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THE IMPACT OF THE DIGITAL ECONOMY ON URBAN POVERTY IN ARAB COUNTRIES: EVIDENCE FROM MENA USING ARDL AND NARDL

Awadelkarim Elamin Altahir Ahmed[1*]

[1]Department of Economics, College of Business, Imam Mohammad Ibn Saud Islamic University (IMSIU), Riyadh, Saudi Arabia. Email: aeahmed@imamu.edu.sa

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Corresponding Author: Awadelkarim Elamin Altahir Ahmed (aeahmed@imamu.edu.sa)

ABSTRACT

In the Arab urban context, poverty remains a constant burden, defined by house informality and limited access to basic services. Rapid digitalisation, especially mobile connectivity, is often promoted as a bridge to inclusion, yet its influences on poverty may be nonlinear and asymmetric. Using the log-log Autoregressive Distributed Lag (ARDL) and Nonlinear ARDL (NARDL), this paper analyses the link between digital connectivity and urban poverty in Morocco and Tunisia from 2000 to 2019. Urban poverty is proxied by the percentage of urban population living in slums, while mobile cellular subscriptions per 100 people proxy the digital economy. ARDL bounding tests confirm co-integration in both countries, showing stable long-run relationships. Long-run elasticities indicate that higher mobile connectivity reduces urban poverty, with effects of -0.286 (Morocco) and -1.099 (Tunisia). Error-correction suggests gradual adjustment towards equilibrium (14%/year in Morocco, 7% in Tunisia). NARDL estimates reveals strong asymmetry in Morocco, where negative digital shocks have stronger long-run effects than positive expansions; Tunisia is less asymmetric and cannot survive a conservative inference. Therefore, when digitalisation can help alleviate urban poverty, policies must build resilience to negative digital shocks, and ensure connectivity growth is accompanied by inclusive urban development.

KEYWORDS: Digital economy, Mobile connectivity, Urban poverty, Slums, ARDL, Nonlinear ARDL (NARDL), Asymmetry, Morocco.

1. INTRODUCTION

The problem of urban poverty is endemic and multifaceted in terms of development in the Arab region and especially in the mid-sized cities that are characterised by a high rate of population increase, unequal services, and limited municipal funds. Although capital cities and mega-urban centres often receive excessive policy focus and investments, deep-seated vulnerabilities may often play out in quieter urban areas of mid-size. These weaknesses are reflected in the growth of informal settlements, residential pressure, labour informality, restricted access to basic services, and spatial marginalisation (UN-Habitat, 2020, Bank, 2018). These challenges have been aggravated in most Arab cities due to poor urban governance and inadequate infrastructure, which have cemented poverty traps that cannot be overcome solely based on traditional growth processes (UN-ESCWA, 2019).

Meanwhile, the digital economy, which is being represented by digital connectivity, mobile diffusion, and more extensive processes of digitalisation, has grown fast throughout the Arab region, and it is increasingly considered as having the possibility to become a productivity force and a social inclusion force. Digital technologies may have effects on poverty in a variety of ways, such as diminishing information frictions, enhancing labour-market matching and job search efficiency, facilitating access to digital finance and public services, as well as creating micro-entrepreneurship and platform-based work (Aker and Mbiti, 2010, Group, 2016). Empirical studies are pointing towards an increasing amount of evidence that the process of information and communication technology (ICT) diffusion is frequently linked to poverty alleviation in developing settings, yet the scale and channels of diffusion can differ significantly among nations and institutional systems (Jack and Suri, 2014, Suri and Jack, 2016).

Nevertheless, the correlation between the digital economy and urban poverty is theoretically and empirically unclear. To begin with, access to digital services in cities is often unequal, as it can be associated with differences in affordability, digital literacy, and availability of infrastructure. Consequently, the benefits of digitalisation can be denied to low-income urban households, especially living in informal settlements, which can contribute to the strengthening of the existing inequalities (Hilbert, 2016, Van Dijk, 2020). Second, technological change can produce asymmetric effects: whereas positive digital expansions could improve poverty over time, by increasing employment and inclusion, the negative shocks, e.g., an increase in the cost of services, unequal distribution of expansions, or technological displacement, can have more immediate or qualitatively new effects on vulnerable populations. Third, poverty reaction to digitalisation can be varied over time, whereby long-term structural impacts and short-term adjustment movements will differ.

In spite of these considerations, much of the available empirical literature is limited in two significant aspects. To begin with, most of the research is concentrated on national poverty levels, neglecting urban dynamics and the unique issues of mid-sized cities. Second, the majority of analyses are based on linear econometric models and implicitly presuppose symmetric and time-invariant implications that can conceal nonlinearities and asymmetric adjustment strategies (Shin et al., 2014).

To fill these gaps, this research discusses the effects of the digital economy on urban poverty in an Arab urban context, with an example of Morocco and Tunisia, where the annual urban indicators are recorded consistently. As much as the motivation relies on the challenges that are usually experienced in mid-sized cities, gaps in similar city-level time-series data will require that nationally comparable measures of cities be used. A mixed approach of Autoregressive Distributed Lag (ARDL) and Nonlinear ARDL (NARDL) models is used in the analysis. The ARDL bounds testing model is very appropriate in a small sample, and it enables the determination of long-run relationships between variables that are combined of mixed orders, I (0) and I (1) (Pesaran et al., 2001). The NARDL model goes further in terms of breaking down digital economy measures into positive and negative partial sums to directly test long-run and short-run asymmetries in the digital poverty relationship (Shin et al., 2014).

