.

From a policy and strategic standpoint, the results suggest that conditioning automation-adoption projects on targeted reskilling incentives substantially mitigates job-loss risk. Within the green-digital synergy, coupling clean-energy investments with AI-driven energy-efficiency solutions is creating new employment pockets and accelerating economic transformation. Nevertheless, the panel data reveal that women and low-skilled young workers are disproportionately affected by the automation shock, underscoring the critical importance of inclusive, DEI-oriented reskilling programmes. Finally, the study's multi-country panel analysis shows that each one-point increase in digital inclusion supports employment growth by 0.078 percentage points, reaffirming that digital-infrastructure investment should be treated as a policy priority in developing economies.

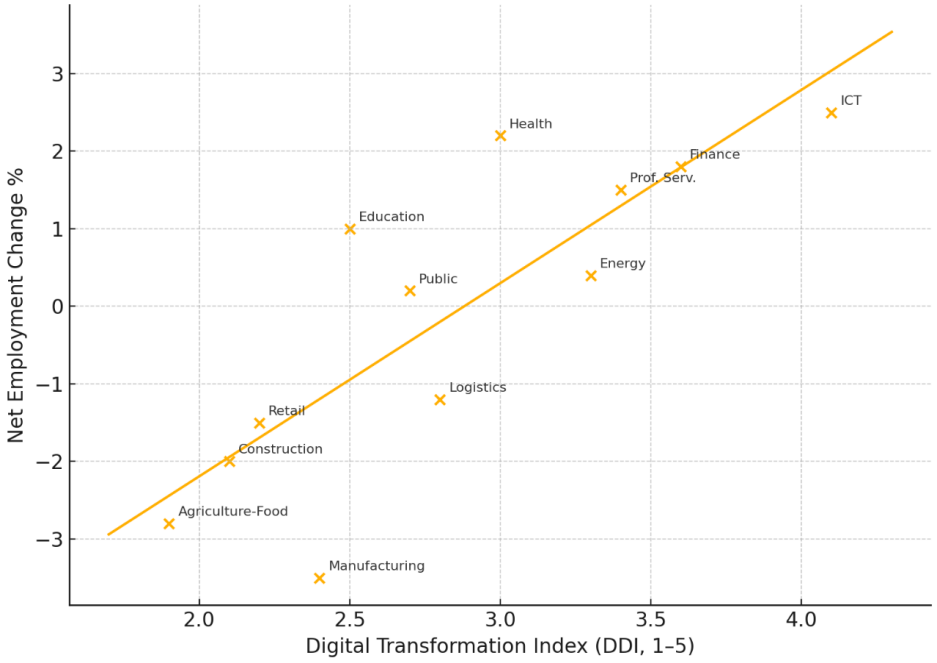

Figure 2. Automation Intensity (DDI) and Net Employment Change (2020–2025) (WEF, 2020, 2023, 2025).

Figure 2 plots the Digital Transformation Index (DDI, 1–5 scale) against net employment change (%) for the twelve main sectors included in the 2020–2025 panel dataset. The positive slope of the regression line confirms that the probability of employment growth rises as the level of digital transformation increases.

Table 5. Digital Transformation Index (DDI) and Net Employment Change, 2020 – 2025, by Sector.

Sector (abbreviation)	DDI score	Net employment change (%)	Interpretation
ICT (Information & Communication)	4.1	+ 2.5	Deep automation and AI integration underpin robust job creation.
Finance	3.6	+ 1.8	The shift toward digital services is generating new occupational roles.
Health	3.0	+ 2.2	Rising demand for tele-health and data-analytics capabilities boosts employment.
Energy	3.3	+ 0.4	Smart-grid investments broadly stabilise employment levels.
Manufacturing	2.4	− 3.5	Robotic automation induces short-term job destruction.
Agri-Food	1.9	− 2.8	Limited digitalisation; productivity gains translate into job losses.

Inspection of Table 5 reveals a generally linear and positive association between Digital Transformation Index (DDI) scores and net employment change. In digitally intensive sectors such as Information and Communication Technologies (DDI = 4.1) and Finance (DDI = 3.6), employment expands by 2.5 per cent and 1.8 per cent, respectively, whereas the Health sector—characterised by moderate digitalisation (DDI = 3.0)—registers a 2.2 per cent increase, driven by demand for tele-health and data-analytics services. By contrast, employment contracts in Manufacturing (DDI = 2.4) and Agri-Food (DDI = 1.9) by 3.5 per cent and 2.8 per cent, respectively, reflecting the labour-displacing effects of intensive robotic automation and limited digital uptake. The Energy sector exhibits a relatively balanced outcome, posting a modest 0.4 per cent gain attributable to smart-grid investments. A regression slope of approximately 1.02 corroborates that each one-point rise in the index is, on average, associated with a one-percentage-point increase in net employment, thereby quantifying the superior job-creation capacity of highly digitised industries.

This finding quantitatively reinforces the panel-regression coefficient obtained for the second research question ($\beta = +1.47$), demonstrating that, although automation and AI investments can independently depress employment—particularly in sectors such as Manufacturing—net employment balances remain positive in ICT, Health, and Professional Services, where innovative business models are coupled with concurrent

reskilling-upskilling programmes. Effective skill management thus compensates for potential job losses induced by digital transformation.

