COLLECTION OF PAPERS
NEW ECONOMY
Volume 4, No. 1, 2026

ARTIFICIAL INTELLIGENCE, IT INFRASTRUCTURE AND CYBERSECURITY IN LABOUR MARKET TRANSFORMATION: BRIDGING THE GAP IN UNDERSTANDING DIGITAL INEQUALITY IN THE EUROPEAN UNION

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Received 16.02.2026. | Send to review 19.03.2026. | Accepted 03.08.2026.

Original Article

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JEL Classification: C23, J24, O33, O38

Doi: 10.61432/CPNE0401027l

UDK: 007.52:331.5.024.52(4672EU)

ABSTRACT

The rapid advancement of artificial intelligence (AI) is reshaping contemporary labour markets, generating both opportunities and challenges within the digital economy. Although existing research has widely examined the effects of AI on employment dynamics, less attention has been given to the combined role of IT infrastructure and cybersecurity in shaping digital inequality. This study addresses this gap by analysing how AI adoption, IT infrastructure quality, and cybersecurity readiness influence labour market transformation and digital disparities across European Union countries. Using panel data from Eurostat, OECD, DESI, and cybersecurity-related indicators for EU Member States, the study develops a multidimensional framework that links technological, institutional, and socioeconomic factors. The empirical findings suggest that AI adoption is positively associated with digital inequality. However, stronger IT infrastructure and higher cybersecurity readiness mitigate this effect through moderating interactions, supporting a more inclusive labour market transformation. The study contributes to the literature by integrating previously fragmented research streams and offering a broader understanding of inequality in the digital economy. The findings suggest that investments in digital infrastructure and cybersecurity should accompany AI-driven innovation to ensure a more equitable distribution of technological benefits. Effective digital transformation therefore requires coordinated strategies that combine technological advancement, digital inclusion, and cyber resilience.

Keywords: *artificial intelligence, digital inequality, labour market transformation, cybersecurity, digital infrastructure, European Union, digital transformation*

1. INTRODUCTION

The rapid advancement of digital technologies has fundamentally reshaped contemporary economies, positioning artificial intelligence (AI) as a key driver of economic and social transformation. AI-enabled automation and data-driven decision-making increasingly influence labour markets by changing skill requirements, employment structures, and productivity dynamics (Brynjolfsson, Rock, & Syverson, 2021; Acemoglu & Restrepo, 2020; Hunady et al., 2025). While these developments create new opportunities for innovation and economic growth, they also generate challenges related to labour market polarization, job displacement, and structural adjustment.

Alongside these changes, digital inequality has emerged as an important area of economic research, reflecting disparities in access to digital technologies, digital skills, and the ability to benefit from digital transformation (van Dijk, 2020; OECD, 2021). Recent studies emphasize that digital inequality extends beyond physical access to infrastructure, encompassing differences in digital competencies, effective technology use, and participation in the digital economy, thereby reinforcing broader socioeconomic disparities (van Dijk, 2020; OECD, 2021). Although the European Union has made considerable progress in digital integration, substantial differences remain across Member States in digital infrastructure, human capital, and technology adoption, as reflected in the Digital Economy and Society Index (European Commission, 2024).

Although a growing body of research examines AI-driven labour market transformation, most studies focus primarily on the direct effects of automation while paying limited attention to the broader technological and institutional environment. In particular, IT infrastructure, which enables digital participation and technology adoption, remains insufficiently incorporated into analyses of labour market outcomes (Aumeboonsuke & Caplanova, 2026). Similarly, cybersecurity has become an increasingly important, yet underexplored, determinant of digital transformation, influencing trust in digital systems and the resilience of economic structures (ENISA, 2023). The rapid diffusion of generative AI has introduced additional cybersecurity challenges related to data integrity, model manipulation, and trust in automated decision-making, with potential implications for organizational performance and labour market dynamics (Łazarski, 2026). Consequently, inadequate cybersecurity readiness may deepen digital exclusion by limiting secure access to digital services and increasing vulnerability to cyber threats.

