



## Internet Access and Inequality in Developing Countries: Roles of Gender Equality and Education

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### ABSTRACT

As digital technologies spread rapidly across the developing world, their potential to shape equitable growth has drawn increasing attention. This study explores whether internet access can reduce income inequality and under what conditions. Utilizing the two-step system generalized method of moments (GMM) estimator with panel data from 125 developing countries spanning 1990 to 2021, the analysis reveals that greater internet access and mobile cellular subscriptions are associated with lower income inequality. Crucially, these inequality-reducing effects of the internet are significantly stronger in countries with higher female labor force participation and secondary school enrollment rates. The findings highlight the pivotal role of gender equality in unlocking the full potential of information and communication technologies (ICT). In societies where women have better access to economic and digital opportunities, the impact of the internet on reducing inequality is substantially amplified. By uncovering these conditional effects, this study provides new evidence on how digital inclusion, gender equity, and education intersect to promote more inclusive development. These insights carry important policy implications for achieving the Sustainable Development Goals.

**Keywords:** Internet and inequality; Internet and gender; SDG; ICT in developing countries; ICT and education; Gender equality and economic development.

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### INTRODUCTION

Income inequality has long been a pressing challenge for many developing countries. This is concerning because high levels of inequality can hinder economic growth, create social unrest, and limit opportunities for large segments of the population. Recognizing these risks, the United Nations (UN) has made reducing inequality a cornerstone of achieving the Sustainable Development Goals (SDGs) (Jack & Suri, 2011). Hence, understanding the factors that can tackle income inequality issues is crucial for devising effective development strategies.

One promising tool for addressing inequality is Information and Communications Technology (ICT), particularly the internet. The interest in ICT stems from its transformative and restructuring effects on economies and societies. In many developing countries, ICT has created economic opportunities for the lower-income population by improving financial access, connecting individuals to jobs, and lowering barriers to information. For example, mobile money services like M-PESA in Kenya have enabled financial inclusion for millions, allowing them to participate more actively in the economy and improve their living standards (Jack & Suri, 2011).

Despite a growing body of research, the extent to which ICT reduces income inequality remains an open question. Existing studies provide mixed evidence. Some highlight ICT's role in enhancing economic inclusion, while others suggest that its benefits are unevenly distributed. For instance, Jaumotte et al. (2013) find that technological progress, including the

spread of ICT, has had a greater impact on increasing inequality than globalization. In contrast, Kocsis & Xiong (2022) argue that the diffusion of ICT infrastructure, particularly in developing countries, has reduced inequality. Similarly, Shah and Krishnan (2023) further explore this relationship, revealing that ICT can serve as an institutional force to reduce gender inequality, thereby lowering income inequality. The contrasting findings in the literature underscore the need for a deeper understanding of how ICT can serve as a catalyst for more equitable growth.

Moreover, the interplay between ICT and other critical factors such as education and gender equality is underexplored. Education enables individuals to leverage ICT for economic gains, while gender equality ensures that women—who are often excluded from digital economies—can also benefit. These elements are pivotal in shaping a nation's socio-economic fabric and can significantly influence the efficacy of ICT in reducing income disparities. The lack of comprehensive empirical analysis that encompasses these moderating variables leaves a gap in the literature, which this study seeks to address.

In this study, we argue that the internet, as part of ICT, should be able to lower inequality through the following mechanism: (1) by improving access to information and knowledge (Aker & Mbiti, 2010; Jensen, 2007); (2) by enhancing financial inclusion (Jack & Suri, 2011); and (3) by facilitating access to employment (Canh et al., 2020). But the impacts of the internet on inequality could be dependent on other factors, as shown by recent empirical evidence (Asongu & Odhiambo, 2020; Tchamyou et al., 2019). We believe that current existing studies have overlooked how these contextual factors interact with ICT to influence inequality. As such, this study examines whether the internet alone is sufficient to reduce inequality or whether its impact depends on complementary factors such as education and gender equality. The purpose of this research is to answer the following empirical questions. Can the internet reduce income inequality? Are the impacts of the internet on income inequality conditioned by some factors, such as education and gender equality? To answer these questions, this study conducts an empirical analysis using cross-country panel data, including up to 130 developing countries, over the period 1990 to 2021. The two-step system GMM (Generalized Methods of Moments) is employed to generate unbiased estimation results for panel regressions. By answering these questions, our research aims to fill the gap in the literature by examining not only the direct effects of the internet on inequality, but also the roles of gender equality and education. In particular, it underlines the importance of contextual factors such as gender equality and education in enhancing the inequality-reducing effects of the internet. This suggests that policy efforts to promote favorable conditions for the internet's benefit are essential in developing countries. Our study also provides insights into designing inclusive ICT policies that are aligned with the SDGs.