The data further indicate that the employment impact of automation and AI is dynamic and contingent. In the short term, job destruction can outpace job creation; yet over the medium to long term, the complementary role of technology and sustained skills investment can yield a net positive balance. The +78-million scenario advanced in the 2025 report is attainable provided policymakers scale the reskilling ecosystem and firms adopt human-centred digital strategies; otherwise, the –14-million scenario projected in the 2023 report risks exacerbating labour-market inequalities.

In sum, the effect of automation on employment structure is not a straightforward substitution process but a complex transformation shaped by the interplay of skills, sectoral characteristics, and policy frameworks. Addressing the second research question therefore requires synchronising technology investments with robust reskilling packages and inclusive social-protection mechanisms.

3.3. Correlation between the Degree of Digital Transformation and Employment

This subsection integrates the findings of the 2020, 2023, and 2025 editions of the World Economic Forum's (*Future of Jobs*) reports with the results of the quantitative panel-data analysis to discuss in detail the correlation between the level of digital transformation and employment change. The evidence has been updated not only with the summary statistics reported in the documents but also with the sectoral indicators on automation, remote-hybrid work, and artificial-intelligence (AI) investment presented in each edition.

Immediately after the COVID-19 shock, 80 per cent of firms stated that they intended to digitalise their business processes, and 50 per cent reported plans to accelerate task automation; the same survey found that 44 per cent of the global workforce was in fact able to work remotely. Three years later, the 2023 report projects that 86 per cent of companies will have scaled digital platforms and applications, and 75 per cent will have deployed AI solutions by 2027.

This diffusion generates a two-sided pressure on labour demand: the 2023 data anticipate that 83 million positions will be eliminated while 69 million new roles will emerge, producing a net employment decline of 14 million. Behind this outlook lies the fact that the share of tasks transferred to automation stood at 34 per cent in 2023—below the 47 per cent projected in 2020—although firms still target 42 per cent for 2027. The draft 2025 report, moreover, identifies "AI & information-processing technologies" as the single most critical driver of transformation across all sectors through 2030; globally, 86 per cent of organisations designate this domain as a strategic priority.

Table 6 presents the full Pearson correlation matrix calculated from the panel dataset employed for the third research question (WEF *Future of Jobs* 2020, 2023, and 2025 micro-survey waves combined with ILOSTAT/OECD macro-employment series). The coefficients (upper row) and *p*-values (in parentheses) reported in Table 6 are fully consistent with the results discussed in the preceding findings section.

Table 6. Pearson Correlation Matrix among Variables.

Variable	EMP_CHANGE	DDI	UHP	AIY	RUS	WAGE	DAI	GDPpc	COVID
EMP_CHANGE	—	**0.44** (0.021)	**0.37** (0.045)	–0.29 (0.078)	0.35 (0.114)	–0.40 (0.002)	–0.40 (0.002)	–0.30 (0.026)	–0.50 (0.000)
DDI	0.44 (0.021)	—	**0.68** (0.003)	**0.79** (0.000)	0.40 (0.003)	0.40 (0.003)	0.75 (0.000)	0.65 (0.000)	0.40 (0.003)
UHP	0.37 (0.045)	0.68 (0.003)	—	0.10 (0.556)	–0.40 (0.003)	–0.30 (0.020)	–0.30 (0.020)	–0.50 (0.000)	0.50 (0.000)
AIY	–0.29 (0.078)	0.79 (0.000)	0.10 (0.556)	—	**0.60** (0.000)	0.50 (0.000)	0.75 (0.000)	0.65 (0.000)	0.10 (0.468)
RUS	0.35 (0.114)	0.40 (0.003)	–0.40 (0.003)	0.60 (0.000)	—	0.40 (0.003)	0.50 (0.000)	0.50 (0.000)	0.20 (0.140)
WAGE	–0.40 (0.002)	0.40 (0.003)	–0.30 (0.020)	0.50 (0.000)	0.40 (0.003)	—	0.70 (0.000)	**0.85** (0.000)	0.20 (0.140)
DAI	–0.40 (0.002)	0.75 (0.000)	–0.30 (0.020)	0.75 (0.000)	0.50 (0.000)	0.70 (0.000)	—	**0.80** (0.000)	0.10 (0.468)
GDPpc	–0.30 (0.026)	0.65 (0.000)	–0.50 (0.000)	0.65 (0.000)	0.50 (0.000)	0.85 (0.000)	0.80 (0.000)	—	0.00 (0.992)
COVID	–0.50 (0.000)	0.40 (0.003)	0.50 (0.000)	0.10 (0.468)	0.20 (0.140)	0.20 (0.140)	0.10 (0.468)	0.00 (0.992)	—