Accordingly, this paper addresses three research questions:

- Does the expansion of digital connectivity reduce urban poverty in the long run in Arab urban contexts (Morocco and Tunisia)?
- Are the effects asymmetric, such that positive and negative digital shocks differ in magnitude or direction?
- How do short-run adjustments interact with long-run equilibrium dynamics in the digital connectivity–urban poverty relationship?

This research contributes to the existing literature in three main ways. First, it offers dynamic long-run and short-run evidence on the nexus of digital economy and urban poverty in the Arab region, in which urban informality and service gaps are still

pertinent policy issues. Second, it directly examines asymmetric digital shocks in the NARDL framework and provides policy-relevant information on whether the benefits of digital expansion are reflected in similar losses in the case of digital worsening. Third, the combined model of linear and nonlinear ARDL in a one-time-series framework empowers the study to make strong inferences with regard to equilibrium relationships as well as adjustment dynamics applicable to digital inclusion and urban poverty alleviation strategies.

The remainder of the paper is organised as follows. Section 2 reviews the related literature and develops the conceptual expectations. Section 3 describes the data, variables, and econometric methodology. Section 4 presents the empirical results. Section 5 discusses the findings, policy implications, limitations, and directions for future research in Arab urban contexts, while Section 6 concludes.

2. LITERATURE REVIEW

2.1. Urban Poverty in Developing and Arab Contexts

The urban forms and processes of poverty in developing regions have become more and more distanced and differentiated, with urban poverty in contrast to the rural form of poverty, in complex relations between housing markets, informality of labour, service accessibility, and spatial inequality. Urban poverty, in contrast to rural poverty, is usually marked by the high cost of living, insecurity in residential places, and not being formal labour market despite physical nearness to economic assets (Ravallion, 2002, UN-Habitat, 2020). Formless settlements, overpopulation, and lack of urban amenities have become part of the deprivation found in most Global South cities.

Urbanisation, population pressures, and disproportionate municipal capacity render urban poverty in the Arab region more complex. Empirical evidence points out that urban centres of the Arab region, including numerous mid-sized cities, can tend to overgrow informality and housing pressure and get less policy attention compared to capital or mega-cities (Bank, 2018, UN-ESCWA, 2019). These cities often have poor fiscal and institutional capacities to handle growing urban populations and, hence, are very susceptible to the traps of persistent poverty. The recent data indicate that the prevalence of slums and insufficient housing continues to be an alarming sign of the urban deprivation in North Africa and the Middle East

2.2. Digital Economy and Poverty: Conceptual Linkages

The digital economy, including information and communication technologies (ICTs) and mobile connectivity, and digital platforms, is a concept that has gained a large following as a possible driver of inclusive growth. In theory, digitalisation has the potential to alleviate poverty through a reduction in transaction costs, improved information flows, market access, and labour-market matching (Aker and Mbiti, 2010, Group, 2016). Especially, mobile technologies have been reported to increase access to financial services, aid in the growth of micro-enterprises, and enhance resiliency in low-income households through facilitating access to liquidity and reducing the susceptibility of households to income shocks (Jack and Suri, 2014, Donner and Escobari, 2010). Recent data indicate that spatial income inequalities can be significantly mitigated through digital financial inclusion because it will enhance access to financial services and economic opportunities, but these effects vary depending on the institutions and infrastructural situations (Huang et al., 2025).

The general evidence of developmental economies is that digital technologies have a role in reducing poverty. The earlier macro-level literature records growth-inducing impacts of telecommunications infrastructure (Röller and Waverman, 2001, Czernich et al., 2011), whereas the more recent studies indicate that mobile connectivity is also the cause of poverty reduction as it diversifies incomes and increases labour-market participation and access to various services (Suri and Jack, 2016, Kpodar and Andrianaivo, 2011). Research on the topic of mobile-based financial services demonstrates that mobile banking application helps to reduce poverty and eliminate inequality by increasing access to financial services and economic inclusion in developing economies (Asongu and Odhiambo, 2019). Emerging cross-country implications also indicate that digitalisation can fortify the financial inclusion channels, which subsequently promote inclusive growth and poverty reduction under institutionally conducive conditions (Basnayake et al., 2024).

On a micro level, household-based research proves the hypothesis that the digital and internet use correlate with the decrease in multidimensional poverty by an increase in access to information, job opportunities, and social services (Yang et al., 2021). The literature, however, also underlines that such effects are not consistent or automatic. Affordability, digital skills, regulatory frameworks, and

complementary institutions are key factors that determine the potential of digitalisation to reduce poverty (Hilbert, 2016, Van Dijk, 2020). The generated evidence is that, although digital connectivity may lead to significant economic values, the achieved welfare gains are much situational and usually tend to appear over time (Hjort and Tian, 2025).

2.3. Digital Divide and Urban Inequality

The digital economy has the potential to widen inequality, although initially it may seem counterintuitive, which is especially applicable to urban areas where access to digital infrastructure and skills is still unequal. The literature on the digital divide highlights the fact that low-income urban residents can be constrained by affordability, education, and digital literacy, which are the hindrances to technological advancement (Van Dijk, 2020, Hilbert, 2016). Consequently, digital growth can create unequal results, becoming beneficial to even more advantaged urban dwellers at the expense of disadvantaged groups.

In addition to the access restrictions, there are other structural mechanisms in which digitalisation can affect inequality. Empirical analysis suggests that digital financial inclusion alters industrial organisation and job set-ups, which means that the impacts of poverty and inequality are not immediate (Wen et al., 2024). It is these structural adjustment processes that can be used to understand why distributional effects of digitalisation have more significant effects in the long run and why short-run reactions can seem damped.