The urgency of this research stems from several converging factors. Developing countries are investing heavily in ICT infrastructure as part of their development strategies, yet the distributional consequences of these investments remain poorly understood. The COVID-19 pandemic has accelerated digital transformation worldwide, making it even more critical to understand how internet access affects inequality. Furthermore, the SDGs explicitly target reduced inequalities, quality education, and gender equality as interconnected goals, necessitating empirical evidence on how these dimensions interact. With over 3.7 billion people still lacking internet access, predominantly in developing countries, understanding the conditions under which internet connectivity promotes inclusive development is essential for effective policy design.

The novelty of this research lies in its systematic examination of the conditional effects of gender equality and education on the internet-inequality relationship. Unlike previous studies that have examined direct effects or considered these factors separately, this research explicitly tests how female labor force participation and secondary school enrollment moderate the impact of internet access on income inequality. The application of two-step system GMM with panel data from 125 developing countries over three decades provides robust empirical evidence while addressing endogeneity concerns. Additionally, the calculation of threshold levels at which the internet begins to reduce inequality, conditional on gender equality and education, offers novel insights for policy targeting.

The remaining of this paper is organized as follows: Section 2 reviews the relevant theoretical framework and empirical evidence. Section 3 elaborates on the data and methodology used in the analysis. Section 4 presents the empirical results and discussion. Finally, Section 5 concludes with policy implications.

## METHOD

This study investigates the determinants of income inequality, with a particular emphasis on the roles of the internet, gender equality, and education. Our econometric model builds upon the work of Canh et al. (2020) and Richmond & Triplett (2018), which examine inequality within the framework of Kuznets' hypothesis. According to Kuznets (1955), as a country develops, income inequality initially increases and then decreases, forming an inverted U-shaped curve. To capture this non-linear relationship, we include both linear and quadratic terms for GDP per capita in our model. Our baseline econometric specification is as follows:

$$Gini_{it} = \beta_0 + \beta_1 Gini_{it-1} + \beta_2 \ln dppc_{it} + \beta_3 (\ln dppc_{it})^2 + \beta_4 Internet\ Access_{it} + \beta_5 Education_{it} + \beta_6 Control\ Variables_{it} + \gamma_{it} + \mu_{it} + \varepsilon_{it}$$

Here, the lagged Gini coefficient captures the persistence of inequality over time, acknowledging that income inequality is likely influenced by its historical levels (Hoynes et al., 2006). Next, the natural log of GDP per capita  $\ln dppc_{it}$  is another important factor that affects inequality, and  $(\ln dppc_{it})^2$  is included to test Kuznets' theory. We expect the coefficients of  $\ln dppc_{it}$  and  $(\ln dppc_{it})^2$  to be positive and negative, respectively, to generate an inverted U-shaped relationship between income and inequality. Country and year fixed effects are incorporated to account for unobserved, time-invariant factors that may affect the relationship between inequality and its determinants. Additionally, the control variables considered in this analysis include inflation, trade openness, and gross capital formation (investment), based on insights from the existing literature (Adams & Akobeng, 2021; Barro, 2008; Canh et al., 2020).

In addition to examining the direct effects of the internet on inequality, this study aims to explore whether the impact of the internet on inequality is influenced by other factors, specifically education and gender equality. To assess these conditional effects, interaction terms between internet and education, as well as internet and gender equality, are included in the analysis. These interaction terms allow us to investigate whether the inequality-reducing effects of the internet are stronger in countries with higher levels of education or gender equality. By doing so, we can gain

a deeper understanding of how the broader socioeconomic context influences the relationship between the internet and inequality.