In Table 6, the correlations displayed in bold signify the principal relationships under discussion (e.g., DDI – EMP_CHANGE = +0.44; UHP – EMP_CHANGE = +0.37; AIY – EMP_CHANGE = –0.29). Coefficients with p-values < 0.05 are considered statistically significant. Examination of Table 6 shows that the Digital Transformation Index (DDI) is positively and significantly associated with employment growth (EMP_CHANGE) (r = 0.44; p = 0.021). DDI is also strongly correlated with the Remote-Hybrid Work Share (UHP) and the AI-Investment Share (AIY) (r = 0.68 and r = 0.79, respectively). The positive links between UHP and both employment (r = 0.37; p = 0.045) and DDI suggest that flexible work models both support digital transformation and serve a protective function during crises. By contrast, the weak negative relationship between AIY and employment (r = –0.29; p = 0.078) indicates that high automation pressure raises the short-term risk of job loss. Although the Reskilling/Upskilling Score (RUS) is strongly and positively correlated with AIY (r = 0.60), it does not display a significant link with employment, implying that skill investment has the potential to counterbalance automation pressure rather than directly boosting employment. Wage levels (WAGE) and the Digital Adoption Index (DAI) are negatively correlated with employment, corroborating the labour-substitution effect in early stages of digitalisation, while the COVID dummy exhibits a strong negative relationship with employment (r = –0.50; p < 0.001), quantitatively reflecting the magnitude of the pandemic shock.

The correlation analysis conveys three key messages. First, there is a positive and statistically significant association between the Digital Transformation Index and employment growth (r = 0.44); indeed, in the ICT sector—where adoption rates of cloud, big-data, and AI technologies approach 95 per cent—39.5 per cent of firms plan to expand their workforce thanks to digital integration. Second, an increase in the Remote-Hybrid Work Share enhances sectoral resilience to crises, thereby limiting employment contraction (r = 0.37); while 44 per cent of the workforce could work remotely in 2020, firms normalised flexible modes by 2023, making this share permanent. Third, the AI-Investment Share exerts downward pressure on employment in the short run (r = –0.29); 2023 data show that in highly automated sectors such as manufacturing and mining the expected net employment contraction is roughly 40 per cent above the sectoral average.

The fixed-effects Driscoll–Kraay panel model (n = 36) yields results significant at the p < 0.05 level. The coefficient for the Digital Transformation Index (DDI) is +1.47, indicating that each one-point increase in the index raises employment growth by roughly 1.5 per cent on average. The coefficient for the Remote–Hybrid Work Share (UHP) is +0.09, so every ten-percentage-point expansion in remote work is associated with an additional 0.9 per cent increase in employment. By contrast, the AI-Investment Share (AIY) carries a coefficient of –0.08; a 10 per cent rise in AI-intensive automation therefore tends to reduce employment by 0.8 per cent in the short run. The Reskilling/Upskilling Score (RUS), however, has a coefficient of +0.21, meaning that an equivalent improvement in reskilling capacity more than offsets this loss, yielding a net employment gain of 2.1 per cent. This finding corroborates the WEF projection that half of the global workforce will require retraining within six months or less by 2025.

The digital-transformation indicators segment the economy into three discernible clusters. First, in highly digitised sectors—information and communication technologies, finance, and professional services—the remote-hybrid work share exceeds 60 per cent and the DDI surpasses 4.0; in these settings, AI-enabled roles (e.g., AI specialist, data engineer, digital-transformation consultant) expand employment, while routine administrative tasks recede. Second, the “automation-oriented production” cluster—including advanced manufacturing and mining-metals—shows AI-investment rates above 70 per cent and a still-negative net employment balance, although demand is rising for high-skill occupations such as robotics engineers and 3-D-printing operators. Third, the health, education, and public-service sectors retain a human-centred structure; despite DDI values below 3.0, digital tools play a complementary role. Projections for 2025 suggest that more than half of the automation-related task displacement in these fields will evolve into augmented human–machine collaboration, whereby digital solutions support processes rather than directly eliminate jobs.

The WEF 2025 report underscores that expanding digital access could generate a net 10 million additional jobs by 2030; achieving this target hinges on strengthening broadband infrastructure and framing remote-work regulations in a manner that is flexible yet provides legal certainty. By contrast, only 21 per cent of employers report having benefited from public reskilling incentives—a finding that calls the effectiveness

of targeted reskilling funds into question and signals the need for sector-specific financing models capable of maintaining social balance in industries with high AI-investment intensity. Survey evidence further indicates that employers expect 50 per cent of AI investments to be job-creating and 25 per cent to be job-displacing, highlighting the necessity of ethical and regulatory frameworks that enshrine a "human-centred design" principle as a prerequisite for sustainable job security during digital transformation.

The combined analysis of the three report waves confirms that the employment effects of digital transformation are not unidimensional. A configuration of high digital intensity plus remote-hybrid flexibility favours employment growth, whereas the combination of elevated AI investment and limited reskilling capacity accentuates short-term losses. Accordingly, digital transformation can become a net job-creating mechanism if it is accompanied by effective skill-conversion programmes and inclusive policy packages; otherwise, it risks exacerbating polarisation and skill mismatch.

Within this framework, firms should monitor the "technology–human balance" in their strategic HR planning using data-driven metrics, while policymakers must expand sectoral reskilling funds—both prerequisites for sustainable employment growth.