The digital divide in Arab cities cuts across income segmentation and neighbourhoods, with the informal settlements frequently being the least connected, less apt to use digital services and effective usage (UN-ESCWA, 2019). Digitalisation can therefore alleviate urban poverty, on certain institutional and policy terms, and adverse digital shocks, including the increase in service prices, uneven distribution, or reversal of policy, can have disproportionately harmful impacts on vulnerable cities. An increasingly comprehensive literature on reviews also emphasises that uneven and asymmetric welfare outcomes can be produced by incessant digital inequalities, which are caused by affordability, skills shortage, the quality of infrastructure, and institutional obstacles to digital adoption, especially where digital conditions worsen instead of improve (Raihan et al., 2025).

2.4. Asymmetric Effects and Nonlinearity in the Digital–Poverty Relationship

A key weakness of a large strand of the existing literature is its reliance on linear empirical frameworks, which implicitly assume that positive and negative changes in digitalisation exert symmetric effects on poverty. Recent advances in applied econometrics challenge this assumption, indicating that economic relationships may be nonlinear and asymmetric over time (Shin et al., 2014). Empirical evidence increasingly suggests that positive and negative shocks can generate markedly different long-run and short-run responses, particularly in emerging and developing economies characterised by structural rigidities and adjustment costs. Both macro-development and applied nonlinear ARDL literatures confirm that responses to economic shocks are often direction-dependent rather than symmetric.

For example, Acheampong et al. (2021) show that globalisation-related processes exert asymmetric impacts on economic outcomes, with adverse shocks generating faster and larger welfare losses than gains arising from favourable shocks (Acheampong et al., 2021). This insight is directly relevant to the digital economy–urban poverty nexus, where expansions in digital connectivity may yield gradual inclusion gains, while adverse digital shocks, such as rising service costs, uneven rollout, or technological exclusion, can impose more severe and persistent welfare burdens on vulnerable urban populations.

Methodologically, the NARDL framework provides a flexible approach for capturing such asymmetries by decomposing explanatory variables into positive and negative partial sums (Shin et al., 2014). Empirical applications of NARDL across development and macroeconomic contexts demonstrate that responses to shocks are systematically directional, highlighting the limitations of linear specifications (Bahmani-Oskooee and Aftab, 2017). Applied to digitalisation, this implies that positive expansions in connectivity may reduce poverty gradually through productivity and inclusion channels, whereas negative shocks can generate sharper and more immediate adverse effects, particularly in urban settings characterised by informality and weak social protection.

2.5. Research Gap and Contribution

To conclude, although there is an emerging literature review on the nexus of the digital economy and poverty, there are three gaps. To begin with, there has been a lack of focus on urban poverty processes in the Arab region, with the use of nationally similar urban indicators enabling a consistent time-series analysis of countries. Second,

the majority of available research is based on linear models of empirical studies without considering possible nonlinearities and asymmetries in response to digital shocks. Third, the literature is not rich in differentiating between long-term equilibrium changes and short-run adjustment processes in the digitalisation-urban-poverty nexus.

This research fills these gaps with the help of the ARDL and NARDL models to analyse the relationship between digital connectivity and urban poverty in Arab cities, which is supported by the country cases of Morocco and Tunisia, with annual indicators of urban areas that are constant. The ARDL framework enables long-run relations to be detected in small-sample conditions with mixed orders of integration, whereas the NARDL method explicitly accounts for the asymmetric impact of positive and negative digital shocks on policy-relevant and nuanced understandings of digital inclusion and reduction of urban poverty.

3. METHODOLOGY

3.1. Data And Variables

The research evaluates the association between the digital economy and urban poverty in the Arab urban context based on annual time-series data between 2000 and 2019. The case study empirical research is based on Morocco and Tunisia, two North African nations that are typified by intensive urbanisation, chronic urban informalities, and widening digital access, despite having divergent institutional and socio-economic contexts. Although the conceptual motivation is based on the issues that can be found within the context of the mid-sized cities, the lack of availability of pure data based on the long-term time-series at the city level seems to oblige the usage of nationally comparable urban indicators.

The proportion of the urban population in slums is a proxy of urban poverty, which represents multidimensional deprivation in terms of poor housing, inability to access basic amenities, and geographical marginalisation. The poverty measure is very common in the urban poverty literature and especially suitable in low and middle-income developing and middle-income contexts where income-based poverty measures might not reflect the structural face of urban deprivation (Ravallion, 2002, UN-Habitat, 2020).

Digital connectivity and the diffusion of information and communication technology (ICT) are measured with a proxy of the mobile cellular subscriptions per 100 individuals, which indicates the digital economy. The penetration of the mobile platform is often called a convenient way of assessing digitalisation in those environments where the broadband infrastructure is not even or complete (Aker and Mbiti, 2010, Group, 2016).

Both variables are then subjected to a natural logarithmic transformation and are estimated. The stabilisation of variance, reduction of heteroskedasticity, and the opportunity to interpret estimated coefficients as elasticities make this transformation possible to examine the percentage change in urban poverty as resulting from a percentage change in digital connectivity.

3.2. Econometric Framework

Since the relationship between the digital economy and urban poverty may be dynamic and nonlinear, the current research uses a mixed econometric model involving the Autoregressive Distributed Lag (ARDL) strategy of bounds-testing and Nonlinear ARDL (NARDL).

