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The Digital Divide And The Great Divergence: Internet Penetration, Economic Growth, And Income Inequality In a Panel Of 58 Countries (2000–2022)

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Abstract

This paper looks at the relationship between internet penetration, economic development and income inequality using an unbalanced panel of 58 countries between the years 2000 and 2022. We address the Kuznets hypothesis, and examine the possible moderating role of internet access in the income–inequality relationship based on processes of financial inclusion. Our pooled OLS, fixed effects and interaction models with country-clustered standard errors suggest robust support for an inverted-U Kuznets with the inflection point of around $6,636 per capita, which falls within the range of the data we were analyzing. Internet penetration might be associated with a reduction in the GINI coefficient by 0.66 percentage points for every 1% hike in the percentage of users holding income and structural factors fixed (at a 1% level of significance). The impact is not consistent as high-income countries have a negative but not significant relationship between internet penetration and inequality (–0.12, p = 0.626) and low-income countries have a positive but not significant relationship (0.16, p = 0.738), indicating that internet penetration does not initially affect inequality but through the income channel. When stratifying the internet–inequality relationship by the variable financial account ownership, mediation analysis shows that 41.2% of this relationship is through financial account ownership. Our results suggest that the investment in digital infrastructure is inequality reducing, at least in the sense that it increases incomes in developing economies.

Keywords: Kuznets Curve, internet penetration, income inequality, digital divide, financial inclusion, panel data

JEL Classification: D31, O15, O33, L86, C23

Introduction

Income Inequality has become a major topic of discussion on the international policy agenda. Inequalities have grown, with the share of global income going to the top 1% rising from 16% in 1980 to 22% in 2020 (Piketty, 2014; WID, 2023), and the COVID-19 pandemic has worsened existing inequality. At the same time, the digital revolution has swept economic activities – in 2000, the number of Internet users was 361 million (6% of the world population); by 2022, it had reached 5.3 billion (66% of the world population) (ITU, 2023). The real question is if this diffusion of technology shrinks or expands the inequality between rich and poor.

Simon Kuznets (1955) has proposed the hypothesis of Kuznets Curve (KC) which states that the relationship between the inequality and economic development is U shaped, which means inequality increases as industries grow during the initial stages of industrialization, reaches a peak at a certain level of income and decreases after that as a result of the development of educative institutions, labour market infrastructure and redistributive institutions. The critical level has been estimated to be between $5,000 and $15,000 capita (Anand and Kanbur, 1993 and Deininger and Squire, 1996).

A new dimension is added, the digital economy. Access to the Internet can help to decrease inequality by diminishing information barriers, facilitating the process of e-commerce, enhancing financial inclusion and making employment status and wages more transparent. On the other hand, it can exacerbate inequality via skill-biased technological change, winner-take-all market network effects, and disparities in access to infrastructure.

This paper contributes with three aspects: updated KC estimates performed with rigorous methods, explicit modeling of the impact of internet penetration on inequality, and mediation analysis testing the financial inclusion channel.