These observations reveal an important research gap concerning the combined effects of AI adoption, IT infrastructure, and cybersecurity on labour market transformation and digital inequality. Existing studies typically analyse these dimensions separately, overlooking their interaction effects and the systemic mechanisms through which they shape digital disparities. This fragmentation limits understanding of the multidimensional nature of inequality across European Union countries.

Accordingly, this study develops an integrated analytical framework to examine how AI adoption, IT infrastructure, and cybersecurity jointly influence labour market transformation and digital inequality in the European Union. The study addresses the following research question:

How do technological and institutional factors jointly influence labour market outcomes and digital inequality in the digital economy?

The novelty of this research lies in integrating artificial intelligence, IT infrastructure, and cybersecurity within a single analytical framework explaining digital inequality. Unlike previous studies that examine these factors independently, this paper analyses both their direct and interaction effects using panel data from European Union Member States. By incorporating cybersecurity as both a technological and institutional determinant, the study extends existing research on labour market transformation and provides a more comprehensive explanation of the mechanisms underlying inclusive digital development.

Based on the theoretical framework and identified research gap, the following hypotheses are proposed:

H_1*: *Artificial intelligence adoption is positively associated with digital inequality in European Union countries.

H_2*: *Higher levels of IT infrastructure development are associated with lower levels of digital inequality.

H_3*: *Higher levels of cybersecurity readiness are associated with lower levels of digital inequality.

H_4*: *IT infrastructure moderates the relationship between artificial intelligence adoption and digital inequality by reducing the inequality-enhancing effects of AI.

H_5*: *Cybersecurity readiness moderates the relationship between artificial intelligence adoption and digital inequality by reducing the inequality-enhancing effects of AI.

These hypotheses assume that the effects of AI on labour market transformation and digital inequality depend on the technological and institutional environment in which digital technologies are implemented. Accordingly, IT infrastructure and cybersecurity are expected to exert both direct effects on digital inequality and moderating effects on the relationship between AI adoption and inequality.

This study makes four main contributions. First, it incorporates cybersecurity as a key dimension in the analysis of digital inequality. Second, it develops an integrated framework linking artificial intelligence, digital infrastructure, and cybersecurity within the context of labour market transformation. Third, it provides empirical evidence from panel data covering European Union Member States, contributing to the literature on the socioeconomic consequences of digital transformation. Finally, it offers policy implications for designing inclusive and resilient digital development strategies that reduce digital disparities while supporting technological innovation.

The remainder of the paper is organized as follows. Section 2 reviews the literature, Section 3 describes the methodology and data, Section 4 presents the empirical results, Section 5 discusses the findings, and Section 6 concludes.

2. LITERATURE REVIEW

Table 1. Summary of Key Literature

Author	Main focus	Key findings	Research gap
Acemoglu & Restrepo (2020)	Automation	Labour displacement	No cybersecurity
Brynjolfsson et al. (2021)	Productivity	Complementary investments	No digital inequality
van Dijk (2020)	Digital divide	Multidimensional inequality	No AI
ENISA (2023)	Cybersecurity	Digital resilience	No labour market analysis
OECD (2023)	AI and employment	Skills adaptation	No integrated model

Source: Own elaboration based on the reviewed literature

Table 1 summarizes the most influential studies on artificial intelligence, digital inequality, and cybersecurity, highlighting the fragmentation of existing research and the need for an integrated analytical framework.

The literature on artificial intelligence (AI), labour market transformation, and digital inequality has expanded rapidly, reflecting the growing role of digital technologies in economic development. Existing research shows that AI does not affect labour markets uniformly; rather, its effects depend on technological adoption, workforce skills, institutional capacity, and digital infrastructure. AI-driven automation is increasingly associated with changes in task composition rather than the direct replacement of human labour. Acemoglu and Restrepo (2020) argue that automation reduces demand for routine tasks while increasing the value of complementary human skills. Similarly, Autor (2022) emphasizes that technological change generates both displacement and augmentation effects, depending on the adaptability of workers, firms, and institutions. Consequently, AI reshapes labour markets by increasing demand for analytical, digital, and problem-solving competencies.