Additionally, it is crucial to address potential endogeneity issues that might arise in this analysis. Income inequality, as measured by the Gini coefficient, can influence various economic and social factors, which may, in turn, affect internet and or ICT development. For example, higher inequality could exacerbate political instability, thereby impeding economic growth and curtailing investment in technology. Moreover, higher inequality may hinder internet adoption, leading to potential reverse causality between the internet and inequality. This possible reverse causality can introduce endogeneity, potentially biasing the estimation results.

To mitigate this problem, this study employs the two-step system Generalized Method of Moments (GMM). GMM is a commonly used method in dynamic panel data analysis that addresses endogeneity. In the first step, the system GMM estimator is applied to generate efficient instruments. In the second step, the model is re-estimated using these instruments to obtain consistent and efficient parameter estimates (Roodman, 2009). Roodman, in this study, mentions that system GMM has the ability to combine level and differenced equations, which makes it suitable for variables with persistence. In our case, several studies report that the Gini coefficient tends to be persistent due to structural factors (Adams & Akobeng, 2021; Hoynes et al., 2006). Moreover, the system GMM has been used in previous studies examining similar dynamics, such as Adams & Akobeng (2021), Asongu & Odhiambo (2020), and Tchamyou et al. (2019). For robustness, we also estimate fixed effects (FE) models, which control for unobserved time-invariant country heterogeneity, such as geographical location and institutions. While FE cannot address endogeneity, the consistency of results across estimators strengthens our findings.

This study constructs an annual panel data of 125 middle- and low-income countries from 1990 to 2021, following the definition of the World Bank. Rather than a 5-year average, annual panel data is employed to capture the dynamics and short-term fluctuations in the relationship between ICT, including the internet, and inequality (Ndjobo & Ngah, 2023; Shah & Krishnan, 2023). We employ the Gini coefficient to measure income inequality, as it is widely regarded for its simplicity and comparability across countries. The Gini coefficient offers a comprehensive view of income distribution, capturing both the extremes of inequality and more subtle shifts in income disparities (Odhiambo, 2022; Tchamyou et al., 2019). The data is derived from the Standardized World Income Inequality Database (SWIID). SWIID provides a wide coverage of cross-country data of the Gini coefficients based on the Luxembourg Income Study and other international sources. This database compiles Gini indices for more than 150 countries from 1960 to the present (Solt, 2020).

Our definition of internet access is the percentage of people who have access to the internet in a population, for which data is derived from WDI. The Internet has been shown to have positive impacts on economic development. For example, internet can improve welfare and drive economic growth (Munyegera & Matsumoto, 2016; Salahuddin & Gow, 2016). By increasing the welfare of the population, income inequality should be reduced. Some scholars argued that the internet can lower inequality (Asongu & Odhiambo, 2019). Thus, we expect this ICT variable to have a negative sign in the regression results.

This study believes that education is also a major predictor of inequality, as argued by Barro (2000). Education reflects human capital accumulation. Higher levels of education enhance

individuals' skills and productivity, leading to higher wages and better job opportunities. This can reduce income inequality by providing more people with the means to earn higher incomes (Coady & Dizioli, 2017; Park, 2017). We use the gross secondary school enrollment ratio from the WDI. These ratios exceed 100 percent because they include students whose ages exceed the official age group, such as late enrollees and repeaters (World Bank, 2024a). As for the proxy of gender equality, female labor participation is employed, also using data from WDI. The definition of female labor participation is adopted from the International Labour Organization (ILO), which is the number of females in the labor force as a percentage of the working-age population. The labor force is the sum of the number of persons employed and the number of persons unemployed. This data is collected annually by the ILO. In accordance with the World Bank (2024b), the number of women in the labor force is generally lower than that of men. Many women are engaged in unpaid labor, either at home or in other family enterprises, creating greater income inequality. Even when educated women in advanced countries have better compensated jobs, access to good-paying occupations for them remains unequal (Njuki & Gollub, 2024; World Bank, 2024b). Therefore, the female labor participation rate is a suitable variable to represent gender equality. In the regression results, we expect negative signs on the interaction between the internet and the female labor participation rate.

