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Digital Economic Transformation, Employment Dynamics, and Gender Inclusion: Empirical Analysis of Wage Labor Participation Across Networked Economies

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Abstract

The intensification of digital transformation and the diffusion of technology-enabled business models have generated significant structural shifts in national labour markets. This article provides a cross-country empirical assessment of how digital economic development affects employment levels and women's participation in wage labour. The study operationalises the concept of digital advancement through the Network Readiness Index (NRI), enterprise-level application of internet platforms for commercial activities, and deployment of information and communication technologies (ICT) for inter-firm transactions. Labour-market outcomes are assessed using the employment-to-population ratio and the female-to-male wage-employment ratio.

Analytical results based on a sample of multiple economies demonstrate that countries with higher degrees of ICT integration into transactional operations tend to exhibit higher overall employment rates. Furthermore, structural inclusiveness appears stronger in more digitally prepared economies: higher NRI scores are shown to correspond with improved gender balance in wage employment. The findings indicate that digital-platform ecosystems, remote work mechanisms, and ICT-based professional services create labour-market entry pathways for previously underrepresented groups, particularly women. However, several country-specific deviations reveal that digital readiness does not function as an isolated determinant. Institutional constraints, demographic conditions, cultural norms, labour regulations, and skill asymmetries mediate these relationships. The study highlights that digitalisation constitutes an enabling rather than automatic mechanism of labour-market improvement. The implications of this research contribute to policy directions in digital-economy planning, women's labour integration strategies, and human-capital formation within technology-driven economies.

Keywords

Digital economy; wage employment; labour-market transformation; Network Readiness Index; information and communication technologies; gender employment dynamics; digital inclusion; workforce restructuring; digital platforms; comparative economic analysis.

Introduction

The rapid expansion of information and communication technologies (ICT) and their broad integration into economic processes have significantly accelerated the development of the digital economy. The digital economy is fundamentally characterised by the substantial utilisation of ICT in economic interactions. Modern digital transformation is shaped by advanced technologies such as Big Data, Cloud Computing, 3D Printing, the Internet of Things, Artificial Intelligence, and advanced robotics (UNCTAD, 2017, p. 4).

According to the U.S. Bureau of Economic Analysis, the digital economy encompasses three core components:

1. The infrastructure enabling digital networks,
2. Digital transactions, including e-commerce, and
3. Digitally created and accessible content, including digital media (BEA, 2018, p. 7).

Over the past decade, global indicators of digitalisation have demonstrated notable growth. International exports of ICT-related services and digitally deliverable services have risen significantly faster than total service exports. In 2018, digitally deliverable services accounted for approximately 50% of global service exports. Furthermore, digital platforms now play a transformative role in global markets: the aggregated value of companies with a market capitalisation above USD 100 million exceeded USD 7 trillion in 2017, reflecting a 67% increase compared to 2015 (UNCTAD, 2019, p. 6).

However, alongside these developments, increasing concern has emerged regarding transformations occurring in the labour market. Researchers continue to debate whether digitalisation may reduce employment levels or reshape employment structures; whether automation will displace workers; and whether digitalisation can contribute to enhanced labour market inclusion for women.

In this context, the present study aims to analyse how digital economic development influences:

- overall employment (employment rate among the working-age population);
- women's participation in wage employment (ratio of female to male wage workers).

The study applies comparative country-level indicators to reveal statistical patterns and validate assumptions concerning labour distribution under conditions of digital transformation.

Literature Review

Considerable academic attention has been devoted to analysing how digitalisation shapes labour markets, employment patterns, and occupational restructuring. International organisations, including UNCTAD, OECD, ILO, and the World Bank, increasingly highlight that digitalisation creates dual effects—opportunities and risks—depending on sectoral structures and country-specific socio-economic conditions.

According to United Nations Conference on Trade and Development reports, digitalisation generates multiple benefits for labour markets. These include:

- the emergence of new forms of employment and digitally oriented professions;
- opportunities for labour participation of individuals with physical limitations or restricted mobility;
- reduction of geographic barriers through digital platforms and remote work mechanisms.