The productivity gains associated with AI are also contingent upon complementary investments. Brynjolfsson, Rock, and Syverson (2021) argue that general-purpose technologies require organizational change, human capital development, and digital capabilities to generate substantial economic benefits. Likewise, Bessen (2018) highlights that AI adoption may create new employment opportunities through demand-side effects that offset automation-related job displacement. Agrawal, Gans, and Goldfarb (2022) further argue that AI should be viewed not only as an automation technology but also as a prediction-enhancing mechanism that transforms organizational decision-making. However, inadequate digital infrastructure may limit the ability of workers and firms to realize these benefits.

Digital inequality represents another important strand of the literature. Rather than focusing solely on access to digital technologies, van Dijk (2020) conceptualizes the digital divide as a multidimensional phenomenon encompassing access, digital skills, usage, and socioeconomic outcomes. This perspective is particularly relevant in the context of AI, where disparities increasingly reflect differences in the ability to use advanced technologies effectively. Consequently, digital inequality should be understood not only as a technological issue but also as a labour market and social policy challenge.

Institutional evidence supports these findings. The European Commission (2024) reports persistent disparities across European Union Member States in digital infrastructure, human capital, and business digitalization, while Eurostat (2025) documents significant differences in ICT use across households, individuals, and regions. These disparities influence the capacity of workers and firms to adapt to AI-driven labour market changes, making digital inequality both a cause and a consequence of technological transformation (Seisenbekov et al., 2026).

Compared with AI and digital infrastructure, cybersecurity remains relatively underexplored in the socioeconomic literature. ENISA (2023) identifies cyber threats as a major challenge to trust, resilience, and the security of digital systems. As labour markets increasingly rely on online platforms, cloud computing, data exchange, and AI-based decision-making, cybersecurity readiness becomes an essential prerequisite for digital participation. Łazarski (2026) argues that generative AI introduces additional risks related to data integrity, model manipulation, and organizational risk management, potentially affecting both firms and workers. Weak cyber resilience may therefore reduce trust in digital services, discourage technology adoption, and deepen digital exclusion.

Labour market institutions and skills policies further shape the impact of AI. OECD (2023) emphasizes that productivity gains depend on workers' ability to adapt to evolving skill requirements. Similarly, the World Economic Forum (2023) and Cedefop (2023) highlight the growing importance of digital and transversal skills, while the International Labour Organization (2021) notes that digital labour platforms create new employment opportunities but also raise concerns regarding job quality, security, and inclusion. Together, these findings suggest that AI-driven labour market transformation should be analysed alongside education, reskilling, and institutional support.

Despite growing interest in cybersecurity, empirical evidence linking cybersecurity readiness directly to digital inequality remains limited, particularly in comparative studies of European Union Member States. Most existing research focuses on technical or organizational aspects of cybersecurity, with limited attention to its broader socioeconomic implications.

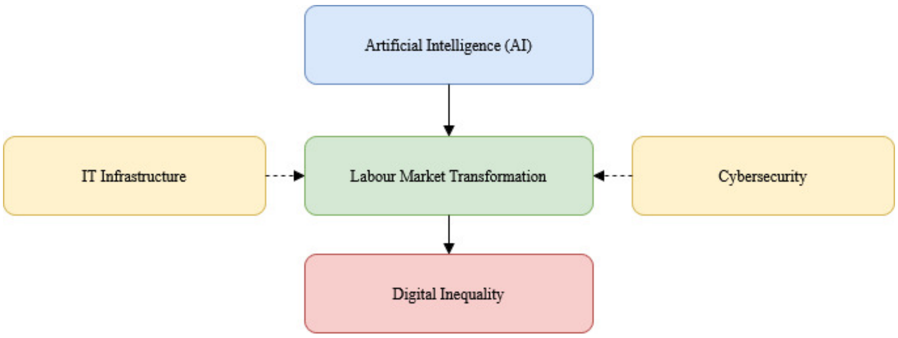
The literature also offers contrasting views regarding the distributional consequences of AI adoption. Some studies emphasize productivity growth and employment creation through technological complementarity (Brynjolfsson et al., 2021; Bessen, 2018), whereas others highlight labour market polarization and unequal access to technological opportunities (Acemoglu & Restrepo, 2020; Autor, 2022). These differing perspectives suggest that the effects of AI depend on contextual factors, particularly digital infrastructure and institutional readiness.