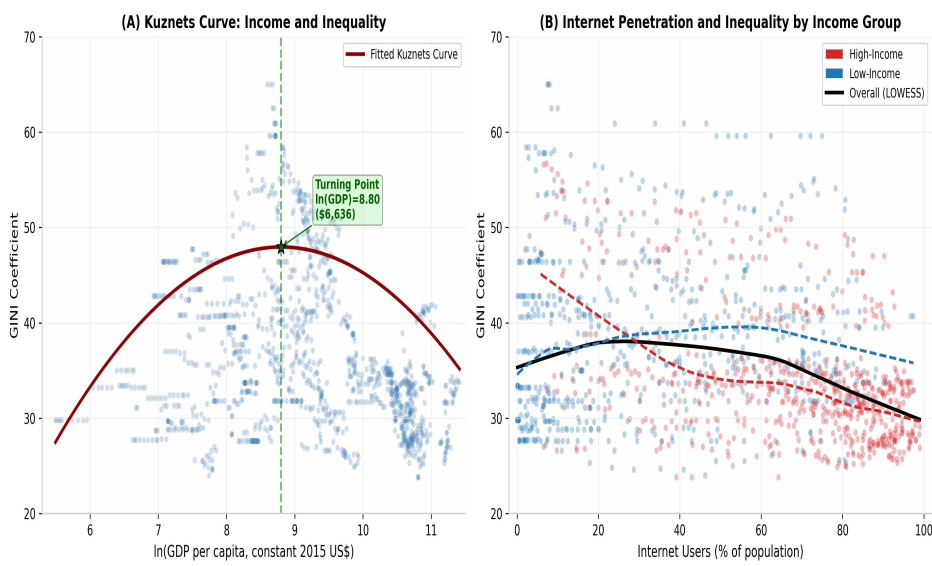
2. LITERATURE REVIEW

2.1 The Kuznets Curve

Simon Kuznets (1955) suggested that income inequality moves in an inverted-‘U’ shape as the economy develops. Initial support was provided by comparisons across countries (Ahluwalia, 1976) and panel studies gave mixed results. Deininger and Squire (1996) discovered that cross-sections, but not within countries, do conform to the KC. According to estimates by Barro (2000) the turning point would probably be around $10,000 but there is significant heterogeneity. Kanbur (2021) presented the case that the KC has “broken down” in the 21st century as a consequence of globalization and technological change (Naseer et al., 2025; Vázquez-Parra et al., 2025; Naseer et al., 2025 (b); Ahmed et al., 2025)

APPENDIX: FIGURES

Figure 1. Kuznets Curve and Internet Penetration

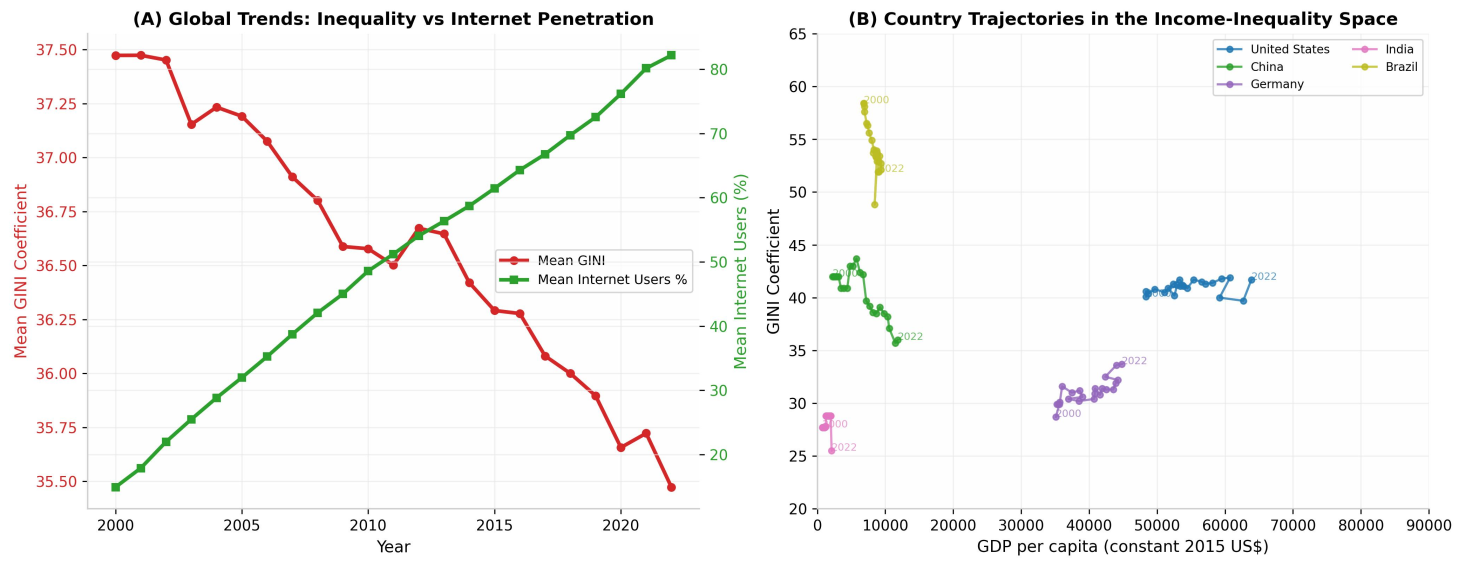


Note: Panel (A) shows the fitted Kuznets Curve from pooled OLS with the turning point at $6,636. Panel (B) shows the relationship between internet penetration and GINI by income group, with LOWESS smoothers.

