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Women in Digital Economies: Evidence from the ICT Labour Market

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Abstract

In this paper, the digital inclusivity of women in Kazakhstan will be explicitly examined from the perspectives of existing gender gaps in Internet connectivity and regional variability in digital readiness from 2015 to 2024. The empirical study combines descriptive statistics, fixed-effects panel regression analysis, the construction of composite indices, and multivariate cluster analysis based on gender-disaggregated annual regional datasets for 21 units. The study also considers women's Internet and mobile telephony usage rates, along with a gender gap index constructed from differences in women's Internet usage rates relative to men. For measuring multidimensionality in digital readiness, a composite index, 'Women Digital Index', is established. The findings show that Kazakhstan has almost overcome the quantitative aspect of the problem of women's access to the Internet and mobile phones, as the level of women's Internet and mobile phone usage across all regions of the country exceeds 90%. Moreover, there are still significant discrepancies between areas in the size and sign of the digital gender gap. The fixed-effect model estimates indicate a sharp positive trend in women's Internet use, and the gender gap remains statistically insignificant. The clustering analysis has shown that there exist three different regional types of women's digital Readiness: digital leaders, transitional regions, and saturated regions. The results confirm that high connectivity does not directly translate to gender equality.

Keywords: Digital Economy, Gender Equality, Women's Digital Inclusion, Digital Gender Divide, Labour Market, Regional Inequality, Kazakhstan

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1. INTRODUCTION

Digital transformation has become one of the key drivers of contemporary economic development, transforming labour markets, production systems, and forms of social participation. ICTs are becoming a decisive factor in employees' access to new jobs, productivity growth, entrepreneurial activities, and innovative behaviour, especially in knowledge-based and service-driven economies. Within this context, women's contribution to the development of the digital economy has assumed a dual role: it is both a critical equity issue and a significant factor in inclusive growth. Moving beyond mere connectivity of women to digital networks and enabling them to transform digital access into meaningful economic outcomes has become the key challenge for policymakers and researchers alike.

Early policy debates on the digital gender divide largely framed inequality in terms of access to infrastructure: computers, mobile devices, and Internet connectivity. However, a growing body of empirical evidence shows that closing access gaps does not automatically lead to equality in digital outcomes. Instead, gender disparities persist in the acquisition of digital skills, participation in ICT-intensive occupations, access to digital finance, and representation in high-value segments of the digital economy. These inequalities result from the complex interactions among education systems, labour-market institutions, sociocultural norms, and regional development patterns. The concept of digital inclusion has moved further away from its initial narrow focus on connectivity toward a multidimensional understanding that emphasises capabilities, agency, and the effective use of digital technologies.

Kazakhstan offers an especially pertinent empirical setting for scrutinising these dynamics. The country has invested heavily in telecommunications infrastructure and digital public services over the last 10 years, with almost the whole of the Internet and mobile phone coverage across most of the country. According to national-level indicators, the gender gap in basic Internet access has decreased significantly, making Kazakhstan one of the regional leaders in digital connectivity. At the same time, Kazakhstan tends to exhibit sharp spatial, socioeconomic, and institutional heterogeneity across urban centres and peripheral regions, as well as between resource-rich and agrarian areas. These structural features immediately raise a relevant question: Does convergence in digital access translate into the reduction of gaps in women's economic participation in the digital economy?

Evidence from Kazakhstan and other Central Asian countries makes clear that such an answer is anything but obvious. On the one hand, the number of women with internet access has grown quite rapidly over recent years. On the other hand, disparities remain regarding higher-order outcomes such as employment in the ICT sector, digital entrepreneurship, and participation in platform economies. Regional disparities also make such an answer complex, since the level of ICT infrastructure can differ significantly, with outcomes for women remaining quite different.

Given the above context, the significance of the present study lies in its contribution to the body of knowledge through a regionally disaggregated empirical analysis of women's digital access and related issues of gender inequality regarding Internet usage in the Republic of Kazakhstan between 2015 and 2024. Rather than using averages, the study emphasises heterogeneity and persistence. This is achieved through a multidisciplinary approach that includes descriptive analysis, fixed-effects panel analysis, construction of composite indicators, and clustering analysis.

The central objective of the research is not to stop at the question of whether women are connected to digital networks, but rather to examine how digital access is distributed across regions and how it relates to persistent gender inequalities. In particular, the study tries to answer the following three interrelated questions: First, to what extent has women's digital access converged across regions of

Kazakhstan over the last decade? Second, does the gender gap in Internet use follow a declining trend, or is it structurally embedded despite rapid digital diffusion? And third, is it possible to identify distinct regional patterns of women's digital readiness, and what do these patterns imply for women's participation in the digital economy?

By answering these questions, this research seeks to contribute to the current shift in both digital and gender policy away from quantitative access and toward qualitative inclusion. These findings are expected to underpin an evidence-based policy design that takes regional diversity into account and accelerates skills development, labour-market integration, and institutional support as the next stage of Kazakhstan's digital transformation. In doing so, the paper contributes to broader debates on gender equality in the digital economy. It offers insights relevant not only to Kazakhstan but also to other middle-income and transition economies facing similar challenges in translating digital connectivity into inclusive economic empowerment for women.