Overall, the literature demonstrates that AI, digital infrastructure, cybersecurity, and digital inequality are closely interconnected. However, these dimensions are typically analysed independently. Studies on AI primarily focus on automation and skills, research on digital inequality emphasizes access and competencies, and cybersecurity is generally examined from technical or organizational perspectives. This fragmentation limits understanding of how these factors jointly shape labour market transformation and digital inequality within the European Union.

The reviewed studies indicate that AI may widen digital disparities when technological benefits are concentrated among digitally advantaged groups, whereas digital infrastructure and cybersecurity function as enabling conditions that promote broader participation in the digital economy. These findings provide the theoretical basis for the hypotheses concerning the direct and moderating effects of IT infrastructure and cybersecurity readiness. To the best of the author's knowledge, no previous study has simultaneously examined these relationships using panel data covering all European Union Member States.

Accordingly, this study adopts an integrated perspective, assuming that the labour market effects of AI are conditioned by the quality of IT infrastructure and the level of cybersecurity readiness. Digital inequality is therefore conceptualized as a multidimensional outcome shaped by technological, institutional, and socioeconomic factors. The conceptual framework is presented in Figure 1 and illustrates how IT infrastructure and cybersecurity readiness condition the relationship between AI adoption and digital inequality.

Figure 1. Conceptual framework linking artificial intelligence, IT infrastructure, cybersecurity, labour market transformation, and digital inequality



Source: own elaboration based on Acemoglu and Restrepo (2020), Brynjolfsson et al. (2021), OECD (2023), and ENISA (2023)

The framework assumes that artificial intelligence directly affects digital inequality through its influence on labour market transformation. Simultaneously, IT infrastructure and cybersecurity readiness exert both direct effects on digital inequality and indirect moderating effects by shaping the conditions under which AI-related technologies are adopted and utilized.

3. METHODOLOGY

3.1. RESEARCH DESIGN

This study employs a quantitative research design to examine the relationships among artificial intelligence (AI), IT infrastructure, cybersecurity, labour market transformation, and digital inequality in the European Union. A panel data approach is applied, enabling the analysis of cross-country heterogeneity and temporal dynamics. This methodological choice is consistent with prior empirical studies on technological change and labour market outcomes (Acemoglu & Restrepo, 2020; Brynjolfsson et al., 2021).

The analysis is grounded in the conceptual framework presented in Figure 1, which assumes that AI affects labour market transformation, while IT infrastructure and cybersecurity operate as enabling and moderating factors. Digital inequality is treated as the dependent outcome, reflecting disparities in access to digital technologies, digital skills, and participation in the digital economy.

The empirical analysis relies on secondary data obtained from several international databases, including Eurostat for labour market indicators, ICT usage, and digital skills; the European Commission's DESI database for digital infrastructure, human capital, and digitalisation indicators; OECD sources for AI adoption, employment structure, and skills; and ENISA indicators for cybersecurity readiness and the cyber-risk environment.

The dataset comprises annual observations for the 27 Member States of the European Union over the period 2016-2023, resulting in a maximum of 216 country-year observations. The panel is treated as balanced where data availability permits. This period captures both the gradual diffusion of AI technologies and the more recent acceleration associated with advances in machine learning and generative AI.

Prior to estimation, missing observations were systematically assessed to ensure data consistency. Where missing values were limited and occurred within continuous time series, linear interpolation was applied. Variables with substantial missingness were excluded from the final specification to reduce the risk of estimation bias.

The use of panel data enables the study to account for both cross-country differences and changes over time in digital transformation processes. It also allows for the control of unobserved country-specific heterogeneity that may influence labour market outcomes and digital inequality. The selected period provides sufficient temporal variation for panel estimation, while the use of harmonised international data sources enhances the reliability, comparability, and consistency of the empirical analysis.

Table 2 presents the structure of the dataset and the main characteristics of the sample.