Our control variables are other factors that we believe might affect inequality: inflation, trade openness, and gross capital formation (investment). Inflation tends to aggravate income inequality by eroding the purchasing power of lower-income households, leading to uneven wage increases, and benefiting asset owners disproportionately. Also, inflation can increase borrowing costs and lead to policy responses that disproportionately affect lower-income workers (A. K. Ali & Asfaw, 2023; Law & Soon, 2020; Polacko, 2021). In our study, inflation is winsorized at the 1st and 99th percentiles to limit the influence of hyperinflation episodes in some developing countries. Trade openness is another important control variable as it affects economic inequality through its impact on economic growth, employment, and income distribution. The impacts of trade openness on income distribution can be mixed. Many studies reveal a positive relationship between trade openness and inequality, while others report the opposite (A. Ali et al., 2022; Cerdeiro & Komaromi, 2017; Dorn et al., 2022; Mahesh, 2011). Lastly, investment is measured as the gross capital formation (% of GDP). It captures total addition to the capital stock. The theory states that investment may reduce inequality through job creation and capital deepening, but past literature shows mixed evidence (Brueckner & Lederman, 2015; Cingano, 2014). We expect negative coefficients for investment in the regression results. Data on these variables are derived from the WDI.

**Table 1. Definition of the Variables**

<b>Name of variable</b>	<b>Definition</b>	<b>Data Source(s)</b>
<b>Gini</b>	Gini coefficient based on disposable income	SWIID
<b>Lngdppc</b>	GDP per capita (natural log)	WDI
<b>Internet access</b>	People in the population who have access to the internet (%)	WDI
<b>Femlabor</b>	Female labor participation (%)	WDI
<b>Education</b>	Secondary school enrolment (%)	WDI
<b>Inflation</b>	Annual percentage change in the Consumer Price Index (CPI)	WDI
<b>Trade</b>	Trade Openness (the sum of exports and imports of goods and services measured as a % of GDP)	WDI
<b>Investment</b>	Gross capital formation (% of GDP)	WDI

## RESULTS AND DISCUSSION

This study aims to determine the effects of the internet on income inequality and whether conditional factors may moderate these effects. The data are derived from 125 developing countries over the period 1990-2021. First, this section discusses the two-step GMM results displayed in Table 2 for the main model, which show the direct effect of the internet on inequality, without interaction terms. The main model controls for macroeconomic variables, which are inflation, trade openness, and investment. Next, the positive sign of the squared income coefficient suggests that the Kuznets curve, which posits an inverted U-shaped relationship between income levels and inequality, may not hold in this context. This aligns with the work of Canh et al. (2020) and Richmond & Triplett (2018), who also observe the absence of a Kuznets curve, particularly in developing countries. Richmond & Triplett (2018) argue that the structural transformations and labor-market changes associated with economic development may have complex implications for income inequality that vary across countries. This could explain why the Kuznet hypothesis does not fit our analysis. Furthermore, as Milanovic (2016) suggests, income inequality fluctuates over long periods and is influenced by a multitude of factors beyond economic growth alone, such as policy decisions, global economic trends, and historical contexts. These broader dynamics may further contribute to the non-existence of the Kuznets curve in our sample of developing countries.

Meanwhile, the lagged Gini coefficients turn positive and significant, showing the persistence of inequality. Such results were also found by Adams & Akobeng (2021). The coefficients for trade openness are consistently positive, indicating that it aggravates inequality. According to Pavcnik (2017), trade openness with high-income countries may negatively affect developing countries due to technological differences. Also, it benefits highly skilled laborers more than low-skilled laborers. Further, inflation is unexpectedly negative to inequality. This contrasts with studies finding that inflation erodes the real wages of the poor, thereby increasing inequality. However, some studies report similar findings that inflation can reduce inequality (Vinayagathan, 2013). Meanwhile, the investment coefficient is negative in our result. This reflects the ability of investment in reducing inequality. According to our results, the coefficient signs of secondary school enrollment are consistently negative in all regressions. This highlights the importance of education in reducing inequality, as reported by many scholars, including Barro (2000), Coady & Dizioli (2017), Hendel et al. (2005), and Nabassaga et al. (2020). These studies emphasize that education equips individuals with the skills and knowledge needed to access higher-quality jobs and improve their economic standing. These results suggest that prioritizing investment in secondary education could be a powerful tool for policymakers aiming to reduce inequality in developing countries.

