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Effects of Digitalization on Income Inequality across the Stage of ICT Development: Evidence from OECD Countries

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This study examines how digitalization influences income inequality in OECD countries, emphasizing that its effects depend on the stage of ICT development. Using panel data and a fixed-effects framework, we analyze four indicators of digitalization—fixed telephone subscriptions, mobile cellular subscriptions, individuals using the internet, and fixed broadband subscriptions—and interact them with a dummy capturing the transition to an advanced ICT era. The results show a clear stage-dependent pattern. In the early ICT-development period, digitalization reduces inequality by increasing income shares of the bottom four quintiles and reducing that of the top quintile. However, in the advanced ICT period, these equalizing effects weaken or reverse: digitalization becomes inequality-increasing, particularly for internet use and broadband subscriptions. The findings indicate that digitalization is not uniformly inclusive and underscore the need for policies that strengthen digital skills, broadband quality, and equitable participation in advanced digital ecosystems.

Keywords: Income Inequality, Digitalization, ICT Development, Digital Divide

JEL Classification: O33, O15, D31

I. Introduction

The rapid expansion of digital technologies has reshaped economic activity, labor markets, and communication patterns across both advanced and emerging economies.

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While digitalization is widely viewed as a key driver of productivity and innovation, its implications for income inequality remain ambiguous. A growing body of research shows that the effects of digitalization are not uniform; instead, they depend critically on the level of ICT infrastructure, the technological environment, and how digital tools are adopted and utilized across different segments of the population. This study investigates these heterogeneous effects by examining whether the relationship between digitalization and income inequality varies across different stages of ICT development within OECD countries. By distinguishing between an early ICT-development period and a more advanced digital phase, we provide new evidence on the evolving distributional consequences of digital transformation.

Early work on digitalization focused on the digital divide, emphasizing inequalities in access to basic ICT tools such as computers, telephones, and early internet services (Hoffman and Novak 1998; Ono and Zavodny, 2003). Later research introduced the concept of digital inequality, highlighting disparities not only in access but also in digital skills, quality of usage, and the ability to leverage technology productively (DiMaggio and Hargittai, 2001; Hargittai, 2003). More recent empirical studies have shown that broadband quality, digital skills, and platform-based technologies generate uneven returns across individuals and regions (Forman et al., 2005; Kolko, 2012; Goldfarb and Tucker, 2019). Together, these studies suggest that digitalization may reduce inequality in its early stages by expanding access to information and markets, but may later increase inequality as digital adoption becomes more skill-intensive and complementary to high-skilled labor.

Despite these insights, existing empirical research remains limited in several ways. Much of the recent literature relies on micro-level datasets, which are useful for identifying individual-level mechanisms—such as skill complementarities or task-based technological change—but often capture only a narrow segment of the digital ecosystem, typically within a single country. Micro studies rarely allow comparisons across economies that differ in ICT infrastructure, broadband quality, or the timing of digital transitions. In contrast, cross-country analyses provide a broader comparative perspective, enabling researchers to exploit large variations in ICT development, institutional environments, and inequality structures. By observing economies at different points along the digital development trajectory, cross-country studies can more effectively identify stage-dependent effects and capture macro-level dynamics—such as structural transformation, national ICT policies, and large-scale shifts in communication and production networks—that micro data cannot fully reflect. Thus,

a cross-country approach is suited for evaluating whether digitalization influences inequality differently across technological eras.

This study contributes to the literature by offering the first systematic cross-country empirical analysis—within the OECD context—that examines how digitalization affects income inequality differently across stages of ICT development. Using four common indicators of digitalization—fixed telephone subscriptions, mobile cellular subscriptions, internet usage, and fixed broadband subscriptions—we estimate a fixed-effects model that incorporates interaction terms between each ICT variable and a dummy that may capture the advanced ICT-development era. This design allows us to compare the inequality effects of digitalization across two distinct technological periods. Our findings reveal a clear stage-dependent pattern: digitalization is associated with reductions in income inequality during the early ICT period, whereas in the advanced digital era, digitalization tends to increase inequality.

Overall, this study contributes to better understanding that the distributional effects of digitalization are dynamic rather than static. By combining a cross-country perspective with a stage-sensitive empirical framework, we highlight how digitalization can act as a force for inclusion in one period and a source of divergence in another. These results underscore the importance of designing digital policies that evolve with technological progress and address new forms of digital inequality that emerge as economies transition into more advanced digital ecosystems.