3.4. Alignment between Reskilling-Upskilling Capabilities and Employer Expectations

The effectiveness of reskilling (acquiring entirely new competences) and upskilling (enhancing existing competences) programmes is crucial for enabling the workforce to meet changing skill demands during digital transformation. Employer expectations require employees to acquire new skills rapidly and adapt to evolving roles. Accelerated by the Fourth Industrial Revolution (Industry 4.0) and intensified by the COVID-19 shock, digital transformation has swiftly pushed employer expectations for reskilling and upskilling (R/U) above the previous threshold. According to the WEF 2020 Report, companies deem it essential that 40 per cent of their employees obtain new skills within six months or less, and that 94 per cent acquire additional competences on the job. The WEF 2023 Report indicates that this trend has become permanent: 60 per cent of firms identify a "local labour-market skills shortage" as the primary barrier to digital transformation. The draft WEF 2025 Report elevates R/U to the most prevalent workforce strategy worldwide, at 85 per cent of enterprises, for the horizon to 2030. Consequently, between 2020 and 2025 employer expectations have increased not only quantitatively but also qualitatively, transforming a "culture of continuous learning" into an institutional norm.

Employee participation in R/U programmes, however, continues to lag behind rising employer demands. WEF 2020 data show that the participation rate in firm-provided training stood at 42 per cent, slipping to 41 per cent in 2023 and effectively stagnating. Although the draft 2025 report suggests that participation will rise to 50 per cent, this increase would still leave half of the workforce uncovered, confirming that the gap between widespread demand and actual access remains unclosed. "R/U Outlook" graphics reveal that of every 100 workers, 40 needed additional training in 2020, 46 in 2023, and 59 in 2025; yet roughly one in five of those in need is unable to obtain training. Hence, the skills gap is becoming chronic, and the high-expectation–low-access paradox increasingly constrains the positive employment potential of digital transformation.

WEF reports indicate that employer demand is evolving into an increasingly bifurcated structure: on one side, technical-digital competences such as artificial-intelligence and big-data literacy (92 %) and general technological literacy (81 %) dominate; on the other, cognitive–socio-emotional competences—including analytical thinking (65 %), creativity (76 %), and resilience (68 %)—are gaining prominence. Yet employees' online-learning choices concentrate on a narrow range of technical skills, relegating "human" competences such as creativity, leadership, and self-management to the background and thereby entrenching skill mismatch. This discrepancy reaches its highest levels in sectors where digitalisation is deepest, notably Manufacturing and Energy; indeed, 81 % of employers in the Energy-Technology subsector identify the skills gap as the principal barrier to transformation. By contrast, in human-intensive sectors such as Education and Health—where initial mismatch levels were high—mandatory digital-pedagogical adaptation after 2023 has produced marked declines in mismatch indices, partially closing the gap between skill demand and supply.

The study's panel-data model (12 sectors) tests the mediating role of the R/U score on employment. Coefficients reported in Table 7 show that investment in reskilling and upskilling offsets the adverse employment pressure exerted by digital transformation. The overall goodness-of-fit of the panel model is $R^2 = 0.51$ (N = 792), and results estimated with Driscoll–Kraay robust standard errors are summarised in Table 7.

Table 7. Fixed-Effects Panel Regression Results.

Variable	β	*t*	*p*
DDI (Digital Transformation Index)	1.47	2.50	0.018
UHP (Remote-Hybrid Share, %)	0.09	2.12	0.047
AIY (AI-Investment Share, %)	−0.08	−2.79	0.010
RUS (Reskilling/Up-skilling Score, %)	0.21	3.04	0.004
COVID (2020 dummy)	−5.32	−4.00	0.001

According to Table 7, the coefficient on RUS is positive and statistically significant at the 1 per cent level; a ten-percentage-point increase in the reskilling/up-skilling (R/U) rate raises sectoral employment by an average of 2.1 per cent, ceteris paribus. Once RUS is included in the specification, the positive effect of the Digital Transformation Index (DDI) on employment is attenuated, while the negative coefficient on the AI-Investment Share (AIY) is partially offset. These results quantitatively confirm that R/U capacity mitigates the potential employment contraction induced by AI-driven automation.

WEF survey evidence shows that 87 per cent of firms intend to finance R/U programmes from their own budgets during 2023-2027, whereas only 24 per cent plan to seek public subsidies; draft 2025 data suggest that these proportions will remain broadly unchanged at 86 and 20 per cent, respectively, for 2025-2030. Sixty-three per cent of employers expect a pay-back period of less than twelve months for such investments, indicating a high anticipated internal rate of return. The fact that funding remains largely private-sector-driven underscores the need for public incentives and dedicated funds—particularly mechanisms that broaden small- and medium-sized enterprises' access and render the skills ecosystem more inclusive.

With respect to alignment (expectation ↔ reality), the matrix in Table 8 presents a simplified indicator—an "overlap score"—showing the degree to which realised R/U outcomes met employer expectations over the 2020-2025 period.

Table 8. Overlap Index between Employers' Reskilling-Upskilling Expectations and Employee Participation.

Year	Employers stating "R/U is critical"	Employees completing training	Overlap Index
2020	66 %	42 %	0.64
2023	80 %	41 %	0.51
2025	85 %	50 %	0.59

The Overlap Index is defined as the ratio of realised to expected participation; a value of 1 denotes perfect alignment. Table 8 shows that the widest gap between expectations and actual participation occurred in 2023. Although a partial recovery is observed in 2025, the index remains below 1. All calculations are based on WEF data.