Most importantly, our regressions indicate a negative relationship between internet access and inequality. Both FE and GMM models presented in Table 2 show significant negative coefficients for internet access, indicating that the internet reduces income inequality. These results align with prior studies that find that the internet is effective in reducing inequality in developing countries. Among these studies is Richmond & Triplett (2018), which finds that the internet has significant negative effects on inequality across 109 developing countries. Likewise, Adam & Alhassan (2021) and Asongu & Odhiambo (2019) found similar results using data from African countries. These findings support the idea that internet has many advantages that may benefit the

poor more. According to Donner (2015), ICT, including the internet, possesses the following features: facilitating informational interaction regardless of place, cheaper cost of devices, and wireless connections. Due to these advantages, communication is seamless, and information sharing has been improved. Task allocation can be more efficient. More importantly, low-income people can enjoy these benefits from ICT as they are inexpensive. Several studies have discussed the use of the internet among the poor. Yu & Cai (2025) write that the internet breaks information barriers for the poor and helps them to gain more job opportunities. Likewise, efficient communication among poor farmers has been found in Niger, after using ICT, which leads to lower price dispersion (Aker & Fafchamps, 2015; Aker & Mbiti, 2010). In Kenya, mobile-based money transfers have also reduced risk and liquidity constraints, in addition to promoting agricultural commercialization (Kikulwe et al., 2014). Similarly, thousands of Kenyan farmers have taken advantage of M-Farm, an internet application that supports them to gain agricultural skills (Macharia, 2013).

**Table 2. Regression Results: Impact of Internet Access on Income Inequality**

Annual Panel, 1990-2021	FE	GMM
VARIABLES	Gini	Gini
Lagged gini		0.900 (0.0128)
lngdppc	-2.436 (1.882)	-4.431 (1.158)
lngdppc square	0.115 (0.0365)	0.0901 (0.0240)
Internet access	-0.0306 (0.00554)	-0.00585 (0.00237)
Education	0.00253 (0.00688)	-0.00448 (0.00247)
Inflation	-0.0681 (0.0605)	-0.0364 (0.0172)
Trade	-0.00311 (0.00360)	0.000204 (0.00176)
Investment	-0.00870 (0.00902)	-0.0180 (0.00416)
Constant	34.00 (24.76)	58.95 (13.92)
Observations	1,372	1,333
R-squared	0.357	
Number of countries	100	98
AR1		0.019
AR2		0.127
Hansen		0.943
Collapse		Yes
IV style		Education, inflation, trade investment, year fixed effects
Number of instruments		97
Standard errors in parentheses: p<0.01, p<0.05, p<0.1		

Further, the work of Adams & Akobeng (2021) using the sample of African countries finds that the Internet seems to be more effective in reducing inequality, probably due to its wider spectrum of potential, compared to mobile cellular. Although both can provide mobile connectivity, cellular features are limited to phone calls and text messages. Meanwhile, the internet allows users to watch videos, use and create applications, and do many things in addition to basic communication. Even smartphones can only do so much if they are connected to the internet. This suggests that internet-enabled mobile cellular offers a huge range of impactful technologies. They have numerous features and applications that create opportunities for people in the low-income group. A number of studies have explained several channels on how the poor's welfare can be improved after using internet-enabled phones (Aker & Mbiti, 2010; Kikulwe et al., 2014; Macharia, 2013; Muto & Yamano, 2009). First, it helps farmers, traders, fishermen, and other types of businessmen to know market information and the latest government regulations. Second, it provides access to weather information that is crucial to farmers. Additionally, it helps the poor build skills and promotes financial inclusion. Overall, our empirical results are consistent with studies that find that the internet is more beneficial to the poor in many ways and thus reduces income inequality.

### Gender Equality

In addition to determining the internet-inequality relationship, this study attempts to discover conditional factors that might influence the nexus. The first interaction explored in this research is internetgender equality. This study uses Female Labor Force Participation (Femlabor) as a proxy for gender equality. Femlabor data are obtained from the WDI and expressed as a percentage. As illustrated in Table 3, the coefficients of internetFemlabor are consistently significant and negative at 1% significant level. This negative coefficient in both FE and GMM results suggests that the effect of the internet on decreasing income inequality becomes larger as gender equality increases. In other words, the joint effect of internet access and gender equality tends to reduce income inequality more effectively.