Table 2. Structure of the Panel Dataset

Item	Value
Geographical coverage	EU-27 Member States
Period	2016-2023
Number of countries	27
Number of years	8
Observations	216
Panel structure	Balanced panel
Data sources	Eurostat, OECD, DESI, ENISA
Missing data treatment	Linear interpolation and listwise exclusion

Source: Own elaboration

3.2. VARIABLES AND MEASUREMENT

Digital inequality (DI) is operationalised as a composite index that captures disparities in digital access, digital skills, and participation in the digital economy. Following the multidimensional approach proposed by van Dijk (2020) and recent OECD recommendations, the index incorporates indicators across three core dimensions of digital inclusion.

The access dimension includes the percentage of households with internet access and broadband coverage. The skills dimension comprises the share of individuals with at least basic digital skills and the share of ICT specialists in total employment. The usage dimension captures the percentage of individuals regularly using online public services and the percentage engaged in online transactions.

All indicators were normalised using min-max transformation:

$$X_{norm} = \frac{X_i - X_{min}}{X_{max} - X_{min}} \tag{1}$$

The Digital Inequality Index was subsequently calculated as the arithmetic mean of the normalized indicators:

$$DI^* = \frac{1}{n}\sum_{j=1}^{n} x_j \tag{2}$$

To facilitate interpretation, the Digital Inequality Index (DI) was subsequently defined as:

$$DI = 1 - DI^* \tag{3}$$

Consequently, higher values of DI indicate higher levels of digital inequality, whereas lower values indicate higher levels of digital inclusion.

All indicators included in the Digital Inequality Index received equal weights. Following normalization, the composite index was calculated using arithmetic averaging, consistent with previous studies on multidimensional measures of digital inclusion.

Table 3. Variables and Operationalization

Variable	Description	Source
DI	Composite Digital Inequality Index	Eurostat, DESI
AI	Share of enterprises using AI technologies	OECD, Eurostat
ITI	Composite IT Infrastructure Index	DESI
CYB	Cybersecurity Readiness Index	ENISA
GDPpc	GDP per capita (PPP)	Eurostat
EDU	Tertiary education attainment	Eurostat
EMP	Employment rate	Eurostat

Source: Own elaboration based on Eurostat, OECD, DESI and ENISA

Table 4. Construction of Composite Indices

Index	Components	Source
DI	Internet access, broadband coverage, digital skills, ICT specialists, e-government use, online transactions	Eurostat, DESI
ITI	Broadband coverage, VHCN coverage, internet quality, connectivity	DESI
CYB	Cybersecurity strategy, preparedness, resilience, incident response	ENISA

Source: Own elaboration based on Eurostat, DESI and ENISA

The IT Infrastructure Index (ITI) is constructed using indicators related to fixed broadband coverage, very high-capacity network availability, internet speed, and household connectivity. Following the methodology applied in the Digital Economy and Society Index (DESI), all indicators are normalised using min-max transformation and aggregated into a composite index ranging from 0 to 1. Higher values indicate more advanced digital infrastructure development.

AI adoption (AI) is measured as the percentage of enterprises using at least one artificial intelligence technology, including machine learning, natural language processing, computer vision, and intelligent automation systems. The indicator is derived from OECD and Eurostat databases and reflects the diffusion of AI technologies across national economies. It is intended to capture the extent to which AI-based solutions contribute to structural changes in labour markets and economic activity.

Cybersecurity readiness (CYB) is operationalised as a composite index based on publicly available ENISA indicators covering national cybersecurity strategies, incident response capabilities, cyber resilience mechanisms and institutional preparedness. To ensure cross-country comparability, the indicators are harmonised, normalised using min-max transformation, and aggregated into a single index ranging from 0 to 1. Higher values represent stronger cybersecurity readiness.

The model incorporates IT infrastructure and cybersecurity as key moderating variables, reflecting the enabling conditions of digital transformation. IT infrastructure captures the availability and quality of digital connectivity, while cybersecurity reflects institutional capacity to manage digital risks and ensure trust in digital systems. These dimensions are particularly relevant given the increasing reliance on digital technologies in economic and labour market activities.

A set of control variables is also included to account for broader socioeconomic factors that may influence digital inequality. These controls capture differences in economic development, educational attainment, labour market conditions, and structural characteristics of national economies. Their inclusion allows the model to better isolate the effects of AI adoption, IT infrastructure, and cybersecurity readiness on digital inequality.