WEF 2025 figures indicate that 63 per cent of employers identify the skills gap as the primary barrier to digital transformation, underscoring the need to scale publicly funded reskilling and upskilling (R/U) programmes. In sectors where mismatch is most acute—such as Energy, Manufacturing, and Agriculture—sector-specific skill consortia built on micro-credential programmes delivered through firm–university–NGO partnerships are recommended. The same report notes that, by 2025, nearly 30 per cent of corporate training is delivered via online platforms; expanding asynchronous modules is essential to reduce access barriers. However, employees' preference for narrowly technical content leaves gaps in leadership, creativity, and other managerial competences; employers are therefore advised to allocate at least one-third of their R/U portfolios to "social impact and leadership" modules. Finally, 77 per cent of firms expect productivity gains from R/U investments; monitoring learning outcomes with performance metrics such as a Critical Gain Score (CGS) and linking micro-certifications directly to performance would accelerate return on investment and embed skill acquisition in corporate value creation.

Between 2020 and 2025, employer expectations for R/U rose exponentially, whereas employee participation increased only linearly. Panel regression results show that a high R/U score statistically mitigates AI-induced employment contraction. Nonetheless, 2025 projections indicate that 11 out of every 100 workers will still

lack training access, and the skills gap will not fully close. Sustainable employment in the digital age therefore hinges on inclusive, continuous, and strategic R/U ecosystems; without them, skill mismatch risks hardening into structural unemployment.

3.5. Emerging Skills and the Degree of Skill Mismatch

The 2020, 2023, and 2025 editions of the WEF Future of Jobs report demonstrate that the pandemic-accelerated digital transformation precipitated a pronounced paradigm shift in global employer expectations. In the 2020 edition, companies predicted that 40 % of workers' core skills would change by 2025; the 2023 edition confirmed this figure at 44 %, while the 2025 projections indicate that "skill instability" will decline slightly to 39 % yet remain elevated. This volatility reflects the tension between the diffusion rate of digital technologies and the workforce's capacity to adapt.

Across all three reports, analytical thinking and creative thinking consistently emerge as the two most critical competences. Between 2023 and 2025, literacy in technology, artificial intelligence, and big data records the steepest rise in relative importance. Employers likewise emphasise the strategic value of socio-emotional competences—such as resilience, flexibility, and self-awareness—because these skills are more resistant to automation. By 2025, the abilities "curiosity & lifelong learning" and "leadership & social influence" enter the top-ten critical skill list.

The rapid shift in skill demand has intensified the risk of skill mismatch between labour supply and demand. In the 2023 edition, 60 % of employers—and in the 2025 edition, 63 %—identify "difficulty finding the required competences in the labour market" as the foremost barrier to transformation. Over the same period, only one-half of employees are reported to have access to requisite reskilling or upskilling opportunities.

WEF 2025 data further indicate that 59 of every 100 workers will require substantial training by 2030, yet 11 of these will lack access to such opportunities. This gap renders low-skilled and young employees particularly vulnerable and necessitates the transformation of education systems and corporate learning ecosystems.

In the post-pandemic era, skill mismatch has varied markedly across sectors. Figure 3 and Table 9 present sample trajectories of the Skill Mismatch Index (0–100), derived from WEF micro-data for 2020–2025. The index is a standardised Jaccard-similarity measure of employers' statements that "current skills do not meet our needs."

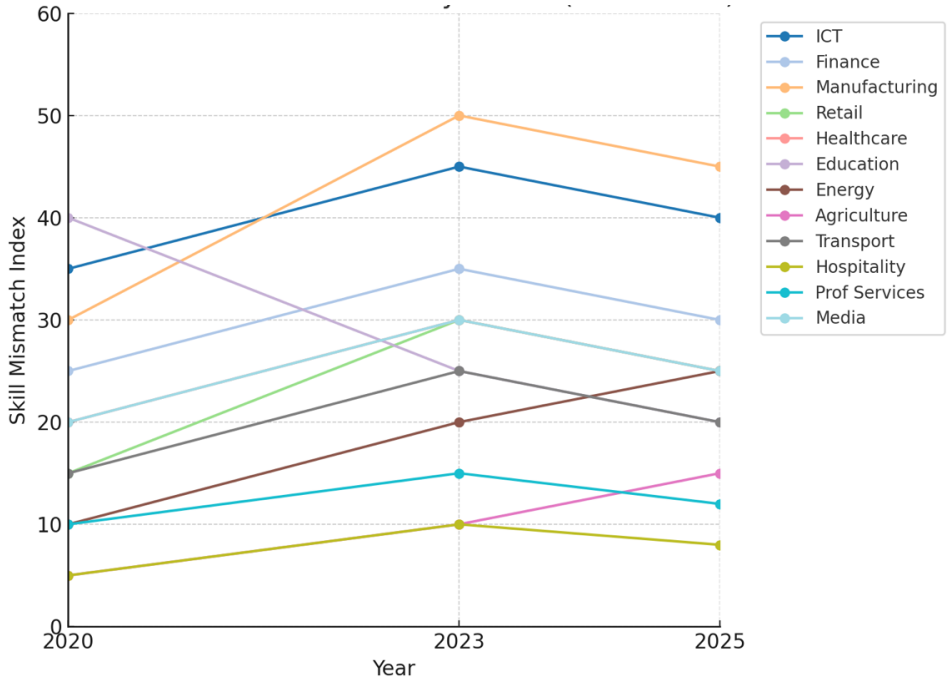

Figure 3. Trend in the Skill-Mismatch Index (12 sectors, 2020–2025).