2. LITERATURE REVIEW

The issue of the digital gender gap can thus be conceptualised within existing research on the digital inclusion of women, which acknowledges that the gender gap about information and communications technology (ICT) outcomes is a function of the complex interplay of (i) physical infrastructure access, (ii) skills, (iii) labour market/financial inclusion, and (iv) institutional/sociocultural factors. The Central Asian state of Kazakhstan, with which this paper engages, presents a practical application of the issue, where the increased physical infrastructure for the digital economy has not yet overcome the identified structural impediments to meaningful ICT use for women, specifically in rural areas.

Recent evidence from Kazakhstan shows that the gender gap in Internet access has narrowed, but this does not necessarily mean the gender gap in online empowerment has narrowed. Kenzheali & Vasa (2025) observe that the gender digital divide has closed quantifiably in Kazakhstan (from 2.8 to 0.6 percentage points between 2015 and 2024) and attribute digital inclusion to socioeconomic participation, suggesting that digital literacy and labour-market factors remain essential drivers.

NB: While national convergence is achieved, subnational stratification may exist. Based on evidence from Kazakhstan, there remains a lack of equity in access to multi-sectoral resources and opportunities, with rural disadvantage identified on several occasions as a limiting factor. In a transition economy like Kazakhstan, as illustrated by Kireyeva et al. (2024), access inequities coexist with broader resource inequities, suggesting that reliance on ICT is part of a wider pattern of development inequities. At the regional level, the CAREC Gender Assessment Report of 2021 confirms the existence of gender inequities in digital technologies across Central Asia.

One of the significant consistent observations has been the mediation of digital inclusion through quality education and skill development. In Kazakhstan, the study by Kireyeva and Kenzheali (2025) examined the processes of quality education and training as mechanisms for overcoming barriers for women.

There is evidence of disparate dynamics of gender also within the Kazakhstan education system at an advanced level. As stated by Satpayeva and Nygmetov in 2023, using the country’s statistics from 2000 to 2022, the issue of gender inequality can be seen in post-graduate education—a concern regarding ICT, since advanced education is an essential route to more esteemed and better-paid digital jobs and senior positions. There is international evidence for the same dynamics, as Mejía-Salazar et al. argued in 2023 that ICT adoption in education can be an essential aspect of better inclusion strategies when implemented in ways that foster actual engagement and learning outcomes, reinforcing the notion that providing "access to devices" alone is not adequate. Participation in STEM disciplines is often cited

as a key long-term factor affecting women's digital inclusion. In this context, CohenMiller et al. (2021) analyse gender equity in STEM higher education in Kazakhstan, addressing pipeline issues that often lead to labour-market segregation in digital industries.

To supplement this, a systematic review conducted by Shoaib in 2025 has synthesised a body of evidence from higher education systems in Muslim countries, concluding that while disparities in academic success exist due to constraints on access, they are influenced by institutional and sociocultural factors, thereby supporting the skills pipeline framework.

There is also a critical application stream that connects ICT with the inclusion of women through e-commerce and online platforms. For Kazakhstan, the issue is explored with direct empirical evidence from Kireyeva et al. (2022) on women and online platforms, and an examination of challenges, including ICT skills and other factors, that limit the inclusiveness of online opportunities.

In terms of broader views of the development sector as a whole, Sicat et al. (2020) contend that ICT can close gaps for women entrepreneurs/traders only if enabled by gender-sensitive policies; otherwise, digitalisation could lock existing inequalities in place. Digital finance has become integral to digital inclusion metrics, as it gauges "use" rather than "access." Sikakebieke & Kuanova (2025) studied the digital banking adoption rate in Kazakhstan to identify gaps influenced by factors such as trust, earnings, and literacy levels, consistent with the "Capabilities + Institutions" perspective on digital inclusion.

Cross-nationally, Antonijević et al. (2022) demonstrate that gender differences in financial inclusion persist, highlighting differences between genders across a variety of inclusion indicators using Global Findex-type datasets, suggesting that digital payments and online financial behaviour play critical roles in the persistence of gender inequality even when internet connections become widely available. There is evidence outside of Central Asia that supports this same argument. Zindi et al. (2025) in Harare argue that social inequities frame women's ICT access/use, supporting the view that the digital divide must be considered as tied to technology *and* social equity considerations, rather than strictly an infrastructure-based problem. Digital industryization impacts digital inclusion beyond urban contexts. For example, Khatri et al. (2024) examine ICT within agricultural extension delivery, highlighting that digital access can enhance delivery but also suggesting that women's inclusion in ICT necessitates access to hardware, training, and other forms of institutional support, particularly pertinent to countryside Kazakhstan and broader Central Asia.

"Institutional factors play a crucial role in whether women can really turn access to ICTs into opportunities." In the labour market of Kazakhstan, for instance, Khamzina et al. (2021) argued that although there is progressive labour legislation striving for equality in the labour market for women and men, "implementation disparities can impede the equality of women and men in the labour market," which can extend to the ICT sector as well.

At its foundation, Hafkin & Huyer (2008) assert that a lack of gender-disaggregated ICT statistics hinders evidence-based policymaking. This problem remains relevant for policy evaluation/region-wide comparisons. The pandemic has brought a significant "stress test" for "digital inclusion." In the Asian Development Bank's publication regarding the impact of the pandemic on Central & West Asia, "The Asian Development Bank highlighted the gendered effects of the pandemic and made clear that the 'digitalisation shock may reinforce women's burdens if there is no policy addressing the issue of care and unequal access to enabling resources.'"