At the same time, potential risks are emphasised:

- intensified competition among workers through global labour platforms,
- substitution of labour through automation,
- disappearance of routine-based occupations, and
- rising labour market inequality (UNCTAD, 2017, pp. 61–63).

Sector-specific impacts of digitalisation are analysed in the work of Degryse (2016), who argues that digital transformation will exert heterogeneous effects across professional domains. Skilled, knowledge-intensive sectors such as fintech, ICT services, engineering and software development will likely gain employment, while sectors based on routine functions will face substantial job displacement.

Further findings from empirical studies indicate that the introduction of industrial robotics enhances productivity, expands demand for highly qualified workers, and generates job opportunities in analytics, programming, cybersecurity, and platform management.

Conversely, demand diminishes in occupations requiring routine manual or cognitive tasks, such as cashiering, routine accounting, auditing, and clerical activities (Chinoracky & Corejova, 2019).

These outcomes suggest that the digital economy does not simply reduce employment; rather, it results in structural transformation of employment, altering gender participation patterns. Digital work ecosystems, remote work platforms, online marketplaces, and flexible digital services potentially strengthen female labour market integration by reducing time-related constraints, household-work conflicts, and mobility barriers.

Expanded Significance of the Study

This study contributes to existing literature by demonstrating measurable relationships between women's wage employment levels and digital readiness indicators across countries. While much research highlights technological changes qualitatively, there are fewer studies comparing quantitative outcomes through international metrics such as NRI. The findings presented here have meaningful policy implications:

- For labour market regulators: they demonstrate the need for digital skill training and gender-oriented education programmes.
- For developing economies: they highlight the importance of accelerating ICT adaptation measures.
- For gender equality institutions: evidence suggests that digitalisation may act as a corrective mechanism narrowing gender-based employment disparities.

The results reinforce that gender-sensitive digital policies—remote employment strategies, flexible digital workspaces, and targeted digital literacy initiatives—are essential for strengthening inclusive labour market participation.

A number of studies have examined how ICT usage—particularly the active integration of digital tools into economic processes, which stimulates digital-economy growth—influences employment levels. One such contribution is Kenneth Rogoff's article *"The Impact of Technology on Employment"*, where the author argues that although many businesses attempt to replace workers with robots once their revenues increase, and although widespread use of online purchasing may negatively affect employment in traditional retail sectors, market economies historically display high adaptability and flexibility, enabling them to avoid long-term adverse labour-market consequences (Rogoff, 2012). Similarly, in one of its flagship reports, the World Economic Forum emphasises that the effects of digitalisation and ICT diffusion on employment are largely dependent on the adequacy of regulatory mechanisms guiding technological transformation. If transformation processes are regulated effectively, digitalisation can facilitate the emergence of new professions and job segments, improve living standards, and expand labour inclusion. Conversely, insufficient regulation increases the risks of widening inequality, skills mismatch, and structural exclusion from labour markets (WEF, 2018a, p. vii).

Opportunities for improving women's labour-force participation in the era of digitalisation are addressed in the study *"Labour-Market Opportunities for Women in the Digital Age."* The authors suggest that digitalisation enables women to enter new occupational niches, including platform-based employment, remote work, and flexible earning systems. At the same time, the study highlights that such opportunities cannot materialise fully unless structural barriers preventing women's equal labour participation are eliminated—particularly in developing and transition economies (Krieger-Boden & Sorgner, 2018).

The Organisation for Economic Co-operation and Development (OECD) also identifies digitalisation as a potentially inclusive transformation mechanism. According to its analytical report, digital tools and platforms significantly expand women's access to knowledge resources, skills acquisition opportunities, and flexible employment arrangements. Through platform-based work systems, women may participate in the labour market without facing rigid time schedules, territorial restrictions, or mobility constraints, thereby improving female employment levels in digitally enabled sectors (OECD, 2018, p. 6).