**Table 3. The Impact of Internet Access on Income Inequality, Conditioned by Gender Equality**

Annual Panel, 1990-2021	FE	GMM
VARIABLES	Gini	Gini
Lagged gini		0.887 (0.0141)
lngdppc	-2.485 (1.873)	-4.229 (0.877)
lngdppc_square	0.115 (0.0363)	0.0876 (0.0181)
Internet access	0.000457 (0.0100)	0.0151 (0.00559)
Internet accessfemlabor	-0.000421 (0.000152)	-0.000543 (0.000112)

Femlabor	-0.0699 (0.0143)	0.00303 (0.00848)
Education	0.000671 (0.00681)	-0.00456 (0.00230)
Inflation	-0.116 (0.0604)	0.0345 (0.0173)
Trade	-0.00282 (0.00356)	0.00329 (0.00149)
Investment	-0.00813 (0.00891)	-0.0207 (0.00262)
Constant	38.73 (24.77)	55.69 (10.63)
Observations	1,369	1,331
R-squared	0.374	
Number of countries	99	97
AR1		0.012
AR2		0.152
Hansen		0.542
Collapse		Yes
IV style		Education, trade, investment, year fixed effects
Number of instruments		96
Standard errors in parentheses: p<0.01, p<0.05, p<0.1		

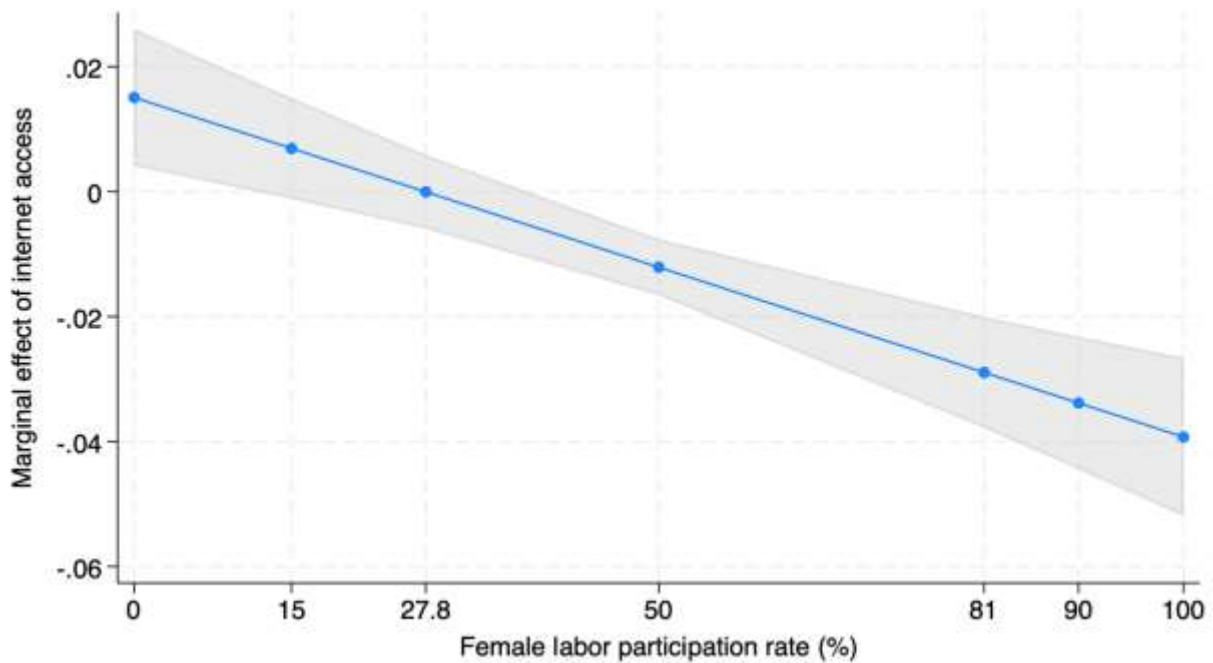
To further understand, we calculated the thresholds at which the marginal effects of *internetfemlabor* become negative. The calculations are based on the following formulas:

$$\frac{\partial Gini_{it}}{\partial internet_{it}} = 0.0151 + (-0.000543 \times Femlabor_{it})$$