Large-scale comparative studies bring forth two points of particular interest to Kazakhstan/CA: (i) digital gender disparities are spatially interdependent, and (ii) digital engagement is both a reflection of and can be a driver for offline inequality. Wang & Lin (2024) examine cross-national datasets to show

the existence of spatial spillovers in Internet access and the digital gender gap, proposing that diffusion can have a neighbourhood effect rather than a national one.

Regarding this analysis, the study of García et al. (2018) entitled "Facebook Gender Divide" examines the gender gaps on online platforms on a massive scale, boasting over 1.4 billion users across 217 countries, indicating the potential for measurement of gender gaps on various levels of gender equality and affecting the risk of exclusion on the internet. Lastly, sociocultural studies are integral for understanding why mere access and skills alone do not account for gender gaps. The discourses from the vantage point of Central Asia, reflecting how the internet is also a site for identity formation and the construction of predetermined norms that may or may not impact women's presence and recognition online.

Through various literature reviews, a coherent empirical storyline can be reconstructed. Kazakhstan has reduced the headline relative gaps in Internet access significantly, but the literature well documents that digital inclusion is a function of capabilities, institutions, and social leverage, leading to systematically unequal levels of significant ICT use, digital financial inclusion, and economic participation via ICTs. The evidence suggests a policy package combining: (1) infrastructure & affordability interventions, (2) human capacity & STEM pipeline interventions, (3) digital financial & platform inclusion strategies, & (4) institutional compliance & monitoring systems.

3. METHODOLOGY

This paper uses a quantitative, regionally disaggregated empirical approach to examine digital access for women, the gender gap in Internet use, and regional heterogeneity in digital readiness across the Republic of Kazakhstan. The methodology combines descriptive statistics, fixed-effect modelling, index calculations, and multivariate clustering analysis. Using a combination of approaches enables researchers to detect trends, on the one hand, and structural differences, on the other, in the issue under consideration.

The empirical analysis uses annual regional data from 2015 to 2024 covering 21 administrative units in Kazakhstan. The dataset collects gender-disaggregated digital access indicators that originate from official statistical releases. Several indicators that lacked gender differentiation have been gender-disaggregated to ensure comparability across regions and over time.

The core variables are defined as follows:

- $Internet_{it}^{f}$: share of women using the Internet in the region $i$at the time t(percent);
- $Mobile_{it}^{f}$: share of women using mobile phones in the region $i$at the time t(percent);
- Gap_{it}: gender gap in Internet access, calculated as the difference between female and male Internet usage rates (percentage points).

The gender gap indicator is constructed as formula (1):

$$Gap_{it} = Internet_{it}^{f} - Internet_{it}^{m} \quad (1)$$

where:

$Internet_{it}^{m}$ – the male Internet usage in the region $i$at the time t. Positive values indicate a female advantage, while negative values indicate male dominance in access.

At the first level, the descriptive statistics are obtained for the set of indicators for 2024, including the mean, standard deviation, minimum value, and maximum value. This allows for the discovery of dispersion and possible differences across regions in women's digital inclusion.

Mathematically, for any variable X, the regional mean and standard deviation are computed as formula (2):

$$\bar{X} = \frac{1}{N}\sum_{i=1}^{N} X_i \, , \sigma_X = \sqrt{\frac{1}{N-1}\sum_{i=1}^{N}(X_i - \bar{X})^2} \quad (2)$$

where:

$N = 20$ – the number of regions included in the cross-sectional analysis for 2024.

To assess the dynamics of digital access among women, fixed-effects panel regression equations are estimated for Internet and mobile phone use separately. The fixed-effects model allows for region-specific characteristics that remain invariant over time and encompass features such as regional structure and institutional features, among other determinants.

The baseline model is specified as formula (3):

$$Y_{it} = \alpha_i + \beta \cdot Year_t + \varepsilon_{it} \quad (3)$$

where:

Y_{it} – represents either $Internet_{it}^{f}$ or $Mobile_{it}^{f}$;
α_i – the region-specific fixed effects;
$Year_t$ – the linear time trend;
ε_{it} – the idiosyncratic error term.

Robust standard errors are employed to account for heteroskedasticity and serial correlation within regions. Model fit is evaluated using the within R^2, reflecting the explanatory power of the temporal dimension after removing regional means.

To examine whether the digital gender gap exhibits a systematic time trend, an analogous fixed-effects model is estimated with Gap_{it} the dependent variable in formula (4):

$$Gap_{it} = \alpha_i + \gamma \cdot Year_t + u_{it} \quad (4)$$

The fact that the results are not statistically significant for gamma is taken to suggest that gender inequalities in Internet access are institutionally embedded rather than dynamically changing.

To measure complex readiness for the digital world in its entirety, a composite variable, Women Digital Index (WDI), is created using standardised factors for Internet usage intensity, mobile phone usage, and the reverse of the gender gap. The composite index is calculated as formula (5):

$$WDI_i = \frac{1}{3}\left(Z_{Internet,i}^{f} + Z_{Mobile,i}^{f} - Z_{Gap,i}\right) \quad (5)$$

Where the subtraction of the standardised gender gap ensures that lower disparities contribute positively to the index value.

To identify homogeneous groups of regions by women's digital readiness, a k-means clustering algorithm is applied to the standardised indicators and the composite index.