Comparable observations are made in the publication titled *"Digital Jobs for Youth: Young Women in the Digital Economy"* released by Solutions for Youth Employment. The report stresses that digital occupations enable young women to bypass long-standing social and economic barriers that restrict their integration into labour markets. The inherent flexibility of digital employment allows women to combine family obligations with paid labour activities, thus supporting work-life balance and labour continuity (SYE, 2018, p. 12).

In 2016, the World Bank launched a pilot capacity-building initiative entitled "Women in Online Work." The programme targeted 100 young women (under the age of 25), providing them with digital skill training in areas relevant to online labour markets. Three months after completion, programme participants were earning twice the average hourly wage, and a number of trainees proceeded to establish independent micro-enterprises, employing other young women and multiplying economic spillovers (World Bank, 2018). This exemplifies the transformative potential of digital competencies in accelerating women's economic empowerment.

Methodology

To achieve the research objective, a cross-country comparative analysis was conducted to determine relationships among selected indicators. To represent the level of digital-economy development, the study employs the Network Readiness Index (NRI), which measures a country's preparedness to develop digital platforms and sustain digital economic activity. The index captures the enabling environment for ICT development, the readiness of economic actors to use digital technologies, and actual ICT adoption levels.

In addition to the composite NRI, two operational ICT deployment indicators are used:

1. Enterprise use of the internet for commercial transactions with consumers (*business-to-consumer ICT application*), and

2. Enterprise use of ICT systems for transactions with other firms (*business-to-business ICT application*).

Both of these indicators constitute integral components of the NRI and directly express the degree to which digital technologies are used within economic processes. Higher values reflect higher operational digitalisation and a stronger digital-economic environment. These values range from 1 to 7, where 7 represents the optimal level (WEF, 2016). Alongside measures of digital-economy maturity, labour-market indicators were incorporated. Specifically:

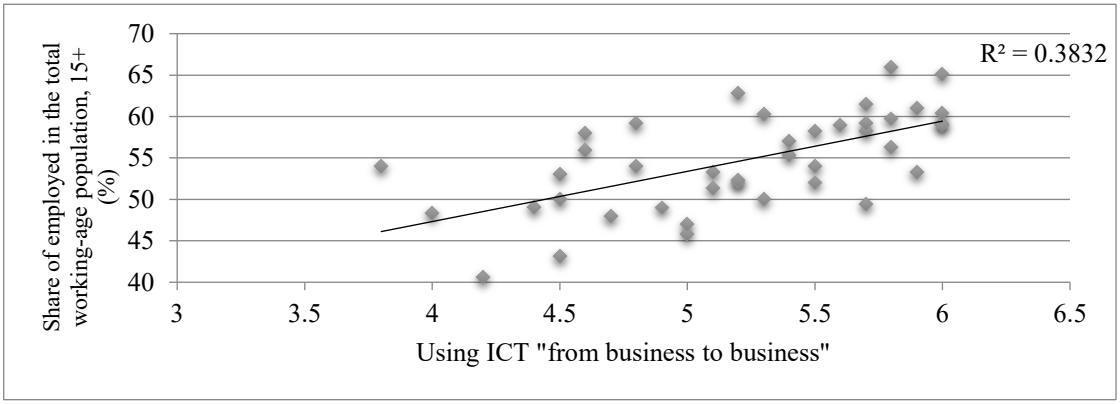
1. The employment-to-population ratio, as calculated by the World Bank, reflecting the share of employed persons within total working-age population (World Bank, 2016), and
2. The ratio of women employed in wage labour (age 15+) to men employed in wage labour (age 15+), calculated by the World Economic Forum.

The methodological rule is straightforward: when this ratio equals 1, men and women participate in wage employment at equal levels. Values below 1 indicate underrepresentation of women in wage employment (WEF, 2018b).

Because earlier versions of the female-labour-participation metric included both employed and unemployed women actively searching for work, this study uses 2017 data, which specifically isolate women participating as wage employees.