ARDL is best applied in small samples of time-series and enables the estimation of long-run relationships with variables that are integrated of mixed order I(0) and I(1) as long as none of them is integrated of second order, I(2) (Pesaran et al., 2001). The NARDL model builds on the linear ARDL model by clearly enabling the presence of a positive and negative asymmetry in the effects of positive and negative change in digital connectivity that is especially likely to be relevant in an urban context where digital expansions and contractions might have qualitatively different effects on vulnerable groups (Shin et al., 2014).

3.3. Unit Root Testing

The time-series characteristics of the log-transformed variables are tested with the help of augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Kwiatkowski-Phillips-Schmidt-Shin (KPSS) unit root tests before model estimation. The use of multiple tests contributes to the strength, where the ADF test and the PP test test the null hypothesis of a unit root, whereas the KPSS test assumes that the null is stationarity (Enders, 2015).

The findings suggest that the series remain stationary or stationary after a first-order difference, and none of them is order two integrated. The properties meet the requirements of the use of ARDL and NARDL models.

3.4. ARDL Bounds Testing and Long-Run Estimation

The ARDL bounds-testing methodology is used to determine whether there exists a long-run

relationship between urban poverty and digital connectivity.

The error-correction form of the log-log ARDL model is represented by the following unrestrained form:

$$\Delta\ln(UP_t) = \alpha_0 + \sum_{i=1}^{p-1} \alpha_i \Delta\ln(UP_{t-i}) + \sum_{j=0}^{q-1} \beta_j \Delta\ln(DE_{t-j}) + \phi_1 \ln(UP_{t-1}) + \phi_2 \ln(DE_{t-1}) + \varepsilon_t$$

Where $\ln(UP_t)$ denotes urban poverty, $ln(DE_t)$ is the digital economy proxy, Δ is the first-difference operator, p and q are lag lengths, and ε_t is an error term.

A significant value of the bounds critical values that reject the null hypothesis implies that there is a stable long-run relationship.

Provided that the two variables are cointegrated, the long-run elasticity of urban poverty to digital connectivity is derived as:

$$\theta = -\frac{\phi_2}{\phi_1}$$

Cointegration is tested via an F-test for the joint hypothesis:

$$H_0: \phi_1 = \phi_2 = 0$$

3.5. Error Correction Model and Short-Run Dynamics

Following the establishment of cointegration between the variables, short-run dynamics are analysed using an error-correction model (ECM) that links the short-run variations to changes in the long-run equilibrium:

$$\Delta\ln(UP_t) = \gamma_0 + \sum_{i=1}^{p-1} \gamma_i \Delta\ln(UP_{t-i}) + \sum_{j=0}^{q-1} \delta_j \Delta\ln(DE_{t-j}) + \lambda ECT_{t-1} + u_t$$

Where ECT_{t-1} is the lagged error-correction term derived from the long-run relationship, and γ Is expected to be negative and statistically significant, indicating convergence toward the long-run equilibrium following short-run shocks.

In a small sample, and with the possible conditions of heteroskedasticity or autocorrelation, the ECM is fit using Heteroskedasticity- and autocorrelation-consistent (HAC) standard errors (Newey West), with HC3 robust standard errors now provided as a robustness check.

3.6. Nonlinear ARDL (NARDL) And Asymmetric Effects

In order to investigate the hypothesis that digital connectivity is asymmetrical in its impact on poverty in urban areas, the analysis employs the framework of NARDL suggested by Shin et al. (2014).

The logarithm of digital connectivity is split into partial sums of positive and negative change:

$$\mathrm{Ln}(DE_t^+) = \sum_{k=1}^{t} \max(ln(\Delta DE_k, 0)), \ln(DE_t^-) = \sum_{k=1}^{t} \min(ln(\Delta DE_k, 0))$$

The nonlinear ARDL specification is then estimated as:

$$\Delta\ln(UP_t) = \alpha_0 + \sum_{i=1}^{p-1} \alpha_i \Delta\ln(UP_{t-i}) + \sum_{j=0}^{q-1} \beta_j^+ \Delta\ln(DE_{t-j}^+) + \sum_{j=0}^{q-1} \beta_j^- \Delta\ln(DE_{t-j}^-) + \phi_1 \ln(UP_{t-1})$$

Long-run asymmetric elasticities are computed as:

$$\theta^+ = -\frac{\phi_2^+}{\phi_1}, \theta^- = -\frac{\phi_2^-}{\phi_1}$$

The tests of asymmetry are formally conducted through Wald tests of the null hypothesis of symmetry in both the long-term and short-term.

3.7. Diagnostic And Robustness Considerations

In all the models estimated, routine diagnostic tests are done to determine the extent of serial correlation, heteroskedasticity, and general model adequacy. The excessive standard errors and the complementary ARDL specifications of linear and nonlinear nature enhance the reliability and credibility of the empirical results.

3.8. Methodological Contribution

The proposed study will help assess the digital economy-urban poverty nexus in Arab urban contexts in a systematic way by applying both log-log ARDL and nonlinear ARDL (NARDL) to present a comprehensive evaluation of this nexus in Arab urban contexts. The methodology provides the equilibrium relationships in the long run, and adjustment processes in the short run and asymmetric reactions to digital shocks, which have policy-relevant insights into digital inclusion and the reduction of urban poverty.

4. EMPIRICAL RESULTS

4.1. Descriptive Overview and Data Coverage

The empirical analysis is done using annual time series data of 2000-2019 on Morocco and Tunisia, with 20 observations on each country. These two nations are urban Arab contexts that are typified by endemic informality, growing digital accessibility, and urban service provision constraints. The balanced sample format makes cross-country comparison possible and is also able to make country-specific inferences without the pooling effect.