The clustering procedure minimises within-cluster variance as formula (7):

$$\min \sum_{k=1}^{K} \sum_{i \in C_k} \| X_i - \mu_k \|^2 \quad (7)$$

where:

C_k – the cluster k, $\mu_k$is the centroid of cluster k;

$K = 3$ – selected based on interpretability and variance decomposition criteria.

Clusters are interpreted as digital leaders, transitional regions, and digitally saturated regions. The cluster structure is further validated by comparing mean indicator values and by visual inspection through scatter plots and composite diagrams. Finally, dynamic trends and spatial patterns are depicted through time-series plots, cluster distributions, and scatter diagrams, which link women's Internet access to the gender gap.

The construction of a synthesis matrix helps to translate empirical findings into analytical interpretations and policy implications linking digital infrastructure outcomes with women's participation in ICT and labour market inclusion.

4. RESULTS

The results indicate that access to both the Internet and mobile communication technologies among women exceeds 90% in all regions, reflecting that basic digital infrastructure is almost entirely saturated. At the same time, despite overall saturation, interregional variation remains relatively high, especially in Internet usage, where the gap between the minimum and maximum values exceeds eight percentage points (Table 1).

Table 1. Regional distribution of women's digital access indicators for 2024

Region	Internet usage (women, %)	Mobile usage (women, %)	Gender gap (Internet, p.p.)
Abay	91.76	97.00	1.51
Almaty	94.04	97.80	0.39
Almaty city	96.63	91.90	−0.54
Astana city	97.52	98.10	−0.26
Atyrau	93.34	96.60	4.44
Akmola	97.11	99.70	1.17
Aktobe	93.76	97.60	0.94
Western Kazakhstan	91.41	97.80	−0.37
Dzhambul	90.22	95.20	−2.14
Tokens	94.62	96.80	0.47
Mangystau	97.00	97.90	0.44
Pavlodar	96.72	99.60	1.13
North Kazakhstan	94.83	99.00	−0.07
Turkestan	97.34	99.60	−0.56
Shymkent	96.76	100.00	−1.79
East Kazakhstan	96.87	99.70	−0.19
Karaganda	98.42	99.10	−0.48
Kostanay	92.80	99.90	−3.15
Kyzylorda	91.70	97.50	−0.89
Ulytau	92.51	97.60	−1.70

Note: compiled by the author

The direction and intensity of the gender gap in Internet access vary widely across regions. Though some areas show a benefit for females or gender equality, others show a persistent benefit for males. This observation suggests that factors beyond infrastructure availability influence digital inclusiveness. The mean Internet and mobile phone usage among women reflects the level of national digital maturity that Kazakhstan has achieved. However, the standard deviation of the gender gap in Internet access indicates noticeable

variation, suggesting the presence of hidden disparities at the regional level despite the high averages. The aggregate descriptive statistics for 2024 are presented in Table 2.

Table 2. Descriptive statistics of women's digital inclusion (regional level, 2024)

Indicator	Obs.	Mean	Std. Dev.	Min	Max
Internet usage (women, %)	20	94.77	2.48	90.22	98.42
Mobile phone usage (women, %)	20	97.92	1.93	91.90	100.00
Gender gap in Internet access (p.p.)	20	−0.08	1.60	−3.15	4.44
Women Digital Index (std.)	20	0.00	0.81	−1.62	1.04

Note: compiled by the author

The Women Digital Index reveals further disparities through its standardised measurement, with regions spanning a wide value range despite equal access conditions. The implications of this finding make it clear that it is necessary to go beyond binary metrics to determine connectivity readiness.

The dynamics of women's digital access are analysed at the time-series level using fixed-effects regression models, as shown in Table 3.

Table 3. Fixed-effects panel regression: dynamics of women's digital access for 2015–2024

Variable	Coefficient	Robust SE	t	p-value
Dependent variable: Internet usage (women)				
Year	2.698	0.216	12.47	0.000
Constant	−5362.96	437.11	−12.27	0.000
Obs. = 176 Regions = 21 Within R^2 = 0.808				
Dependent variable: Mobile phone usage (women)				
Year	1.298	0.140	9.29	0.000
Constant	−2527.48	282.15	−8.96	0.000

Note: compiled by the author

This divergence represents a shift in the digital behaviour structure, with Internet-based services increasingly supplementing and substituting for traditional mobile communication. A high value of the within R^2 indices indicate the dominance of dynamic elements over the within variation, and the within variation represents region-level variation, which is substantial for Internet access.

Figure 1 presents graphical evidence that confirms econometric findings and illustrates acceleration in access between 2015 and 2024