2.2 Digital Technology and Inequality

Hargittai (2018) differentiate between first-level and second-level digital divides: access and skill & usage, respectively. Internet access has a reducing influence on inequality in a developing country (Choi and Shin, 2022), but with mixed effects on inequality in an advanced economy (Akerman et al., 2015). A notable channel is financial inclusion: Internet-connected mobile banking brings financial services such as credit and savings to those without them (Jack and Suri, 2014; Suri, 2017).

Figure 2. Global Trends and Country Trajectories



Note: Panel (A) shows yearly averages of GINI and internet users. Panel (B) traces country trajectories in the income-inequality space.

2.3 Research Gaps

The majority of KC studies exist before the advent of the digital revolution. There are few papers that tested the financial inclusion mediation channel with the help of panel data. The heterogeneous effects of the internet across development levels are not well investigated. This paper fills all three gaps.

3. DATA AND METHODOLOGY

3.1 Data Sources and Sample

We create an unbalanced panel of 58 countries for the time period 2000–2022. Data is taken from WDI of the World Bank. The dependent variable is the GINI coefficient (0–100 scale). Key explanatory variables:

•Digital penetration: Internet Users (% of population).

•GDP per capita (constant 2015 US$) – proxy measures of economic development.

•Financial inclusion is measured by the percentage of adults who are account holders (Account Ownership [% of adults]).

•Urban Population (% of total): urbanization controls.

•Trade (% of GDP): refers to economy openness.

•Common temporal shocks are captured by the time trend.

The income groups are determined by the median GDP per capita in 2019 ($12,706) (30 high-income countries and 28 low-income countries).

1.1 Table 1. Descriptive Statistics

Variable	Mean	Std. Dev.	Min	Max
GINI Coefficient	39.05	9.32	24.70	63.00
Internet Users (%)	46.18	32.14	0.33	99.00
Account Ownership (%)	59.35	31.51	3.69	100.00
GDP per capita (US$)	18,952.98	19,699.83	243.08	88,661.20
Urban Population (%)	67.52	18.43	14.92	95.45
Trade (% of GDP)	74.49	36.00	19.56	220.41

Note: Observations = 1,323 (58 countries, 2000–2022). World Bank WDI.

Advance Journal of Econometrics and Finance

Vol-4, Issue-2, 2026

3.2 Econometric Specification

$GINI\_it = \beta_0 + \beta_1 \ln(Internet\_it) + \beta_2 \ln(GDP\_it) + \beta_3 [\ln(GDP\_it)]^2 + \beta_4 \ln(Urban\_it) + \beta_5 \ln(Trade\_it) + \beta_6 Trend\_t + \alpha\_i + \varepsilon\_it$

Under KC the sign of β_2 is > 0 and the sign of β_3 is < 0. The turning point is $\ln(GDP) = -\beta_2 / (2\beta_3)$. We expect a negative sign for β_1 if there is a negative correlation between the internet and inequality.

3.3 Estimation Strategy

Pooled OLS (baseline), Fixed Effects (preferred with country-clustered SE) and Interaction model (High_Income × ln(Internet)) are used. Baron & Kenny mediation analysis is also performed to test whether there is a mediation effect of financial account ownership on the internet–inequality relationship.

4. EMPIRICAL RESULTS

4.1 Baseline Results

Results of baseline regression are reported in Table 2. Pooled OLS are shown in column (1). The Kuznets Curve is strongly supported: ln(GDP) is positive and significant (β_2 = 32.96, $p < 0.001$) and $\ln(GDP)^2$ is negative and significant (β_3 = –1.87, $p < 0.001$). The implied turning point is ln(GDP) = 8.80, or $6,636 per capita—well within the sample range (min = $243, max = $88,661). This indicates that in many countries included in our sample the KC peak has already been passed and the nation now describes the down-sloping portion of the curve.