An urban slum population ratio is used to measure urban poverty, and mobile cellular subscriptions per 100 individuals are used to measure the digital economy. To enable the econometric estimation, both the variables have been transformed into natural logarithms (ln_slum and ln_mobile) to stabilise the variance and allow interpretation in terms of elasticity.

Table 1 reports the sample coverage. Both countries exhibit complete coverage over the study period.

Table 1: Sample Coverage (2000–2019).

Country	Observations	Start year	End year
Morocco	20	2000	2019
Tunisia	20	2000	2019

Fig 1 shows how there have been an increase in digital connectivity and urban poverty over time. The level of mobile penetration in both nations rose at a high rate, and the proportion of the urban population in slums decreased gradually but with varying rates.

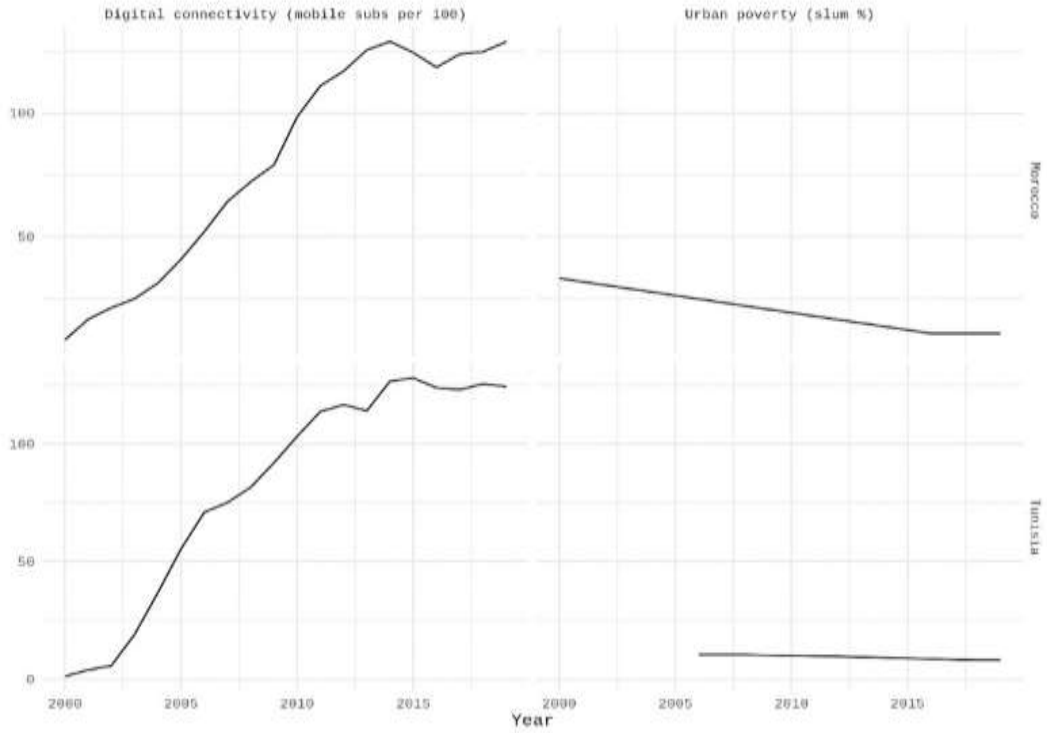

Fig 1: Time-Series Trends of Urban Poverty and Digital Connectivity (2000–2019).

Notes: Urban poverty is measured as the share of the urban population living in slums; digital connectivity is proxied by mobile cellular subscriptions per 100 people. Tunisia's slum series contains missing observations in early years; plots reflect available data.

4.2. Unit Root Test Results

The time-series nature of the log-transformed variables (ln slum and ln mobile) is analysed through the use of the Augmented Dickey Fuller (ADF), Phillips-Perron (PP), and KPSS tests before model estimation. The application of several tests makes the study more robust, as the ADF and PP test the null hypothesis of unit root, and the KPSS tests the null hypothesis of stationarity.

According to Table 2, the two independent variables in Morocco and Tunisia are (according to ADF and PP) non-stationary in levels and KPSS non-level stationary at traditional levels of significance. Once the series are first differentiated, then all the series become stationary. Notably, the variables are not integrated of order two; and hence meet the

preconditions of ARDL and NARDL estimation.

Table 2: Unit-Root Tests (Levels, Log Variables).

Country	Series	ADF p-value	PP p-value	KPSS p-value	Conclusion
Morocco	ln_slum	0.406	0.668	0.010	I(1)
Morocco	ln_mobile	0.731	0.888	0.014	I(1)
Tunisia	ln_slum	0.920	0.796	0.030	I(1)
Tunisia	ln_mobile	0.904	0.987	0.042	I(1)

4.3. ARDL Model Selection and Cointegration Analysis

4.3.1. Lag Order Selection

Akaike Information Criterion (AIC) is used to pick the best lag lengths. The preferred specifications are ARDL (2, 2) in the case of Morocco and ARDL (1, 1) in the case of Tunisia. These lag structures are sufficiently accurate as far as dynamic persistence identification is concerned, and they maintain degrees of freedom in small samples.

Table 3: Selected ARDL Specifications and Short-Run Coefficients (Log–Log Models).