Fig. 1. ICT usage by businesses for transactions with other businesses (score) and the share of employed in the total working-age population (%), group of countries studied (41 countries)

Sources: WEF, 2016; World Bank, 2016.



ICT Usage Indicators and Employment Rates

The level of digital-economy development is frequently evaluated by examining the degree to which firms implement ICT technologies for inter-enterprise transactions (B2B) and digital channels for selling goods and services to final consumers (B2C). Countries with high operational-level ICT utilisation demonstrate stronger integration of digital systems across organisational activities. Greater ICT intensity suggests greater maturity of digital economic environments, where digitalisation influences transaction mechanisms, business models, and operational productivity.

Empirical comparison shows that nations where enterprises widely apply ICT for business-to-business exchanges and actively use digital channels for commerce exhibit, on average, higher employment-to-population ratios. This suggests that digitalisation does not necessarily crowd out employment, but rather facilitates the formation of new digital employment niches, enhancing labour absorption capacity.

The graphical representation indicates that, in most observed cases, an increase in the level of ICT usage by enterprises for conducting transactions with other firms (hereafter, the ICT-use indicator) is accompanied by an increase in the employment-to-population ratio (hereafter, the employment level). Countries where the ICT-use indicator ranges between 3.8 and 5.0 demonstrate an average employment level of approximately 50%. When this indicator lies between 5.1 and 5.5, the average employment level increases to 55%, and when ICT usage rises to the interval 5.6–6.0, the average employment level reaches 59%.

Among all analysed countries, the lowest employment level—approximately 41%—is observed in Moldova, which simultaneously has one of the lowest ICT-use scores (4.2). Conversely, the highest employment level is recorded in Singapore, where ICT application by enterprises for inter-firm transactions is relatively advanced; ICT usage reaches 5.8, and the employment level approaches 66%.

At the same time, the data reveal several atypical country-specific deviations from the general trend. There are countries with relatively low ICT-use scores (below the average value of 5.2) but relatively high employment levels (above 55%, which is higher than the general average). These include Brazil (4.6 and 56%), Georgia (4.6 and 58%), and Mexico (4.8 and 59%). Conversely, some countries display considerably high ICT-use scores (above 5.2) while simultaneously maintaining relatively low employment levels (below 55%). Examples include France (5.3 and 50%), Portugal (5.5 and 52%), Slovakia (5.5 and 54%), Belgium (5.7 and 49%), and Finland (5.9 and 53%).

Despite these exceptions, the overall statistical tendency confirms that in countries where enterprises actively use ICT solutions to execute transactions—an indicator of higher digital-economy maturity—the share of employed individuals in the working-age population is noticeably higher than in countries with lower ICT-use levels. This suggests that digital-economy expansion contributes to the creation of new employment opportunities. The emergence of digital-intensive occupations—such as IT-managers, data analysts, cybersecurity specialists, developers of artificial-intelligence solutions, and specialists in 3D-printing—represents one of the direct channels through which ICT diffusion stimulates labour-market expansion.

However, this relationship is not absolute and should be assessed with reference to several moderating factors. These may include demographic dynamics (e.g., age structure and labour mobility), ongoing economic reforms, labour-market regulations, levels of digital literacy and innovation capabilities, sectoral restructuring, and the state's employment-support policies. Hence, while higher ICT diffusion generally strengthens employment prospects, the degree of this effect varies depending on the broader institutional, economic, and structural environment.

A similar pattern is observed when analysing the relationship between enterprise use of the internet for business-to-consumer purposes and national employment levels (as illustrated in the previous analysis related to Figure 1). In countries where the indicator reflecting the use of internet technologies for selling goods and services ranges between 3.7 and 5.0, the average employment-to-population ratio is approximately 51%. When the indicator increases to 5.1–5.6, the average employment level rises to around 55%, and at 5.7–6.4, it reaches approximately 59%. These values collectively suggest that higher levels of digital-economy development are generally associated with an increase in the employment rate within the working-age population.