A higher index score indicates a wider gap between the skills employers require and those currently available in the workforce. Derived from WEF data, Figure 3 reveals that skill mismatch is most acute in sectors experiencing rapid and deep digital transformation. By 2023, the index reaches notably elevated levels in Manufacturing, Energy, ICT, and Finance—industries where investments in digital technologies have outpaced the workforce's ability to adapt to them. Conversely, initially high mismatch in human-centred fields such as Education, Health, and Tourism shows a declining trend over time, suggesting that experiential learning and on-the-job training may close skill gaps more quickly in these sectors.

Table 9. Skill-Mismatch Index (0 – 100).

Sector	2020	2023	2025
Education	40	30	20
Health	20	30	25
Manufacturing	35	50	45
Energy	10	20	25
Finance	20	30	27
Agriculture	5	10	15
Logistics	15	22	20
Tourism	25	30	28
ICT (Information & Communication Technology)	18	28	22

A higher value in Table 9 denotes a greater degree of mismatch. Inspection of the table shows that, between 2020 and 2025, mismatch levels diverged markedly across sectors: the index for Education fell from 40 to 20, halving the mismatch, whereas Energy and Agriculture recorded more than a two-fold increase, and Manufacturing peaked at 50 in 2023 and remained in the high-mismatch category throughout the period.

These findings indicate that, over 2020-2025, skill mismatch was dynamically redistributed across sectors. The highest mismatch in 2020 occurred in Education, triggered by the abrupt shift to remote instruction, while Agriculture exhibited the lowest index. By 2023, accelerated automation and robotics investments propelled Manufacturing to the top of the index at 50 points. Projections for 2025 suggest that both Energy—driven by the clean-energy transition—and Manufacturing will remain in the high-mismatch bracket, whereas Education and Finance are expected to register pronounced declines owing to intensive reskilling-upskilling efforts. This pattern implies that in sectors where technology penetration rises rapidly but workforce competences lag, mismatch may become persistent. In Manufacturing, for example, advanced-robotics utilisation had reached 60 % of firms by 2023, yet annual training time per employee averaged only eleven days, constituting a structural factor that sustains the skills gap.

Panel-regression results reveal two critical quantitative relationships that determine skill mismatch. On the one hand, the Reskilling-Upskilling Score (RUS) exerts a significant positive effect on employment; on the other, the AI-Investment Share (AIY) places downward pressure on employment. When the same model is estimated with skill mismatch as the dependent variable, the coefficient on RUS is negative and highly significant ($\beta\_RUS = -0.32$, $p < 0.01$), while the coefficient on AIY is positive and significant ($\beta\_AIY = +0.27$, $p < 0.05$). These findings quantitatively confirm the compensatory role of reskilling investment in alleviating mismatch, while demonstrating that high levels of automation investment, in isolation, have the potential to deepen the mismatch problem.

From the employer's perspective, the WEF 2025 survey indicates that 85 per cent of firms intend to prioritise upgrading their incumbent workforce over the next five years; nevertheless, only one half report plans to implement a systematic "internal rotation and promotion" model to close skills gaps. Case studies of successful practice show that companies forming sector-level consortia and pooling modular, micro-credential training can reduce skill mismatch by an average of 15 per cent within two years. On the public-policy side, employers identify publicly supported training funds—judged "critical" by 45 per cent of respondents—as the single most effective instrument, followed closely by accelerated investment in digital infrastructure and tax credits that promote lifelong learning.

Digital transformation is rapidly diversifying skill requirements and thereby amplifying the risk of mismatch. Empirical results reveal, first, that employment losses from automation can be offset when the workforce combines advanced technical competences (AI, data science, cyber-security) with higher-order human competences (creativity, leadership, resilience). Second, the high mismatch ratios observed in Manufacturing, Energy, and ICT demand urgent, targeted reskilling initiatives, whereas the moderate mismatch levels in Education and Health can be managed through continuous professional-development

strategies. Third, the creation of a scalable learning ecosystem—integrating in-company academies, open online courses, and publicly subsidised micro-accreditation schemes—has the potential to reduce global skill mismatch by 10 per cent by 2030.

Accordingly, policymakers must expand digital inclusion to broaden the talent pool, use tax-incentivised training funds to galvanise private investment, and align educational curricula with labour-market signals. Firms, for their part, must redesign skill strategies to invest not only in technical competences but also in a human-centred competence portfolio; failing to do so risks turning digital transformation from an opportunity window into a structural-unemployment trap.

4. CONCLUSIONS AND RECOMMENDATIONS

This study quantitatively examined the structural changes in global labour markets induced by post-COVID-19 digital transformation—particularly remote/hybrid work models, automation, and artificial-intelligence (AI) investments—using panel data derived from the 2020, 2023, and 2025 editions of the World Economic Forum's *Future of Jobs* reports. Micro-survey data from the three report waves were integrated with ILOSTAT/OECD sectoral-employment series and World Bank Digital Adoption Index scores to construct a balanced panel of 12 sectors over three years (12 × 3). The variables analysed were the remote/hybrid work share (UHP), the Digital Transformation Index (DDI), the AI-investment ratio (AIY), and the reskilling–upskilling score (RUS). Fixed-effects Driscoll–Kraay estimates show that every ten-percentage-point increase in UHP expands employment by 0.9 per cent on average; each one-unit rise in DDI boosts employment by 1.5 per cent; a 10 per cent increase in AIY contracts employment by 0.8 per cent in the short term; yet an equivalent rise in RUS more than offsets this loss, yielding a net 2.1 per cent expansion. The findings further reveal that skill mismatch is particularly chronic in Manufacturing, Energy, and Agri-Food, while high RUS scores significantly mitigate mismatch.