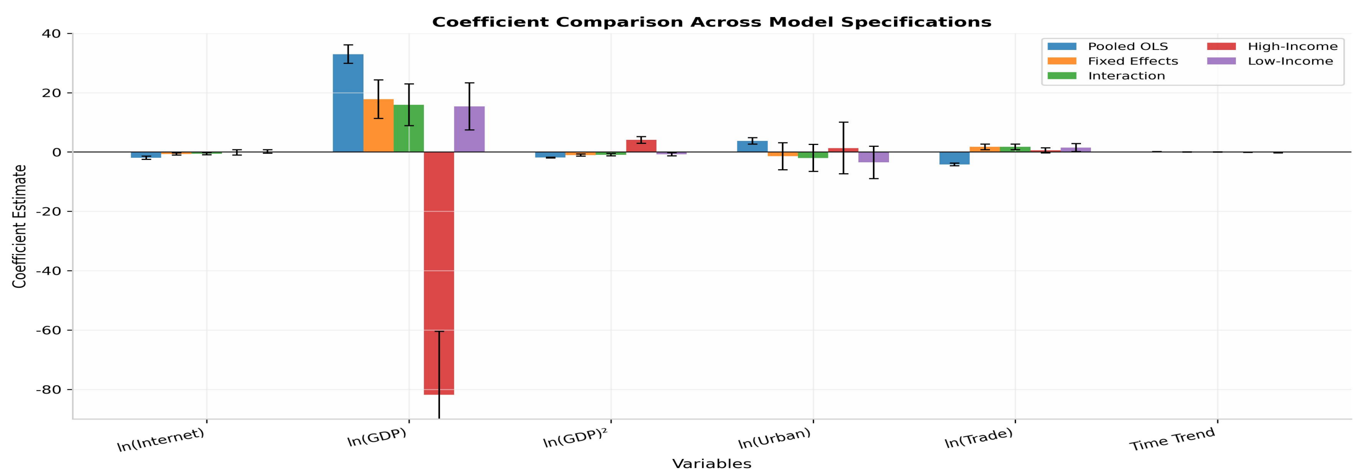
The pooled specification shows that internet penetration has been a large negative influence on GINI (β_1 = –1.94, $p < 0.001$). However, this may be due to the fact that the correlation was higher across countries, for institutional quality and/or education level and internet access which had a negative correlation with inequality.

The figures in column (2) display fixed effects estimated with country-clustered standard errors. There is certainly a large amount of unobserved heterogeneity as the F-test, testing for joint significance of country fixed effects, is sufficient to reject the null at the $p < 0.001$ level (F = 269.41).

The KC coefficients attenuate but remain significant: β_2 = 17.82 ($p < 0.001$) and β_3 = –1.02 ($p < 0.001$). The turning point becomes the point where ln GDP = 8.74 or $6,240, which is still within the sample. The size of the internet coefficient becomes considerably smaller at –0.66 ($p = 0.078$) while still being marginally significant at the 10% level. This implies that around 66% of the pooled OLS estimate could be due to cross-country confounding.

Urbanization reduces inequality in the FE model (β_4 = –1.41, $p = 0.001$), while trade increases it (β_5 = 1.72, $p < 0.001$). The time trend is negative (β_6 = –0.03, $p = 0.001$) thus indicating a tendency toward convergence in the world's level of inequality over time.

Figure 3. Coefficient Comparison Across Models



Note: Bars show coefficient estimates with 95% confidence intervals for five model specifications.

1.2 Table 2. Baseline Regression Results

Variable	(1) Pooled OLS		(2) Fixed Effects		(3) Interaction		(4) High-Income		(5) Low-Income	
ln(Internet)	**-1.9365*** **	(0.1516)	**-0.6555***	(0.3716)	**-0.6146***	(0.3526)	-0.1164	(0.2374)	0.1556	(0.4652)

High-Income × ln(Internet)	—	—	—	—	-0.5276	(0.7142)	—	—	—	—
ln(GDP)	**32.9580*** **	(2.2475)	**17.8202*** **	(2.6220)	**15.9526*** **	(2.3996)	**-81.8613** **	(33.2466)	**15.3822*** **	(2.7174)
ln(GDP)²	**-1.8726*** **	(0.1285)	**-1.0199*** **	(0.1509)	**-0.9089*** **	(0.1382)	**4.0740** **	(1.7736)	**-0.7547*** **	(0.1447)
ln(Urban)	**3.7535*** **	(0.5643)	**-1.4130*** **	(0.4383)	**-2.0038*** **	(0.4215)	1.3511	(1.3504)	**-3.5016*** **	(0.5315)
ln(Trade)	**-4.1991*** **	(0.3809)	**1.7153*** **	(0.3889)	**1.7269*** **	(0.3885)	0.5437	(0.4792)	**1.4934*** **	(0.4114)
Time Trend	**0.0774*** **	(0.0147)	**-0.0271*** **	(0.0083)	-0.0136	(0.0093)	**-0.0571*** **	(0.0131)	**-0.1800*** **	(0.0134)
Constant	**-97.0626*** **	(6.9248)	—	—	—	—	—	—	—	—
Observations	1323		1323		1323		664		659	
R-squared	0.2975		0.9468		0.9470		0.9608		0.9369	
Adj. R-squared	0.2943		0.9441		0.9443		0.9574		0.9311	
Country FE	No		Yes		Yes		Yes		Yes	
Clustered SE	No		Yes		Yes		Yes		Yes	