Morocco – ARDL (2,2)		
Variable	Coefficient	p-value
ln_slum(t-1)	1.293	<0.001
ln_slum(t-2)	−0.437	0.036
ln_mobile	0.248	0.041
ln_mobile(t-1)	−0.289	0.019
Tunisia – ARDL (1,1)		
Variable	Coefficient	p-value
ln_slum(t-1)	0.931	<0.001
ln_mobile	−0.076	0.002

4.3. ARDL Bounds Test for Cointegration

To test the presence of a long-run relationship between digital connectivity and urban poverty, the ARDL bounds-testing procedure is used. The calculated F-values of Morocco and Tunisia are 7.229 (p = 0.016) and 9.895 (p = 0.00195), respectively, which are greater than the upper critical values at the 5% significance level, confirming the existence of cointegration.

Table 4: ARDL Bounds Test and Long-Run Relationship (Log–Log).

Country	ARDL (p,q)	Bounds F	p-value	Cointegration	Long-run elasticity
Morocco	(2,2)	7.229	0.016	Yes	−0.286
Tunisia	(1,1)	9.895	0.002	Yes	−1.099

4.4. Long-Run ARDL Estimates (Elasticities)

The models of long-run elasticities are obtained based on the ARDL models, conditional on cointegration. The relationship between digital connectivity and urban poverty is statistically significantly negative in both countries in the long run.

In the case of Morocco, the estimated value of -.286 elasticity means that a 1 per cent increase in mobile connectivity lowers the percentage share in the urban slums by about 0.29% in the long run. In the case of Tunisia, the elasticity is significantly high at -1.099, which means that an increase in mobile connection by 1% is correlated with a 1.10% decrease in urban poverty.

The results indicate that the digital growth has a significant influence on the reduction of urban deprivation, and the long-run impact seems to be more powerful in Tunisia in the time frame of the study.

4.5. Short-run dynamics and error-correction results

Short-run dynamics are being analysed based on error correction models (ECM) obtained based on the ARDL specifications. Under HAC inference, Table 5 reports that an error-correction term (ECT) is negative and significantly different in both countries, which indicates that deviations from the long-run equilibrium are corrected over time following short-run shocks.

Table 5: Error-Correction Model (ECM) Results (HAC And HC3).

Country	Term	Estimate	p-value (HAC)

Morocco	ECT(t-1)	−0.142	0.028
Tunisia	ECT(t-1)	−0.067	<0.001

The estimated adjustment speeds show that about 14% of the disequilibrium is being corrected at an annual rate in Morocco, and Tunisia is doing the same, much slower, at around 7% per year. HC3 inference is more conservative, especially in the case of Morocco, which is sensitive to small samples but does not reverse the general findings.

4.6. Nonlinear ARDL (NARDL) Results

4.6.1. NARDL Cointegration Tests

Bound tests on the nonlinear ARDL specifications reject the null of no cointegration in both countries. The F-values of Morocco and Tunisia are 65.443 ($p<0.001$) and 8.474 ($p = 0.0009$), and hence, nonlinear long-run relationships are stable.

4.6.2. Asymmetric Effects and Dynamic Behaviour

According to the estimates of the NARDL, it is clear that there is great asymmetry in Morocco. The asymmetry tests in the long run are powerful to reject the symmetry under HAC and HC3 inference, which means that the negative digital shocks have disproportionately more significant impacts on urban poverty relative to the positive ones.

In the case of Tunisia, asymmetry is statistically significant when inferred using HAC but not when using HC3, indicating weaker and weaker nonlinear dynamics.