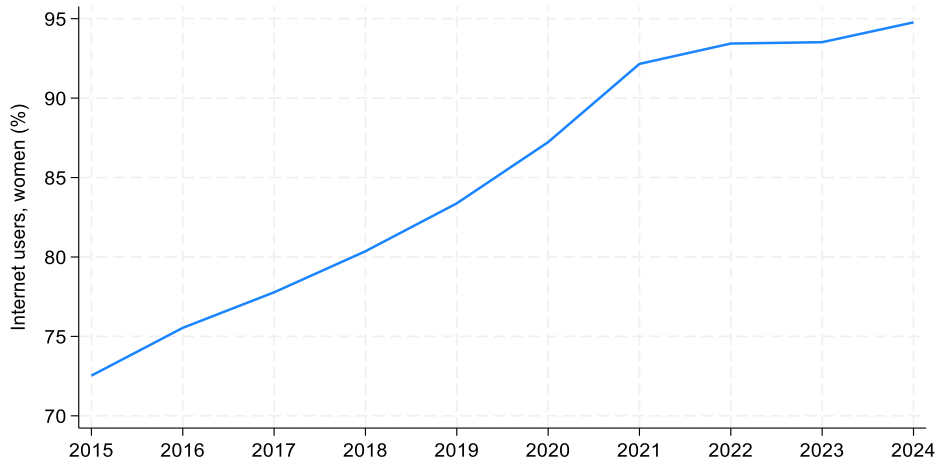

Figure 1. Dynamics of women's Internet access for 2015–2024

The persistence of gender disparities is analysed in Table 4. Fixed-effects regression: gender gap in Internet access. The absence of a statistically significant time trend indicates that, despite rapid growth in overall access, the relative position of women vis-à-vis men has remained broadly unchanged over the last decade.

Table 4. Fixed-effects regression: gender gap in Internet access

Variable	Coefficient	Robust SE	t	p-value
Year	0.055	0.061	0.91	0.373
Constant	−111.87	122.54	−0.91	0.372

Note: compiled by the author

This result implies that the digital gender gap in Kazakhstan is not a transitory phenomenon that diminishes automatically with technological diffusion, but rather a structurally embedded regional characteristic. The temporal stability of the gap is further illustrated in Figure 2, which shows the dynamics of the Internet gender gap (female − male).

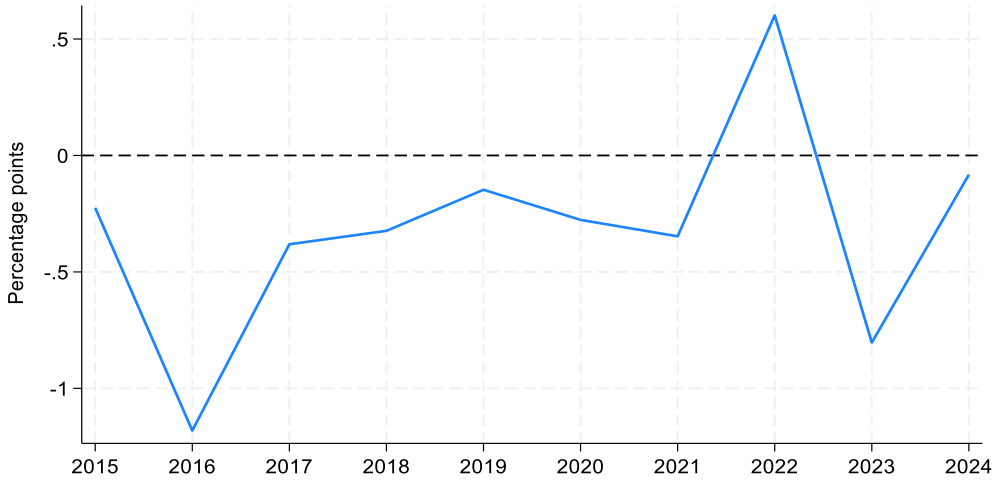

Figure 2. Dynamics of the Internet gender gap (female − male)

To capture structural heterogeneity across regions, cluster analysis is conducted, with results reported in Table 5. Regional composition of clusters. Three distinct regional clusters are identified: digital leaders, transitional areas, and digitally saturated regions.

Table 5. Cluster structure of regions by women's digital readiness (2024)

Cluster	Obs.	Internet usage (women, %)	Mobile usage (women, %)	Gender gap (Internet)	Women Digital Index
Cluster 1 – Digital leaders	5	92.25	97.60	−1.50	−0.59
Cluster 2 – Transitional regions	6	93.59	96.28	1.08	−0.66
Cluster 3 – Digitally saturated regions	9	96.95	99.19	−0.07	0.77

Note: compiled by the author

Table 5 shows the structure of regions by women's digital readiness in Kazakhstan in 2024 and the heterogeneity in digital inclusiveness outcomes despite universal access. The digitally saturated regions (Cluster 3), with nine areas, score the highest in terms of the usage rate of the Internet and mobile communication services by women (96.95% and 99.19%, respectively), with the best composite outcomes, as evidenced by a positive Women Digital Index of +0.77 and a near-zero gender gap in Internet usage. Digital leaders (Cluster 1), with a conceptual assignment to leaders in terms of digital advancement, score lowest in terms of digital access and display a negative Women Digital Index of -0.59, together with a male benefit in Internet usage of −1.50 per cent, showing that despite moderate levels of digital access, inequality persists. The transitional regions (Cluster 2) are positioned in a medium group in terms of levels of access but display the highest positive benefit in favour of females with a +1.08-percentage point difference, showing a benefit for females in digital advancement not reaching the best overall digital readiness, with the lowest Women Digital Index of −0.66.

Table 6 shows regional composition of clusters.

Table 6. Regional composition of clusters

Cluster	Region
Digital leaders	Almaty, Zhambyl, Kostanay, Kyzylorda, Ulytau
Transitional regions	Abay, Almaty, Atyrau, Aktobe, West Kazakhstan, Zhetysu
Digitally saturated regions	Astana, Akmola, Mangistau, Pavlodar, North Kazakhstan, Turkestan, Shymkent, East Kazakhstan, Karaganda

Note: compiled by the author

It is precisely the digitally saturated cluster that presents the highest levels of Internet and mobile use and simultaneously has the most favourable values of the Women Digital Index. However, this quantitative advantage does not necessarily translate into superior outcomes in women's economic participation in ICT-related activities. Digital leaders and transitional regions, in contrast, present more mixed profiles, combining moderate access levels with varying gender gap configurations.