However, as in the previous case, several country-specific exceptions deviate from the main tendency. Some economies demonstrate relatively high levels of internet use by firms for online commerce (with values exceeding 5.2, which represents the average for the analysed sample of countries), yet their employment levels remain below the overall sample average of 55%. These include:

- Belgium (5.3 and 49%, respectively),
- France (5.5 and 50%, respectively), and
- Slovakia (5.7 and 54%, respectively).

Conversely, there are economies where the digital-commerce indicator remains below 5.2, yet employment levels exceed the average benchmark:

- Georgia (4.0 and 58%, respectively),
- Mexico (4.3 and 59%, respectively),
- Azerbaijan (4.9 and 63%, respectively), and
- Brazil (5.0 and 56%, respectively).

Thus, while the prevailing relationship confirms that greater digital-economy maturity tends to stimulate growth in national employment levels, the existence of opposite cases reveals that employment patterns remain influenced by additional structural, demographic,

institutional, and policy-driven factors. These may include labour-market regulations, demographic age structures, national strategies for industrial diversification, educational reforms, technological readiness of enterprises, and macroeconomic stability. Accordingly, digitalisation should be viewed not as an exclusive determinant of employment, but as part of a multi-factor system shaping labour-market outcomes.

Network Readiness Index and Female-to-Male Wage-Employment Ratio

As highlighted in the literature review, a widely accepted position in contemporary labour-market discourse is that ICT development—particularly its active integration into production, organisational processes, and platform-based commerce—expands opportunities for women's employment. Increased digitalisation reduces spatial barriers, supports flexible working arrangements, promotes remote working models, and decreases transaction-related costs that traditionally constrained women's labour participation.

The emergence of digital labour platforms, gig-economy structures, online entrepreneurship, and knowledge-intensive digital professions creates potentially favourable conditions for women to access formal employment. These mechanisms provide working environments less dependent on rigid working hours, physical workplace presence, or traditional organisational hierarchies.

Furthermore, digital tools facilitate access to:

- professional training, including online certification programmes,
- entrepreneurial ecosystems (e-commerce, digital marketing, online service delivery),
- remote and hybrid forms of employment, and
- digital project-based collaborations.

Therefore, examining the relationship between the Network Readiness Index and the female-to-male ratio in wage employment allows us to empirically assess whether digital-economy development contributes to narrowing gender gaps. The hypothesis underlying this segment of the analysis is that higher readiness of a country to adopt and scale ICT solutions should correspond with higher proportional representation of women in formal, wage-based employment. However, as demonstrated earlier for employment in general, these relationships may also be moderated by institutional frameworks, cultural norms, labour legislation, social-policy incentives, and the digital-skills distribution between genders.

Table 1. Relationship Between Enterprise Internet Use (B2C) and Employment Levels Across Selected Countries

Range of enterprise internet use for selling goods and services (score)	Average employment-to-population ratio (%)	Interpretation
3.7 – 5.0	51	Low-to-moderate level of digital-economy maturity corresponds to modest employment outcomes
5.1 – 5.6	55	Medium level of digital-economy development correlates with moderately higher employment
5.7 – 6.4	59	High level of digital-economy development generally associated with highest employment level

Table 2. Countries Deviating From the General Relationship ("Negative Deviations")