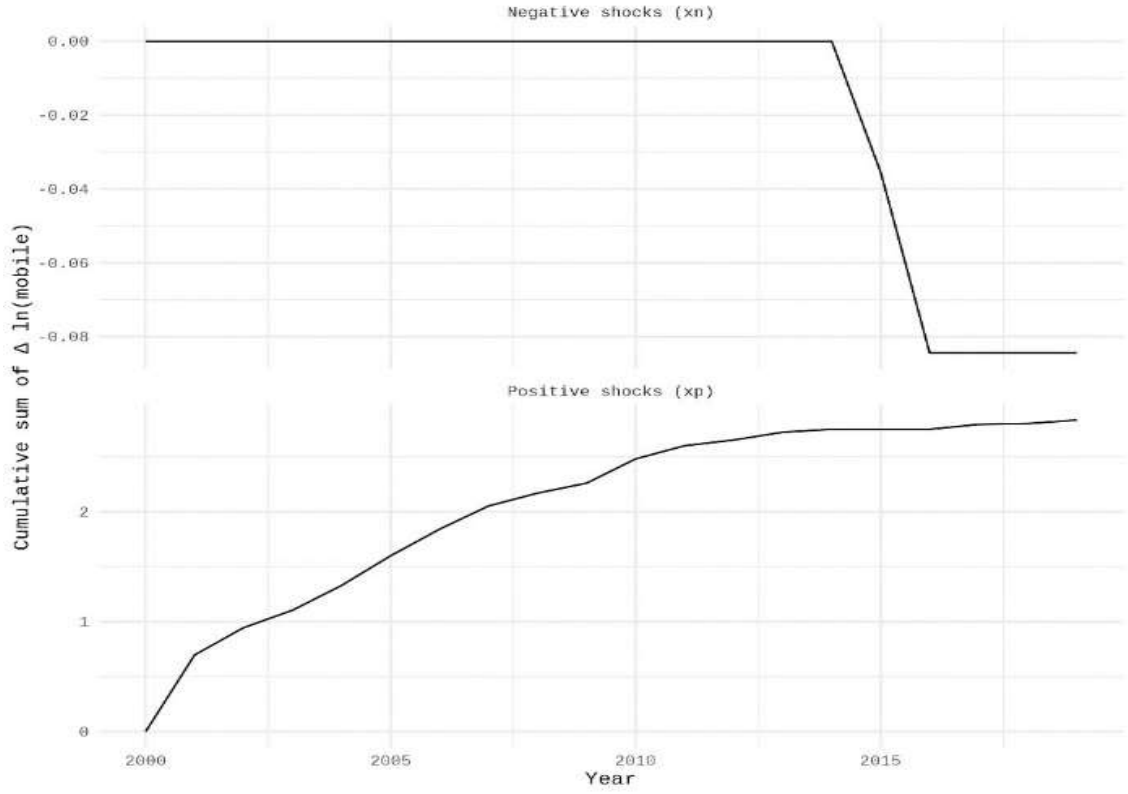

Fig 2: NARDL Partial Sums for Digital Shocks (Morocco).

Notes: The Figure Shows Cumulative Positive (Xp) And Negative (Xn) Partial Sums Constructed from Changes in Ln (Mobile Connectivity).

4.6.3. Wald Tests for Asymmetry

Formal Wald tests reveal a strong long-run asymmetry in Morocco, whereas they give weak evidence of asymmetry in Tunisia.

Table 6: NARDL Cointegration and Asymmetry Tests.

Country	Bounds F	p-value	Asymmetry (HAC)	Asymmetry (HC3)	Interpretation
Morocco	65.443	<0.001	<0.001	0.023	Strong asymmetry

4.7. Diagnostic And Robustness Checks

According to the diagnostic tests, there is good performance among specifications. Strong standard errors (HAC, HC3) are the mitigation of the heteroskedasticity and small-sample bias. The similarity of the results obtained in the framework of ARDL, ECM, and NARDL gives the results of the empirical analysis more weight.

4.7.1. Summary Of Key Findings

Four main findings emerge. First, digital connectivity and urban poverty are cointegrated in both Morocco and Tunisia using log-log ARDL and NARDL. Second, the long-run impacts of digital expansion are that it decreases urban poverty, where the elasticities of Morocco and Tunisia were found to be -0.286 and -1.099. Third, it is slow to adjust towards an equilibrium, and convergence rates in Morocco and Tunisia are about 14% and 7% per year, respectively. Fourth, the asymmetry of digital shocks in Morocco is much stronger, as compared to the signs of asymmetry in Tunisia, which are not very strong and cannot be inferred conservatively.

5. DISCUSSION

5.1. Long-Run Effects of the Digital Economy on Urban Poverty

Empirical findings are strong enough to the point that the growth of the digital economy is linked to the enduring decrease in urban poverty in Morocco and Tunisia. The existence of cointegration between digital connectivity and the urban slum population share confirms that digitalisation is not merely associated with short-term fluctuations in urban deprivation, but instead forms part of a stable long-run structural relationship that determines urban living conditions.

The long-run elasticities estimations of the log-log ARDL models show that the proportions of the urban population residing in slums have statistically and economically significant and negative links with increases in mobile connectivity. The mobile connectivity has a negative association with urban slum prevalence in Morocco (1%) and Tunisia (0.29%). These results can be correlated with the literature on the conceptualisation of digital infrastructure as an enabling input that enhances labour-market matching, access to information, financial inclusion, and service delivery, especially when the situations are informal and characterised by institutional limitations (Aker and Mbiti, 2010, Group, 2016). They also correlate with the recent findings according to which digitalisation enhances inclusion-related channels, in particular, financial inclusion, which statistically contribute to poverty reduction (Basnayake et al., 2024). Additionally, the micro-level data also indicate that the access-to-opportunity processes can also mediate the relationships between digital and internet use and multidimensional poverty outcomes (Yang et al., 2021), which supports the overall plausibility of the connectivity-deprivation relationship when urban poverty is measured through housing informality.

Evidence across countries also supports the idea that financial inclusion is systematically related to reduced poverty and income inequality, especially the cases where the connection is not limited to basic connectivity but is based on the effective and sustained utilisation (Saka et al., 2025). This greater empirical conformity enhances the external validity of the long-run elasticities of Morocco and Tunisia.

The higher long-run elasticity in Tunisia implies that digital connectivity can be a comparatively bigger influence on the urban poverty outcomes in the presence of a facilitative institutional or socio-economic environment. According to previous studies, the poverty-mitigating impact of ICT relies on other complementary aspects, including affordability, regulatory policies, and human capital (Hilbert, 2016, Van Dijk, 2020). In this regard, cross-country variations in elasticities are probably associated with heterogeneity in the translation of digital access to inclusive urban outcomes but not with variations in digital diffusion.

Notably, the findings support the perception that digitalisation helps reduce poverty mostly by enhancing structural changes but not direct welfare benefits. This goes in line with macro-development findings that the advantages of ICT diffusion become realised in the long-term as labour markets, service delivery, and household strategies adjust to new technological settings (Kpodar and Andrianaivo, 2011, Group, 2016). The recent synthesis literature is in line with this argument, stating that connectivity can have significant economic effects, yet realised benefits are highly contextual and subject to complementary conditions (Hjort and Tian, 2025). This interpretation is also confirmed by other developing regions, which suggests that financial inclusion can be an efficient channel to poverty reduction when it is incorporated into the right regulatory and institutional setting (Rubio and León, 2025).

5.2. Short-Run Dynamics and Speed of Adjustment

The outcomes of the error-correction also help to

shed light on the dynamism of the relationship between the digital economy and urban poverty. The variable error-correction in the two countries is negative and statistically significant when using HAC inference, which confirms that long-run equilibrium correction errors are corrected with time and establishes the consistency of the estimated relationships.