The spatial distribution of clusters is visualised in Figure 3.

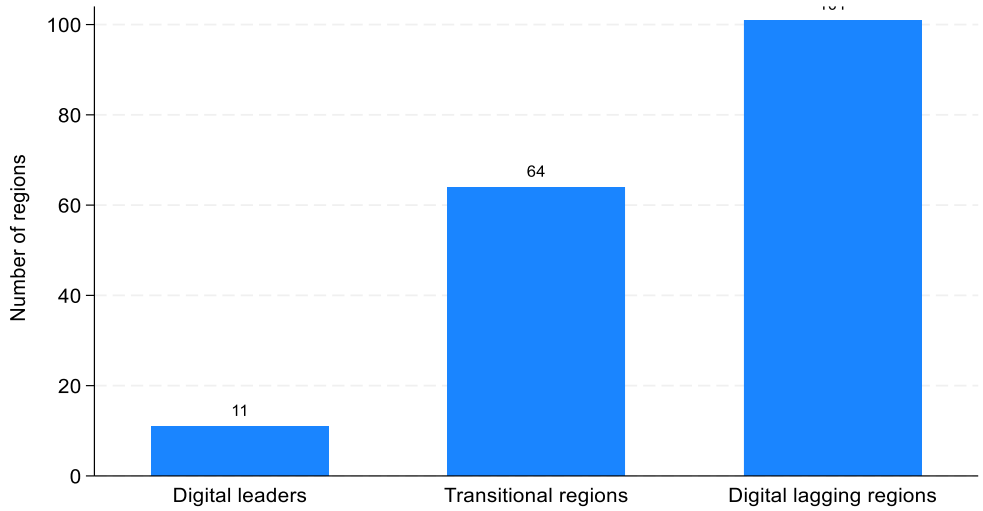

Figure 3. Distribution of regions by women's digital clusters in 2024

Figure 4 shows how regions in Kazakhstan and women's digital readiness align and are structured in 2024, indicating a highly imbalanced structure. The most significant number of regions is in the digitally lagging or saturated category. This suggests that even with extremely high digital access, a minimal number of regions continue to have unbalanced gender digital outcomes. A rather large category consists of transitional regions and depicts incomparably slower progress in women's digital readiness. Digital leaders constitute a relatively small segment, suggesting that regions with better women's digital access and gender equity in power are underrepresented in this study. Distribution of regions by women's digital clusters shown in Figure 4.

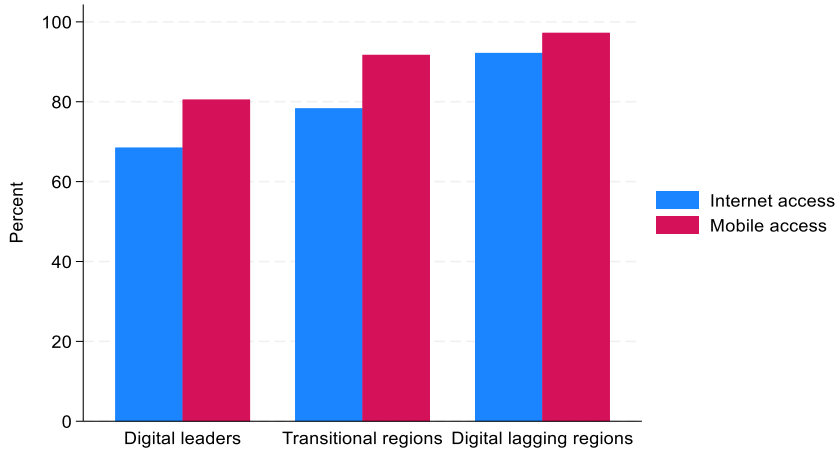

Figure 4. Women's Internet and mobile access by cluster in 2024

Figure 4 contrasts women's access to the Internet and mobile phones across clusters of digital readiness in 2024, and a rather striking access gradient between regional groups appears. The digitally lagging-saturated regions have the highest rates of both women's access to the Internet and to mobile phones, reflecting near-universal penetration of basic digital technologies. Transitional regions take an intermediate position, characterised by relatively high but still incomplete Internet use, while mobile access already approaches saturation.

Figure 5 displays the distribution of the standardised Women Digital Index for regional clusters in 2024.