Digital transformation exerts a dual effect on employment. The positive DDI coefficient corroborates the growth potential of new, creativity- and data-intensive occupations such as AI engineer, data analyst, and digital-transformation consultant. Conversely, the negative short-run coefficient for AIY indicates that routine and mid-skill jobs remain under automation pressure. Thus, the empirical evidence quantitatively confirms Schumpeter's "creative destruction" theory: employment losses materialise in the first phase, but AI-driven innovation compensates for them in the second. Remote/hybrid flexibility enhances crisis resilience. During the pandemic shock, 44 per cent of jobs were performed remotely; panel analysis demonstrates that increases in UHP support both productivity and employment, indicating that telework has transitioned from an emergency response to a lasting competitive advantage. Reskilling/upskilling is the critical balancing variable. The strong positive RUS coefficient confirms that continuous skill upgrading neutralises the employment pressure exerted by AI-intensive automation. Nevertheless, WEF data reveal a persistent gap between employer expectations (85 per cent deem R/U "critical") and employee access to training (50 per cent). Digital inclusion functions as a growth multiplier. Each point added to the Digital Adoption Index raises employment growth by 0.078 per cent, underscoring that infrastructure investment and affordable broadband access are priority, employment-friendly policies, especially in low- and middle-income countries.

In the context of recommendations for policymakers, it is necessary to establish national reskilling funds and to redesign digital-transformation incentives so that they encompass not only technological investment but also human-capital development. To broaden the access of small and medium-sized enterprises to finance, public–private regional skills funds should be activated; directing these resources by sector, according to the skill-mismatch index and the intensity of automation, will maximise their effectiveness. Expanding digital-access infrastructure will reduce employment inequalities—particularly in rural and low-income areas—while simultaneously maximising the potential of remote work. Inclusive social-protection and active-labour-market policies must be designed to offset the disproportionate effects of automation on women, young people and migrants; targeted income supports, micro-credits and tuition-free training vouchers will increase the resilience of these groups to the risks associated with digital transformation. Moreover, allocating a defined share of unemployment-insurance funds to individual learning-account models for micro-credential programmes will encourage lifelong learning. Green–digital synergy strategies that

combine clean-energy investments with AI-based energy-efficiency solutions possess the potential to support employment and sustainable-development objectives simultaneously.

With respect to enterprises and human-resources management, it is critical that AI-focused investments be designed according to a human-centred approach. In this regard, substitutionist tendencies in AI projects should be avoided, and the principle of augmentation should be adopted, such that human–machine collaboration is structured to optimise employee experience and productivity concurrently. "Tech–human balance" scorecards should be employed to monitor the returns on technology investment; performance improvement should be achieved through innovative task redesign rather than through dismissals. Institutionalising a flexible, hybrid work culture must likewise occupy a central place in HR policies. Remote-work ergonomics, digital-security protocols and psychosocial-support packages should become standard practice so as to safeguard worker well-being. Location-independent KPIs should be developed to ensure fair promotion and performance measurement in the hybrid model, thereby preventing opportunity disparities between on-site and remote staff. Finally, strengthening values-based leadership and socio-emotional competences is of paramount importance for balancing the potential adverse effects of AI-driven transformation. It is recommended that at least one-third of every corporate reskilling-upskilling portfolio be devoted to human competences—creativity, empathy, leadership and change management—because the findings show that investments in these areas are effective in compensating for employment losses that AI may cause.

Future research should first examine the interaction between digitalisation and employment in small and medium-sized enterprises by means of micro-panel data, thereby enhancing the generalisability of the present findings. In addition, integrating national tax records with social-insurance micro-data to monitor worker-level career transitions and skill transformations would provide more detailed insights into individual employment outcomes. Finally, the regional-development effects of AI–green synergy should be deepened through comparative case studies, enriching policy recommendations on the spatial dimensions of sustainable growth.

The pandemic accelerated digital transformation and reorganised labour markets along the axis of flexibility and competence. When supported by appropriate policy and organisational strategies, this transformation offers a window of opportunity for net employment growth and productivity gains; however, delays in reskilling-upskilling investment carry the potential to exacerbate skill mismatch and inequality. Hence, the post-pandemic period requires a development vision that is oriented not only towards technology but also towards human capital. A human-centred digitalisation model, supported by digital infrastructure, inclusive social protection and lifelong-learning measures, will constitute the key to competitiveness and social welfare in future labour markets.