3.3. MODEL SPECIFICATION

The empirical analysis employs a panel data regression framework to examine the relationships between artificial intelligence, IT infrastructure, cybersecurity readiness, and digital inequality across European Union countries. The model assumes that digital inequality is shaped not only by technological adoption but also by the institutional and infrastructural conditions under which digital technologies are implemented. In this context, AI is expected to influence labour market structures and access to digital opportunities, while IT infrastructure and cybersecurity readiness may condition the magnitude and direction of these effects.

To capture these mechanisms, the model includes both direct effects and interaction terms. The interaction terms assess whether the relationship between AI adoption and digital inequality varies according to the level of IT infrastructure development and cybersecurity readiness. This specification reflects the assumption that the socioeconomic effects of technology are context-dependent rather than uniform across countries. Control variables capturing macroeconomic and structural characteristics, including income levels, education, and labour market conditions, are incorporated to reduce omitted variable bias and improve the robustness of the estimates.

A panel data approach is applied to account for unobserved heterogeneity across countries and over time. Country-specific effects capture time-invariant structural differences among Member States, while time effects control for common shocks affecting all countries in a given year. The model is estimated using both fixed-effects and random-effects specifications, with the preferred specification selected on the basis of standard diagnostic tests.

To determine the most appropriate estimation approach, both fixed-effects (FE) and random-effects (RE) models were estimated. Both fixed-effects and random-effects specifications were considered. Given the objective of controlling for unobserved country-specific heterogeneity, the fixed-effects model was adopted as the primary estimation approach.

Robust standard errors clustered at the country level were used to address potential heteroskedasticity and serial correlation.

Description of variables used in the model:

- level of digital inequality in country i at time t,
- level of artificial intelligence adoption,
- quality of IT infrastructure,
- cybersecurity readiness,
- interaction terms capturing moderating effects,
- vector of control variables (macroeconomic and structural factors),
- unobserved country-specific effects,
- time-fixed effects,
- stochastic error term.

3.4. DIAGNOSTIC AND ROBUSTNESS PROCEDURES

Potential multicollinearity was assessed using the correlation matrix. All pairwise correlation coefficients remained below the commonly accepted threshold of 0.80, suggesting that multicollinearity was unlikely to affect the estimation results. Furthermore, the consistency of coefficient signs and significance levels across model specifications indicates that the main findings are robust.

4. RESULTS

4.1. DESCRIPTIVE STATISTICS

Table 5. Descriptive statistics

Variable	Mean	Std. Dev.	Min	Max
DI	0.54	0.18	0.21	0.89
AI	0.37	0.15	0.1	0.72
ITI	0.68	0.14	0.35	0.92
CYB	0.61	0.16	0.28	0.88
GDP per capita	32.4	12.6	8.5	78.3
Education	0.42	0.09	0.21	0.65
Employment rate	0.69	0.08	0.52	0.82

Source: own elaboration based on Eurostat, OECD, and DESI data

Table 5 reports the descriptive statistics for the main variables included in the analysis. The results reveal substantial variation across European Union countries in digital inequality, AI adoption, IT infrastructure, and cybersecurity readiness. The relatively high standard deviation of digital inequality indicates persistent cross-country disparities in digital access, skills, and participation. AI adoption also displays considerable variation, reflecting differences in technological diffusion, firm-level digitalisation and economic development across Member States.

The IT infrastructure indicators suggest that, although some countries have achieved advanced levels of connectivity and digital readiness, others continue to lag behind. Cybersecurity readiness likewise varies notably across the sample, indicating differences in institutional capacity, cyber resilience, and exposure to digital risks.

4.2. CORRELATION ANALYSIS

Table 6. Correlation matrix

Variable	DI	AI	ITI	CYB
DI	1	-	-	-
AI	0.214	1	-	-
ITI	-0.482	0.356	1	-
CYB	-0.401	0.298	0.522	1

Source: own elaboration

Table 6 presents the pairwise correlation coefficients among the variables. The results indicate a negative correlation between IT infrastructure and digital inequality, suggesting that higher levels of connectivity are associated with lower disparities in digital access, skills, and participation. A similar negative association is observed between cybersecurity readiness and digital inequality. Moreover, all correlation coefficients remain below the commonly accepted threshold of 0.80, indicating no evidence of severe multicollinearity among the explanatory variables.