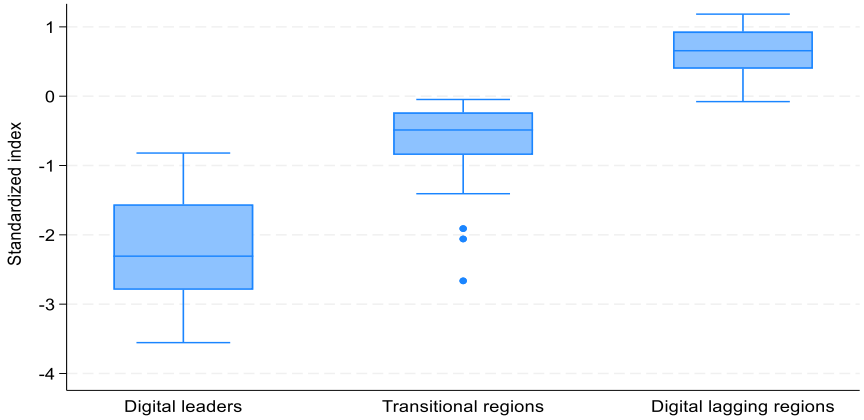

Figure 5. Women Digital Index by cluster

Digital leaders report the lowest average access levels, especially in Internet use, despite being classified as leaders in this clustering framework. This pattern shows that connectivity levels do not solely drive cluster differentiation, but rather that the combined configuration of access and gender inequality indicators does.It brings out a striking contrast in multidimensional digital readiness. The media is positive, and dispersion is relatively low for digitally lagging-saturated regions, showing strong digital readiness across these regions and lower gender disparities by comparison. Transitional regions show a negative median and higher variability, reflecting uneven progress, with advancing access coexisting with persistent structural constraints. Finally, digital leaders show the lowest values with the widest spread, indicating that even for the leading regions, there are significant limitations in translating digital access into balanced and inclusive outcomes for women. Figure 6 shows internet gender gap by cluster.

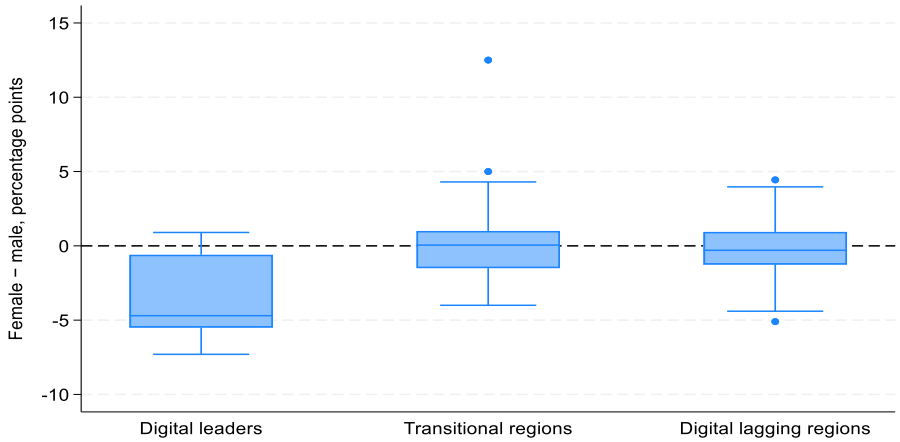

Figure 6. Internet gender gap by cluster

Figure 6 above shows the distribution of the Internet gender gap (female minus male use, percentage points) for the digital regions in 2024. Digital leaders have a clearly negative median internet gender gap, showing a systematic male advantage in internet use with little inequality within the group. The transitional regions have a median around zero with a vast spread and, in some cases, a positive internet gender gap, showing unstable and diversified internet use gender relations with both female and male dominance.

The digitally lagging/saturated regions have a slightly negative median and a smaller spread, indicating equality but with some regional inequality. Scatter internet access vs gender gap, which reveals the absence of a simple linear association between higher access and lower inequality. Several high-access regions continue to exhibit negative gender gaps, reinforcing the conclusion that infrastructure alone is insufficient to eliminate gender disparities. On the basis of this distributional proof, the comparison made in the digital typologies indicates that the direction of the Internet gender gap and its extent seem to be not mechanically correlated with the overall digital maturity of the region in question. Indeed, the homogeneity of digital leaders expresses relatively homogeneous results with an attested superiority of the male gender, but this fact does not reveal a convergence towards gender equity, as it marks the consolidation of the usage structures, rather than their evolution towards homogeneity.

The relationship between women's Internet access and the gender gap is further explored in Figure 7.

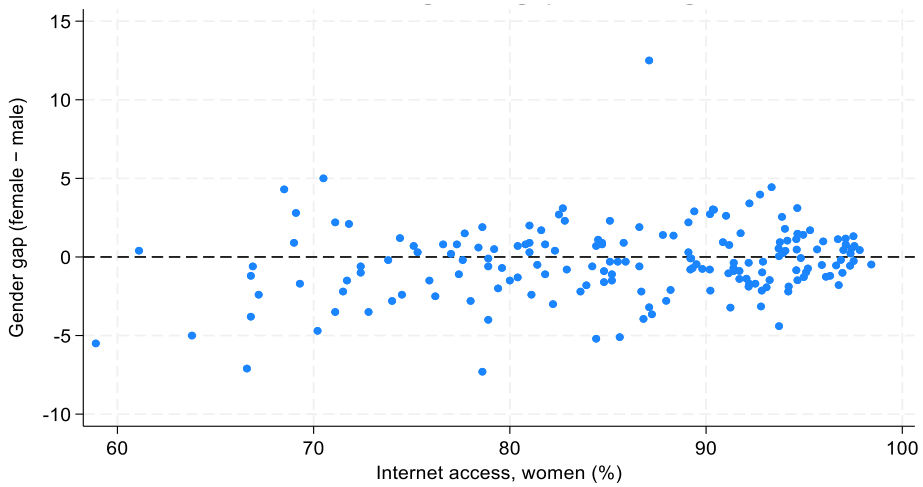

Figure 7. Scatter: Internet access vs gender gap in 2024

Composite view: Women Digital Index by region, highlighting pronounced spatial differentiation even under conditions of near-universal connectivity. The key empirical insights and their broader implications are synthesised in Table 7 synthesis matrix: implications for women's participation in ICT. Collectively, the results indicate that Kazakhstan has largely resolved the quantitative dimension of women's digital access, while qualitative dimensions—skills, labour market integration, and institutional support, remain the primary constraints shaping gender equality in the digital economy.