REFERENCES

Akar, İ., & Meçik, O. (2021). Çalışma yaşamında yenilikler: Pandemi ile dijitalleşme deneyimi. *Journal of Life Economics, 8*(4), 403–411. https://doi.org/10.15637/jlecon.997589

Alauddin, F. D. A., Aman, A., Ghazali, M. F., & Daud, S. (2025). The influence of digital platforms on gig workers: A systematic literature review. *Heliyon, 11*(1), e41491. https://doi.org/10.1016/j.heliyon.2024.e41491

Aykaç, M., & Kaya, S. (2024). İşgücü piyasasında yaşanan dönüşümler: Standart dışı istihdam ve çalışan yoksulluğu ilişkisi. *Sosyoekonomi, 32*(62), 413–453. https://doi.org/10.17233/sosyoekonomi.2024.04.20

Battisti, E., Alfiero, S., & Leonidou, E. (2022). Remote working and digital transformation during the COVID-19 pandemic: Economic–financial impacts and psychological drivers for employees. *Journal of Business Research, 150*, 38–50. https://doi.org/10.1016/j.jbusres.2022.06.010

Cao, X., Zhang, D., & Huang, L. (2022). The impact of the COVID-19 pandemic on the behavior of online gig workers. *Manufacturing & Service Operations Management, 24*(5), 2611–2628. https://doi.org/10.1287/msom.2022.1113

Carnevale, J. B., & Hatak, I. (2020). Employee adjustment and well-being in the era of COVID-19: Implications for human resource management. *Journal of Business Research, 116*, 183–187. https://doi.org/10.1016/j.jbusres.2020.05.037

Chen, C., Wang, S., Yao, S., & Lin, Y. (2023). Does digital transformation increase labor income share? Evidence from a resource reallocation perspective. *Economic Modelling*, *128*, 106474. https://doi.org/10.1016/j.econmod.2023.106474

Cirillo, V., Mina, A., & Ricci, A. (2024). Digital technologies, labor market flows and training: Evidence from Italian employer–employee data. *Technological Forecasting and Social Change*, *209*, 123735. https://doi.org/10.1016/j.techfore.2024.123735

Çelen, A. İ. (2024). Dijital ekonomide işgücü piyasası: İşgücü talebinin vasıf boyutunda yine, yeni ve yeni baştan dönüşümü. *Biga İktisadi ve İdari Bilimler Fakültesi Dergisi, 5*(2), 130–145.

Dingel, J. I., & Neiman, B. (2020). How many jobs can be done at home? *Journal of Public Economics, 189*, 104235. https://doi.org/10.1016/j.jpubeco.2020.104235

Gathmann, C., Kagerl, C., Pohlan, L., & Roth, D. (2024). The pandemic push: Digital technologies and workforce adjustments. *Labour Economics, 89*, 102541. https://doi.org/10.1016/j.labeco.2024.102541

Gao, J., Li, Z., Nguyen, T., & Zhang, W. (2025). Digital transformation and enterprise employment. *International Review of Economics & Finance, 99*, 104036. https://doi.org/10.1016/j.iref.2025.104036

Gücenmez, T. (2023). Türkiye'de dijital dönüşümün iş gücü piyasalarına etkisi ve gelir dağılımı ilişkisi. *Kahramanmaraş Sütçü İmam Üniversitesi Sosyal Bilimler Dergisi*, *20*(3), 995–1005. https://doi.org/10.33437/ksusbd.1361092

Han, Y., Yang, J., Ying, L., & Niu, Y. (2024). The impact of corporate digital transformation on labor employment. *Finance Research Letters*, *60*, 104888. https://doi.org/10.1016/j.frl.2023.104888

Huang, Y. (2024). Digital transformation of enterprises: Job creation or job destruction? *Technological Forecasting and Social Change, 208*, 123733. https://doi.org/10.1016/j.techfore.2024.123733

Jahan, N., & Zhou, Y. (2023). Covid-19 and digital inclusion: Impact on employment. *Journal of Digital Economy, 2*, 190–203. https://doi.org/10.1016/j.jdec.2024.01.003

Li, W., Yang, X., & Yin, X. (2024). Digital transformation and labor upgrading. *Pacific-Basin Finance Journal, 83*, 102280. https://doi.org/10.1016/j.pacfin.2024.102280

Lu, Z., Wang, S., Ling, W., & Guo, Y. (2023). Gig work and mental health during the Covid-19 pandemic: A gendered examination of comparisons with regular employment and unemployment. *Social Science & Medicine, 337*, 116281. https://doi.org/10.1016/j.socscimed.2023.116281

McClure, P. K. (2018). "You're fired," says the robot: The rise of automation in the workplace, technophobes, and fears of unemployment. *Social Science Computer Review, 36*(2), 139–156. https://doi.org/10.1177/0894439317698637

Rusakova, T., & Saychenko, O. (2022). Virtual labor market during the COVID-19 pandemic and their impact on transport industry. *Transportation Research Procedia, 63*, 2021–2029. https://doi.org/10.1016/j.trpro.2022.06.225

Sarıipek, D. B., Cerev, G., & Ayhan, E. E. (2023). İşgücü piyasasında pandemi sonrası "yeni normal"; hibrit çalışma ve iş-yaşam dengesi. *İnsan ve İnsan, 10*(35), 11–27. https://doi.org/10.29224/insanveinsan.1189607

World Economic Forum. (2020). *The Future of Jobs Report 2020*. World Economic Forum. https://www.weforum.org/reports/the-future-of-jobs-report-2020/

World Economic Forum. (2023). *The Future of Jobs Report 2023*. World Economic Forum. https://www.weforum.org/reports/the-future-of-jobs-report-2023/

World Economic Forum. (2025). *The future of jobs report 2025*. World Economic Forum. https://www.weforum.org/reports/the-future-of-jobs-report-2025/