The relationship between AI adoption and digital inequality appears more complex. Although AI adoption is positively correlated with economic development, its direct association with digital inequality is less clear, suggesting that its effects may be conditional on moderating factors such as IT infrastructure and cybersecurity readiness.

4.3. REGRESSION RESULTS

Table 7. Panel regression results (Fixed Effects)

Variable	Coefficient	Std. Error	p-value
AI	0.215	0.082	0.011
ITI	-0.342	0.095	0.002
CYB	-0.198	0.073	0.008
AI x ITI	-0.156	0.067	0.019
AI x CYB	-0.121	0.059	0.041
Observations	216	-	-
R-squared	0.62	-	-

Source: own elaboration

Table 7 presents the results of the panel regression analysis.

The fixed-effects specification was retained as the primary model, as it controls for unobserved country-specific characteristics that may influence digital inequality. The model explains approximately 62% of the variation in digital inequality across countries and over time ($R^2 = 0.62$).

The results indicate that artificial intelligence has a positive and statistically significant effect on digital inequality. This suggests that, in the absence of adequate supporting conditions, greater AI adoption may intensify digital disparities. IT infrastructure shows a negative and statistically significant coefficient, indicating that improvements in digital connectivity and infrastructure contribute to reducing digital inequality. This finding confirms the importance of technological accessibility for inclusive digital transformation.

Cybersecurity readiness also has a negative and statistically significant effect on digital inequality, suggesting that stronger cybersecurity frameworks enhance trust in digital systems and facilitate broader participation in the digital economy.

The interaction terms provide further evidence of conditional effects. The interaction between AI and IT infrastructure is negative and statistically significant, indicating that the inequality-enhancing effect of AI is weaker in countries with more developed digital infrastructure. Similarly, the interaction between AI and cybersecurity readiness is negative, suggesting that stronger cybersecurity capacity mitigates the adverse distributional effects of AI adoption.

Overall, the findings confirm that the impact of artificial intelligence on labour market outcomes and digital inequality depends on the quality of IT infrastructure and the level of cybersecurity readiness. The empirical results support all five research hypotheses. AI adoption is positively associated with digital inequality (H_1), whereas IT infrastructure (H_2) and cybersecurity readiness (H_3) reduce digital inequality. In addition, the negative and statistically significant interaction effects support the moderating roles of IT infrastructure (H_4) and cybersecurity readiness (H_5).

Table 8. Hypotheses verification

Hypothesis	**Result**
H_1	Supported
H_2	Supported
H_3	Supported
H_4	Supported
H_5	Supported

Source: own elaboration

As reported in Table 8, all proposed hypotheses are empirically supported. The findings confirm the direct effects of artificial intelligence, IT infrastructure, and cybersecurity readiness on digital inequality, as well as the moderating roles of IT infrastructure and cybersecurity in the relationship between AI adoption and digital inequality.

Overall, the results are consistent with the proposed theoretical framework. AI adoption is positively associated with digital inequality, whereas IT infrastructure and cybersecurity readiness significantly reduce digital disparities. Moreover, the negative and statistically significant interaction effects indicate that both factors mitigate the inequality-enhancing impact of AI adoption. These findings suggest that the socioeconomic consequences of artificial intelligence are contingent upon the broader technological and institutional environment.

4.4. ROBUSTNESS CHECKS

To assess the robustness of the results, alternative model specifications were estimated, including models excluding selected control variables and models without interaction terms. The results remained qualitatively consistent across specifications. The stability of coefficient signs and significance levels indicates that the main findings are robust to alternative model formulations.

5. DISCUSSION

The findings provide empirical support for all five hypotheses and offer important insights into the relationship between artificial intelligence, IT infrastructure, cybersecurity, and digital inequality in the European Union. They confirm that the effects of AI on labour market transformation are not uniform, but depend on the technological and institutional environment in which AI is adopted.