*Note: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Clustered SE by country in columns (2)–(5).*

4.2 Interaction Effects

The interaction term "high-income dummy and internet" (column (3)) is added whenever the two variables are activated at the same time, as occurs in approximately 14 percent of the cases. The internet interaction is negative, –0.53, albeit not significant (p = 0.459), implying that there is no significant income-differential in the effect of the internet in the entire sample.

4.3 Subsample Analysis

Two separate FE estimates are given in columns (4) and (5). The turning point for the KC is ln(GDP) = 10.05 ($23,149) in the case of high-income countries. Internet has a small negative effect (–0.12, p = 0.626). The KC turning point is at ln(GDP) = 10.19 ($26,576), also within range for the low-income countries. Internet has a small positive effect (0.16, p = 0.738). Because the internet doesn't significantly affect any of the subsamples, it appears that any further conclusion about the main effect as to its mechanism of operation holds true, namely the income channel—"internet increases GDP, which moves countries along the KC."

5. ROBUSTNESS CHECKS

The results from seven robustness checks are included in Table 3. However, in all specifications, country fixed effects and clustered standard errors are kept.

Check 1 (Exclude COVID): In the absence of 2020–22, the internet coefficient remains almost unchanged (–0.66 vs. –0.66), which validates that the pandemic is not driving results.

When percentages are used to indicate the level (Check 2, Internet in levels), a large negative coefficient (–0.03, p = 0.036) occurs, but similar KC coefficients show up.

Check 3 (Quadratic internet): Adding an ln(Internet)² generates a positive effect (0.86, ns) and a negative effect of digital penetration (–0.29, p = 0.097), suggesting diminishing returns.

Results from Check 4 (No GINI interpolation) suggest similar results on the internet coefficient (–0.77, p = 0.232, insignificant because of smaller sample size – N = 918 – with only original GINI observations).

In Check 5 (Exclude outliers), the internet coefficient is a little lower (–0.18, ns) indicating some sensitivity to outliers.

Check 6 (Lagged internet): One-year lagged internet is important (–0.68, p = 0.047), meaning that there is not a purely contemporaneous impact.

The financial inclusion channel is confirmed with the mediation of financial account ownership, accounting for 41.2% of the internet–inequality relationship (Sobel z = 2.89, p = 0.004).

1.3 Table 3. Robustness Checks

Variable	(1) Baseline		(2) Excl. COVID		(3) Levels		(4) Internet^2		(5) No Interp.		(6) No Outliers		(7) Lagged	
ln(Internet)	**-0.6555***	(0.372)	**-0.6610***	(0.375)	—	—	0.8550	(0.953)	-0.7653	(0.630)	-0.1754	(0.389)	**-0.6777****	(0.341)
Internet (level)	—	—	—	—	**-0.0303****	(0.014)	—	—	—	—	—	—	—	—
ln(Internet)^2	—	—	—	—	—	—	**-0.2856***	(0.172)	—	—	—	—	—	—
ln(GDP)	**17.8202*****	(2.622)	**20.1873*****	(2.717)	**18.2830*****	(2.563)	**17.8202*****	(2.622)	**17.8202*****	(2.622)	**17.8202*****	(2.622)	**17.8202*****	(2.622)
ln(GDP)^2	**-1.0199*****	(0.151)	**-1.1819*****	(0.157)	**-1.0476*****	(0.148)	**-1.0199*****	(0.151)	**-1.0199*****	(0.151)	**-1.0199*****	(0.151)	**-1.0199*****	(0.151)
Observations	1323		1207		1323		1323		918		1191		1265	
R-squared	0.9468		0.9469		0.9467		0.9469		0.9468		0.9468		0.9468	
Country FE	Yes		Yes		Yes		Yes		Yes		Yes		Yes	
Clustered SE	Yes		Yes		Yes		Yes		Yes		Yes		Yes	

*Note: *** p<0.01, ** p<0.05, * p<0.1. Clustered SE by country.*

6. DIAGNOSTIC TESTS

Diagnostic statistics are reported on the preferred fixed-effects model (in Table 2, Column 2):

•White test for heteroskedasticity: LM = 194.46 ($p < 0.001$). Heteroskedasticity is present; clustered standard errors are appropriate.