Nonetheless, the rate at which it is adjusted is quite sluggish, with an estimate of 14% of the disequilibrium having been corrected every year in Morocco and 7% in Tunisia. These magnitudes imply that digital connectivity shocks are not immediately converted into urban poverty. Rather, change comes in step-by-step progressive responses of households, labour markets, and urban institutions to changing digital conditions.

This is in line with the literature on urban development focusing on how urban cities of the Global South continue to experience housing informality, spatial exclusion, and service deficits (Ravallion, 2002, UN-Habitat, 2020). Policy-wise, the slowness of the process of adjustment highlights the shortcomings of digital responses at a short-term level. Although investing in digital infrastructures can create political awareness, the poverty alleviating impact takes a long-term commitment and needs to be accompanied by other reforms. It is also in line with the general data that connectivity-based benefits are generally realised over time and are reliant on the compatibility of investments and institutional capability (Hjort and Tian, 2025).

5.3. Asymmetric Digital Shocks and Urban Vulnerability

One of the key contributions that this paper provides is the direct analysis of asymmetric digital shocks in terms of the NARDL model. The findings indicate that Morocco has significant and strong asymmetry, as negative digital shocks have significantly greater long-run impacts on urban poverty compared to positive digital expansions.

This imbalance implies that any urban populations that are vulnerable, including an increase in costs of services and uneven coverage of infrastructures, or technological exclusion, can be adversely affected by such changes. Negative digital shocks in informal urban areas, where mobile connectivity generates income, serves as a job search tool, remittance flows, and provides access to government services, can quickly turn into even greater housing insecurity and vulnerability to slums.

Conversely, positive digital expansion is found to decrease urban poverty at a lower rate, which is an adjustment cost, institutional bottleneck, and access inequality. This tendency fits into the nonlinear development research that the losses in welfare due to adverse shocks tend to manifest themselves faster and more acutely than the benefits of positive shocks (Acheampong et al., 2021). Also, it is consistent with applied nonlinear ARDL information in corresponding macro relationships with responses that vary materially by direction of shocks (Bahmani-Oskooee and Aftab, 2017).

In the case of Tunisia, asymmetry is not robust in the face of conservative inference, indicating that Tunisia is responding more to digital expansions and contractions in a balanced way. Such a difference could be associated with fewer social protection mechanisms, regulatory settings, or digital market institutions that alleviate extreme welfare effects. Collectively, these findings indicate that regional approaches to digital policies should be implemented in context-specific ways, as opposed to a generalised approach.

5.4. Policy Implications for Urban Development and Digital Inclusion

These findings have a number of critical implications for digital and urban policy in Arab contexts. To begin with, digital expansion can reduce poverty in the long run, but digital connectivity cannot be used to solve deep-rooted urban deprivation. Its success is contingent on the complementary investment of housing, education, access to the labour force, and access to the city service provision.

Second, the existence of asymmetric outcomes highlights the necessity of policies that would shield vulnerable groups of people against adverse digital shocks. The potential solution is regulatory control of the prices of digital services and investments into universal access and specific digital literacy programmes to mitigate the negative effect of technological change on welfare. Ensuring the channels towards inclusion (e.g., digital financial inclusion) can supplement the pathways to poverty reduction (Basnayake et al., 2024).

Third, policy continuity and patience can be noted because of the slowness of the adjustment. Short-term assessments can be overly optimistic about the gains of digital investments, and found the possibility of early policy reversals that might eventually lead to a worsened urban poverty.

5.5. Limitations

This study has limitations. First, the analysis is

based on nationally comparable urban indicators, as there is no consistent long-run city-level time-series data, which cannot be used to determine the heterogeneity within a city or isolate the concept of mid-sized cities. Second, mobile subscriptions per 100 people are the proxy of digitalisation, and they fail to reflect the quality of broadband, the speed of mobile internet, platform use, and digital proficiency. Third, small-sample time-series limitations restrict the number of extra controls and imply that the findings can be taken as country-case proves, but not country-wide approximations.

5.6. Directions For Future Research

The future work should focus on (i) sub-national or urban-level panels as this will isolate the mid-sized cities and large metropolitan areas (ii) a broader measure of digitalisation (mobile broadband, internet quality, digital financial inclusion, platform uptake), and (iii) institutional moderators (e.g., affordability regulation, housing policy intensity, urban upgrading programs) that can identify cross-country heterogeneity. The evidence of high-quality review suggests that connectivity effects may be significant but rely on context and complementary circumstances, which supports the importance of the next step (Hjort and Tian, 2025).

6. CONCLUSION

This paper explored how the digital economy influences urban poverty in Arab urban contexts through linear and nonlinear ARDLs that were implemented in Morocco and Tunisia between the years 2000 and 2019. The results have a strong indication of a fixed relationship in the long run between digital connectivity and urban poverty, where expansion of digital connectivity is linked to a substantial decrease in the proportion of urban slum dwellers. This can be explained by a slow adjustment towards equilibrium with a statistically significant adjustment change in the short run, which is structural in character due to digitalisation-induced poverty changes. Notably, the nonlinear analysis shows that there is a lot of asymmetry in Morocco, as negative digital shocks have significantly bigger long-run effects on urban poverty than negative digital expansions, whereas Tunisia has more symmetric responses. On balance, the findings prove that digitalisation can contribute to the reduction of urban poverty in Arab situations, yet only when integrated into inclusive, resilient, and institutionally supportive urban development policies.

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