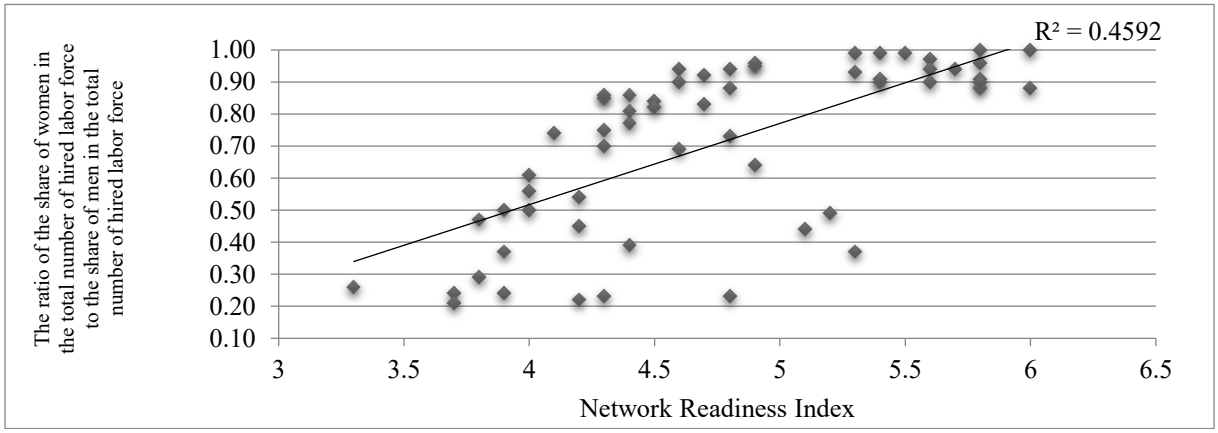
Country	Internet-use score (B2C)	Employment level (%)	Expected trend	Actual result
Belgium	5.3	49	High ICT use → high employment	Below expected level
France	5.5	50	High ICT use → high employment	Below expected level
Slovakia	5.7	54	High ICT use → high employment	Slightly below expected

Analytical note:
Despite high digital-application scores, labour-market performance remains below group average, suggesting external influencing factors (institutional, demographic, labour-regulatory).

Table 3. Countries With Low ICT Use but Higher Employment ("Positive Deviations")

Country	Internet-use score (B2C)	Employment level (%)	Expected trend	Actual result
Georgia	4.0	58	Low ICT use → lower employment	Higher than expected
Mexico	4.3	59	Low ICT use → lower employment	Higher than expected
Azerbaijan	4.9	63	Average ICT use → moderate employment	Significantly higher than expected
Brazil	5.0	56	Average ICT use → moderate employment	Higher than expected

Analytical note:
These countries appear to compensate weak ICT adoption through other drivers such as demographic advantages, economic reforms, labour-market activation policies, or structural productivity shifts.



Conclusion

The empirical findings confirm that digital-economic maturity, measured through ICT utilisation and network readiness, is strongly associated with favourable employment outcomes. Economies with active integration of ICT systems in inter-organisational transactions and online commercial operations tend to achieve higher employment-to-population ratios. This outcome may be explained by labour-absorptive effects of emerging digital professions, platform-mediated service markets, and productivity-enhancing effects of technological adoption.

Moreover, digital readiness appears to foster gender-inclusive employment relations. Countries demonstrating advanced NRI scores record more balanced participation of women and men in wage employment, indicating that digital labour systems broaden accessibility to formal jobs, enhance flexible work models, and reduce geographical and temporal constraints traditionally affecting women's labour continuity.

Nevertheless, the analysis highlights substantial heterogeneity. Countries with high digital readiness but low female wage participation reveal that digitalisation is not solely labour-determining; cultural restrictions, legal frameworks, socio-economic norms, childcare systems, and human-capital asymmetries substantially influence labour outcomes. Thus, digital policies must be integrated with social-policy instruments, equal-opportunity frameworks, labour-market protections, and lifelong-learning strategies.

Overall, digitalisation not only reshapes employment structures but expands the labour ecosystem by facilitating hybrid and remote work, platform-based entrepreneurship, technology-enabled professional roles, and data-driven industries. For sustainable employment expansion, national strategies must prioritise strengthening skills formation, STEM-education accessibility, women's digital literacy, and workforce adaptability.

Ethical Considerations

This study was conducted using publicly available statistical sources, ensuring compliance with ethical research standards. All data used are secondary and aggregated at the country level; therefore, no personal, confidential, or identifiable information was collected. Analytical interpretations follow objective statistical reasoning and avoid any stereotyping or cultural bias. Ethical responsibility has been maintained by providing transparent methodological procedures and referencing credible international institutions.

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Conflict of Interest Statement

The author declares no conflict of interest related to authorship, analysis, financial incentives, institutional affiliation, or publication of the present research.

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