Table 7. Synthesis matrix: implications for women's participation in ICT

Empirical result	Interpretation	Policy implication
Universal digital access	Infrastructure constraint removed	Shift focus from access to skills and employment
No trend in gender gap	Equality in access achieved	Target qualitative ICT inclusion
Strong regional clustering	Institutional heterogeneity	Region-specific ICT and gender policies
High access ≠ high participation	Structural barriers dominate	Labor market and governance reforms

Note: compiled by the author

Also, Table 7 integrates the main empirical observations from the paper and develops implications for the participation of women in the ICT industry on the grounds of the evidence on the state of digital access universally, which shows infrastructure is no longer a hindrance, hence a shift in the focus of policies on the skills component for employment-enhanced digital inclusion. The fact that the gap does not decline implies that the problem of formal equality in access for girls has been rectified; hence, the need for interventions that enhance meaningful use to close the productivity gap in ICT use. The fact that all regions show a high level of concentration indicates that institutional differences across areas are essential; hence, the need for region-specific policies tailored to each region. Finally, the fact that a high level of access does not necessarily imply a high level of participation in ICT activities shows that the barriers are structural, specifically employment-related, and that modified policies targeting the soft component are needed to ensure beneficial environments for girls .

5. CONCLUSION

The paper presents a comprehensive empirical analysis of women's digital access

and gender disparities in Internet use across regions in Kazakhstan over the period 2015-2024. By combining descriptive analysis, fixed-effects panel regression, composite index construction, and cluster analysis, this research moves beyond national averages and uncovers the structural and spatial dimensions of digital inclusion. The findings permit a few substantive conclusions with direct relevance for digital, gender, and labour market policies.

First, the findings show that Kazakhstan has succeeded mostly in solving the quantitative aspect of women's access to digital technology. The use of the Internet and mobile phones among women exceeds 90% across all regions, indicating near-universal diffusion of basic digital infrastructure. From a purely infrastructural perspective, the digital exclusion of women can no longer be viewed as a binding constraint at the national level. This is an outcome of continuous public and private investment in telecommunications infrastructure and the spread of mobile and broadband technologies across urban and rural areas alike.

Second, despite the high overall accessibility, the analysis reveals non-trivial regional disparities. The evidence of dispersion in women's use of the Internet, as well as, more importantly, the indicator of the gender gap, revealed that formal equality of access does not necessarily ensure equivalent levels of success. While certain regions show a favourable bias toward females or near-parity, other regions demonstrate a consistent advantage for males. The fact that the degree of the gender gap shows no significant dynamics over time implies that these differences are not transient phenomena but rather structure-driven; that is, overall technological diffusion did not suffice to attenuate differences between males and females, and additional institutional correction seems necessary.

Third, the dynamic analysis reveals a shift in digital inclusion, which, in the context of the Web, represents a significant change. The use of the Internet among women has increased at a substantially faster rate than the use of mobile phones, reflecting the enhanced use of the Web rather than the physical device that delivers its benefits. Consequently, it is time that future policies on digital inclusion prioritise the qualitative dimensions of access-skill development, digital confidence, and the capability to translate connectivity into economic and social opportunities.

Fourth, the cluster analysis supports the presence of different regional models of women's digital readiness. The fact that a cluster identifies digital leaders, transitional regions, and digitally saturated regions proves that high access levels do not necessarily translate to favourable gender outcomes or broader digital empowerment. Quite surprisingly, the digitally saturated cluster, characterised by the highest access rates and composite index values, does not correspond to stronger participation by women in ICT-related economic activities. This points to institutional and labour-market barriers that make translating digital access into employment, entrepreneurship, and leadership in the digital economy costly.

Fifth, the multidimensional view provided by the Women Digital Index, together with the scatter plot between access and gender gaps, points to a key conclusion of this report: infrastructure is a necessary but not sufficient condition for gender equality in the digital world. Regions with similar levels of access might have sharply different gender outcomes, reflecting the determining role of education systems, labour market structures, cultural norms, childcare availability, and governance quality. These factors shape women's ability to use digital technologies for productive and remunerative purposes.

The findings, therefore, suggest an unmistakable reorientation of digital gender policies in Kazakhstan. As infrastructure constraints recede, policy emphasis should shift toward advanced digital skills, ICT-oriented education and training, support for women's employment and entrepreneurship in the digital sectors, and region-specific interventions which account for local institutional contexts. Given the pronounced spatial heterogeneity identified in this study,

nationwide uniform approaches are unlikely to be effective.

Kazakhstan has reached a critical juncture in the trajectory of digital inclusion for women. The country has moved beyond the issue of access. It is currently faced with the task of effectively including women to ensure that they can translate their access to the Internet and technology to their benefit and actualisation. The empirical findings presented and discussed in the research form a solid foundation for advancing the country to the next level of transition without being quantitatively inclusive of women's needs.

AUTHOR CONTRIBUTION

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Development of research methodology: Akan Nurbatsin.
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Software and supervisions: Akan Nurbatsin.
Data collection, analysis and interpretation: Akan Nurbatsin.
Visualization: Akan Nurbatsin.
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