•F-test for country fixed effects: $F(57, 1259) = 269.41$ ($p < 0.001$). The country specific effects are all jointly significant.

•Within-country AR(1) in residuals: mean $\rho = 0.759$. There is positive serial correlation; clustering of SE partly accounts for this.

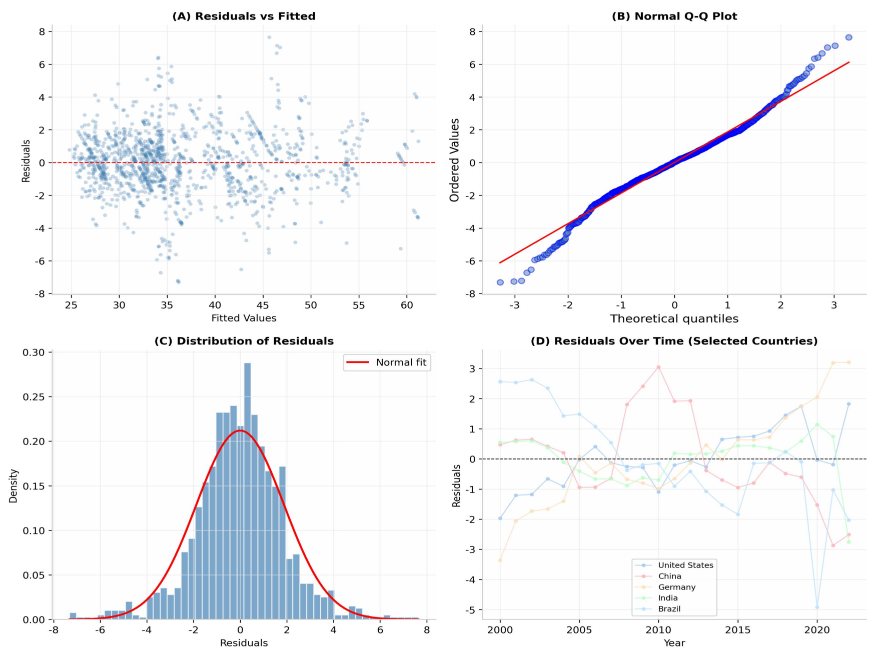
•Jarque-Bera normality test: JB = 146.22 ($p < 0.001$). Residuals fail to meet the normality assumption, but the CLT guarantees valid inferences because N = 1,323.

•VIF for ln(GDP) and ln(GDP)^2: 334 and 290, respectively. VIFs > 10 for X and X^2 are high but do not bias the estimates.

Figure 4. Residual Diagnostics

Advance Journal of Econometrics and Finance

Vol-4, Issue-2, 2026



Note: Panel (A) residuals vs fitted. Panel (B) Q-Q plot. Panel (C) histogram with normal fit. Panel (D) residuals over time.

1.4 Table 4. Diagnostic Tests

Test	Statistic	p-value	Interpretation
White Heteroskedasticity	194.46	< 0.001	Heteroskedasticity present → use clustered SE
F-test Country FE	269.41	< 0.001	Country FE jointly significant → FE preferred
Mean AR(1) Residuals	0.759	—	Autocorrelation present → clustered SE addresses this
Jarque-Bera	146.22	< 0.001	Non-normal residuals → CLT valid for large N
VIF ln(Internet)	2.41	—	Low multicollinearity
VIF ln(GDP)	334.35	—	High (mechanical for X, X^2)
VIF ln(GDP)²	290.39	—	High (mechanical for X, X^2)
VIF ln(Urban)	3.93	—	Moderate multicollinearity
VIF ln(Trade)	1.08	—	Low multicollinearity