The positive and statistically significant effect of AI on digital inequality suggests that, without adequate supporting conditions, technological advancement may intensify existing disparities. This result is consistent with studies showing that the benefits of technological change are unevenly distributed across individuals, regions, and sectors (Acemoglu & Restrepo, 2020; Autor, 2022). Workers with stronger digital skills and better access to advanced technologies are more likely to benefit from AI-driven change, while others may face greater risks of exclusion. This supports the view that digital inequality concerns not only access, but also capabilities, effective use, and adaptability (van Dijk, 2020; OECD, 2021).

The negative coefficients for IT infrastructure and cybersecurity readiness highlight their role in reducing digital inequality. Improved infrastructure expands access to high-quality connectivity and digital services, enabling wider participation in the digital economy. This finding is consistent with the view that infrastructure is a prerequisite for inclusive digital transformation (OECD, 2021; European Commission, 2024; Ha et al., 2026). Similarly, cybersecurity readiness appears to reduce inequality by strengthening trust in digital systems and protecting users from digital risks. This supports the argument that cybersecurity is not merely a technical issue, but also a socioeconomic factor shaping participation in digital environments (ENISA, 2023; Łazarski, 2026).

The interaction effects further confirm the conditional nature of AI-related outcomes. The negative interaction between AI and IT infrastructure indicates that the inequality-enhancing effect of AI is weaker in countries with more developed digital infrastructure. In such contexts, individuals and firms are better positioned to adopt and use advanced technologies, supporting more inclusive labour market outcomes. Similarly, the moderating effect of cybersecurity suggests that stronger cyber resilience mitigates the risks associated with AI adoption and facilitates more equitable participation in the digital economy.

These findings contribute to the literature by integrating previously fragmented research streams. While earlier studies have examined AI-driven labour market change or digital inequality separately, this study demonstrates that these phenomena are closely interconnected. It highlights the importance of analysing both technological and institutional conditions when assessing the distributional effects of digital transformation.

From a policy perspective, the results suggest that AI-driven economic growth should be accompanied by sustained investment in digital infrastructure and cybersecurity. Without such support, AI adoption may reinforce existing inequalities and limit the inclusive potential of technological innovation. Policymakers should therefore adopt a comprehensive approach that combines technological development with digital skills policies, broader access to digital resources, and stronger cyber resilience. Such an approach is essential for ensuring that labour market digitalisation contributes to inclusive and sustainable economic development.

Despite its contributions, the study has several limitations. The analysis relies on aggregate country-level data, which may not fully capture within-country disparities or sector-specific dynamics. In addition, the measurement of AI adoption and cybersecurity readiness is constrained by data availability and the use of proxy indicators. Future research could address these limitations by using micro-level data, examining sectoral differences, and incorporating more refined measures of technological adoption and cyber risk.

6. CONCLUSION

This study examined the relationship between artificial intelligence, IT infrastructure, cybersecurity, and digital inequality in the context of labour market transformation in the European Union. Using an integrated analytical framework and panel data analysis, it addressed a gap in the literature, where these dimensions have often been studied separately.The findings indicate that artificial intelligence is positively associated with digital inequality, suggesting that AI adoption may intensify existing disparities when adequate support systems are lacking. However, IT infrastructure and cybersecurity appear to mitigate these effects. Strong digital infrastructure improves access to digital resources and participation in the digital economy, while robust cybersecurity enhances trust and reduces exposure to cyber risks. The results also show that the effect of artificial intelligence on digital inequality depends on levels of infrastructure and cybersecurity readiness. This highlights the importance of considering the broader institutional and structural context of digital transformation. The study contributes by integrating technological, infrastructural, and institutional factors into a single framework, emphasizing cybersecurity as a key dimension of digital inequality, and providing empirical evidence from the European Union. From a policy perspective, the findings suggest that AI-driven growth should be supported by investments in connectivity, digital skills, and cyber resilience. Coordinated policies are needed to promote innovation while advancing digital inclusion and institutional capacity. The study is limited by its reliance on aggregated country-level data and proxy indicators for artificial intelligence and cybersecurity. Future research could use more granular data, examine sector-specific dynamics, and assess long-term labour market effects. Overall, the study shows that the relationship between artificial intelligence and digital inequality is complex and context-dependent. Inclusive digital transformation requires technological advancement alongside strong infrastructure, cybersecurity, and effective public policy.

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