The threshold for internet accessfemlabor is 27.8%. When the female labor force participation rate exceeds these thresholds, the overall marginal effect of joint internet-female labor on reducing income inequality becomes negative. A number of scholars have discussed the impacts of gender inequality on income inequality. According to Elborgh-Woytek et al. (2013), many women contribute to the economy by performing unpaid work, such as child rearing and household chores. These unpaid tasks have restricted them from finding paid work, let alone participating in the formal labor force. As a result, there is a high gap in the formal labor force between genders. Gonzales et al. (2015) argue that this gap leads to unequal earnings between men and women. This has worsened inequality. In contrast, lower gender inequality in the labor force can increase household income and reduce income inequality (Costa et al., 2009).

Our study builds on these insights by emphasizing the role of gender equality as a moderating factor in the ICT-inequality relationship. In societies with high levels of gender equality, where women have relatively equal access to education, employment, and decision-making opportunities, the benefits of the internet can be more pronounced. Gender equality creates an

environment conducive to leveraging the internet for inclusive growth. When women are active participants in the labor market and have access to educational opportunities, they are better positioned to benefit from the opportunities facilitated by mobile technology. Mobile cellular phones with internet access, in particular, enable women to overcome traditional barriers to economic participation, such as geographic isolation, limited access to formal networks, and limited mobility. Mobile technology can serve as a powerful equalizer, empowering women economically by providing access to markets, information, and financial services. This highlights the critical role of gender equality in enhancing the effectiveness of the internet in reducing inequality.



**Figure 1. The marginal effect of Internet Access on inequality in developing countries, conditional on the level of female employment.**

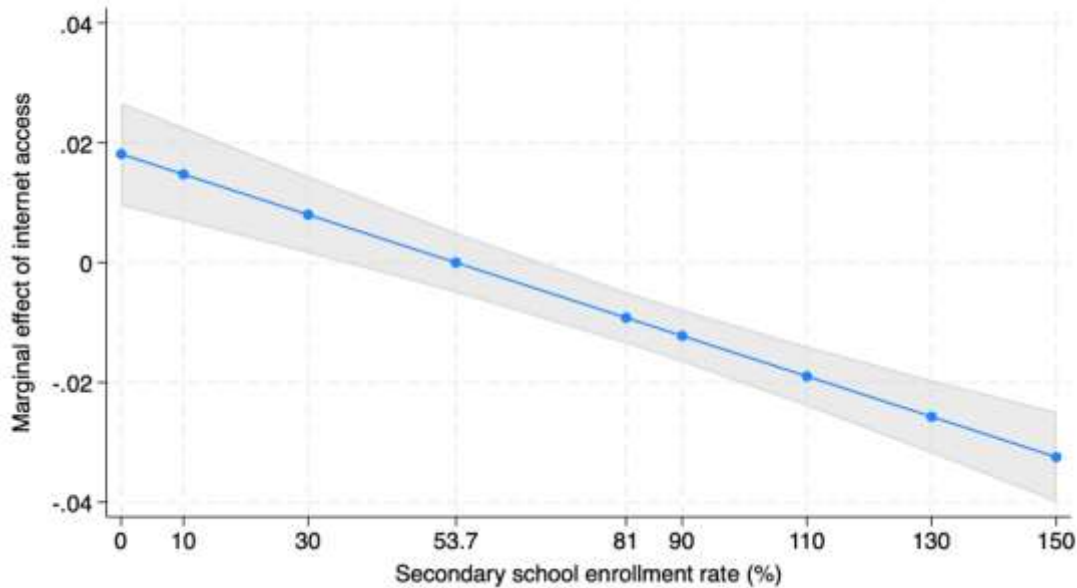
**Education**

We interact internet access with education and display the results in Table 4. As expected, interneteducation is negative and statistically significant at the 5% level. Also, the coefficients for these interactions are higher than those for the individual variables in the baseline results. The results suggest that as internet access increases, its negative effects on inequality will intensify with rising school enrollment. In other words, the internet and education work together effectively to reduce inequality.