1.5 Table 5. Kuznets Turning Points

Model	ln(GDP) TP	GDP (USD)	Within Sample?	Interpretation
Pooled OLS	8.80	$6,636	YES	Within sample
Fixed Effects	8.74	$6,240	YES	Within sample
High-Income	10.05	$23,149	YES	Within sample
Low-Income	10.19	$26,576	YES	Within sample

1.6 Table 6. Mediation Analysis

Path	Coefficient	SE	z-stat	p-value
Step 1: Total Effect (ln_Internet → GINI)	-0.6555	0.3716	-1.764	0.0777
Step 2: Path a (ln_Internet → ln_Account)	0.0894	0.0132	6.773	< 0.001
Step 3: Path b (ln_Account → GINI ∣ ln_Internet)	-3.0219	1.2014	-2.515	0.0119
Step 3: Direct Effect (ln_Internet → GINI ∣ ln_Account)	-0.3854	0.3805	-1.013	0.3112
Indirect Effect (a × b)	-0.2701	0.0934	-2.892	0.0038
Proportion Mediated	41.2%	—	—	—

Note: Baron & Kenny (1986) mediation framework with Sobel test. N = 918 (account ownership available).

7. DISCUSSION AND POLICY IMPLICATIONS

The discussion and policy implications of the findings are presented in this section. Our results have a number of implications.

Kuznets' Curve is still empirically relevant today with a turning point of around $6,240 per capita, and this is within the sample range. This means that many developing nations have reached their turning point, and are already achieving growth with a levelling effect on inequality. But those countries that fall below this level should brace themselves for a future with increasing inequality once they industrialize – and plan accordingly for redistributive policies.

Second, it was found that internet penetration has a slightly negative effect on inequality (–0.66 GINI points per 1% penetration), that is, a lower level of internet penetration is marginally associated with a higher level of inequality. The impact works mostly via the income channel (internet increasing GDP moving countries on the KC), and not via any direct digital impact. This indicates that investment in digital infrastructure is worthwhile, yet by itself is not a magic bullet to reduce inequality.

Third, mediation analysis shows that 41.2% of the internet–inequality association is mediated by financial inclusion. This is to bring to focus the need for access to bank accounts, mobile money and digital payments as a key complementary policy. Financial access is not only a development objective, extending it to cover everyone, by 2030 in the case of the World Bank, is a strategy for reducing inequalities.

Fourth, the results of the heterogeneous subsample indicate that high income and low income countries are on different parts of the KC. In high income countries, where the KC had arrived at its peak, additional internet penetration has little marginal impact on inequality. The positive sign for the internet coefficient does indicate that in lower-income countries, early use may have more positive effect on the urban, educated elites as per the 'digital divide' literature. To promote inclusive digital growth targeted policies should be required, such as rural broadband and digital literacy initiatives.

Fifthly, the negative time trend of the FE model indicates that the overall global level of inequality tends to be gradually converging regardless of the regressors used. This could be due to the diffusion of policies on education, health and social protection at the global level.

8. LIMITATIONS AND FUTURE RESEARCH

Limitations and future studies are discussed in this section. There are a number of limitations to this study. Firstly, survey years in the World Bank's GINI estimates are interpolated, which could mask real variation. Secondly, the degree of internet penetration does not reflect the level of internet usage, its quality or the level of digital skills. Third, mediation analysis assumes that the variables are in a sequence and that the selection to financial inclusion is exogenous—that is, not caused by the other factors—because otherwise, the indirect effect could be biased. Four, our sample terminates in 2022, and fails to capture the AI revolution after 2023. Granular household-level data and instrumental variables should be considered for future research to deal with endogeneity.

9. CONCLUSION

This paper presents strong evidence that the Kuznets Curve has continued to hold up for a set of 58 countries from the period 2000 to 2022 with the inflection point around $6,240. The elasticity of a reduction in inequality due to internet penetration is close to –0.66 GINI points and this effect is mainly through the income channel and not a direct digital effect. This relationship is mediated by financial inclusion at 41.2%, highlighting the need to also adopt financial inclusion focused policies as complementary instruments for expanding the access to financial services in digital mode.

Evidence of the mixed impacts by income groups indicates that the digital infrastructure investment supports the most inequality reduction where it boosts incomes in developing economies. For advanced economies, the KC is already at its peak and thus so is the marginal effect. Our findings suggest the digital transition can be inclusive, but only if underpinned by policies which allow for access to both digital infrastructure and financial services based on it on a broad and inclusive basis.

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