**Table 4. The Impact of Internet on Income Inequality, Conditioned by Education**

Annual Panel, 1990-2021	FE	GMM
VARIABLES	Gini	Gini
Lagged gini		0.874

		(0.0130)
lngdppc	-2.717	-6.385
	(1.890)	(1.073)
lngdppc square	0.119	0.129
	(0.0366)	(0.0218)
Internet access	-0.00748	0.0181
	(0.0166)	(0.00440)
Internet accesseducation	-0.000229	-0.000337
	(0.000155)	(4.64e-05)
Education	0.00608	0.000567
	(0.00729)	(0.00201)
Inflation	-0.0665	0.1000
	(0.0605)	(0.0175)
Trade	-0.00252	0.000455
	(0.00362)	(0.00135)
Investment	-0.00818	-0.0219
	(0.00902)	(0.00268)
Constant	37.93	83.75
	(24.89)	(12.97)
Observations	1,372	1,333
R-squared	0.358	
Number of countries	100	98
AR1		0.016
AR2		0.132
Hansen		0.495
Collapse		Yes
IV style		Education, trade, investment, year fixed effects
Number of instruments		96
Standard errors in parentheses: p<0.01, p<0.05, p<0.1		



**Figure 2. Average marginal effects of Internet on inequality in developing countries, conditional on the level of education.**

In our regression analysis, we calculate thresholds at which the internet begins to reduce income inequality, conditional on education. The following formulas are used:

$$\frac{\partial Gini_{it}}{\partial internet_{it}} = 0.0181 + (0.000337 \times education_{it})$$

The threshold value reflects the level of education required for the overall effect of the internet on inequality to be negative. Using these formulas, the threshold level of education is 53.7%. These values are derived by setting the partial derivatives of the Gini coefficient with respect to internet access equal to zero, thereby marking a shift from an inequality-increasing to an inequality-reducing effect. At these thresholds, the internet starts to reduce inequality.

Figure 2 display the marginal effects of *ICTeducation* on inequality, using our econometric specification. The tables illustrate the trends of  $\frac{\partial Gini_{it}}{\partial ICT_{it}}$  with the existence of *ICTeducation*. Along with the increase in education, the Gini coefficient declines given the level of ICT. For example, when the education level increases from 30% to 53.7%, the marginal effects of internet access change from almost 0 to 0. This suggests that the reducing effect of the internet on inequality will be enhanced at a higher level of education in developing countries.

Much existing literature has emphasized the role of education in lowering inequality. For example, Barro (2000) argues that elementary and secondary school enrolment negatively impacts inequality. Likewise, Nabassaga et al. (2020) reveal that the increase in education opportunities would reduce the gap in wealth distribution in 37 African countries. Also, a study by Park (2017) using data from Asian countries showed that a higher level of schooling in a population has

lowered inequality. In accordance with Nabassaga et al. (2020), education is a way to acquire new skills and increase productivity. It is crucial to maximize the benefits of the internet, as one needs skills to operate the technology. However, these studies do not explore how the interaction between the internet and education affects inequality. By incorporating interaction terms, our study provides new insights into how the benefits of the internet are amplified by educational attainment, supporting the opinion of Lucas (1988) that human capital is pivotal for technological progress. Therefore, education is a good condition for the internet to reduce inequality further.

## CONCLUSION

This study analyzes the relationship between internet access and income inequality in 125 developing countries from 1990 to 2021 using a two-step system GMM approach to address endogeneity. The findings show that greater internet access significantly reduces income inequality by improving access to information, expanding financial inclusion, and creating broader employment opportunities, particularly for lower-income groups. However, these benefits are conditional on structural factors. Gender equality, measured by female labor force participation, strengthens the inequality-reducing effect of the internet, with the impact becoming negative once participation surpasses about 28 percent and intensifying at higher levels. Similarly, education plays a complementary role: internet access begins to reduce inequality when secondary school enrollment exceeds roughly 54 percent, reflecting the importance of human capital for effectively utilizing digital technologies. Overall, the results highlight that digital infrastructure alone is insufficient; its inclusive benefits depend on supportive social conditions such as women's economic participation and educational attainment. Future research could further explore the role of digital skills, the quality of internet infrastructure, and differences across regions or income groups to better understand the mechanisms through which digital access influences inequality.

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