II. Digitalization and Its Mechanisms on Income Inequality

1. Measuring Digitalization

While the contemporary digital economy is increasingly characterized by emerging innovations such as Artificial Intelligence (AI), the Internet of Things (IoT), and blockchain technology, its foundation was built over the last 30 years. During that period, the digital economy was underpinned by several key components, including mobile communications, broadband internet infrastructure, the search engine and information accessibility, e-commerce platforms, digital content and streaming services, social networking services, and cloud computing. These ICT-based applications have emerged as critical components of productivity and efficiency gains across firms, households, and public institutions (Brynjolfsson and McAfee, 2014; OECD, 2020). The pace at which such applications are developed and diffused is largely determined

by the development of a country's information and communication technology (ICT) infrastructure—particularly the degree of ICT accessibility and ICT use intensity. ICT accessibility reflects the physical availability of network infrastructure and the extent to which economic agents can connect to ICT services, whereas ICT use intensity captures the degree to which digital tools are actively employed within economic and social activities (UNCTAD, 2021).

When measuring a nation's degree of digitalization, the evolution of ICT applications has become an increasingly crucial dimension. Early measures of digitalization largely emphasized the availability and adoption of ICT infrastructure such as internet access and telephone penetration (ITU, 2023). However, as internet connectivity has evolved into an indispensable element of modern economic infrastructure, scholarly and policy attention has shifted. The advent of broadband technology—which has substantially enhanced internet speed and reliability—exemplifies this transformation. Broadband diffusion has redefined the conventional understanding of the digital divide (van Ark, 2016; OECD, 2019). Rather than focusing solely on disparities in access to ICT (the “first-level divide”), recent discussions emphasize inequalities in usage intensity and in the quality of digital engagement—a phenomenon commonly referred to as the “second-level digital divide” (Hargittai, 2002; van Deursen and Helsper, 2015).

Taking these developments into account, our empirical analysis employs four indicators commonly used to measure national-level digitalization: (i) fixed telephone subscriptions per 100 people; (ii) mobile cellular subscriptions per 100 people; (iii) individuals using the internet (% of population); and (iv) fixed broadband subscriptions per 100 people. The first three indicators measure ICT accessibility, while the fourth indicator captures ICT use intensity. Specifically, the share of individuals using the internet reflects general adoption of internet services, whereas fixed broadband subscriptions per 100 people measure the quality and speed of internet access.

According to ITU, “fixed telephone subscriptions per 100 people” represents the total number of fixed analog telephone lines in active use during the previous three months, “Mobile telephone subscriptions” denotes the total number of active public mobile service accounts, including all postpaid cellular subscriptions that provide voice communication services and prepaid cellular accounts that have been used within the past three months. An internet user is defined as an individual who has accessed the internet within the past three months at one or more locations, including the home, workplace, or public institutions. Internet access may occur through either fixed or mobile networks using a range of digital devices such as computers, mobile

phones, personal digital assistants, game consoles, or digital televisions. This category also includes individuals who engage in internet-based activities such as sending or receiving email, accessing news or entertainment content, transferring data files online, or accessing e-commerce platforms.

A “fixed broadband subscription” refers to a subscription to an applied ICT service that provides public internet access at a downstream speed of at least 256 kb per second through a fixed (wired) connection. Since the early 2000s, broadband subscriptions have grown rapidly, enabling substantially faster internet access compared to earlier technologies. Broadband connections differ markedly from earlier dial-up services in terms of both performance and user experience. Most notably, broadband provides significantly faster internet speeds and supports higher-quality online applications. For these reasons, broadband has become an important component of modern digital infrastructure. International organizations such as the OECD and ITU indeed employ fixed broadband subscriptions as an indicator reflecting the qualitative dimension of internet access.

2. The Mechanisms

The effects of digitalization on income inequality are in general not uniform. They depend critically on the development of ICT infrastructure, technology level, and economic structure. As economies move from early to advanced digital development, the same digitalization indicator can shift from having equalizing effects to contributing to greater inequality. Below, we describe how the relationship between these indicators and income inequality evolves across different stages of digital development.

Several studies indicate that the effect of fixed telephone subscriptions on income inequality is highly dependent on a country’s stage of ICT development. In the early ICT era, fixed-line telephony functioned as a fundamental communication infrastructure that expanded access to information, markets, and public services for rural and low-income populations; evidence from Roller and Waverman (2001) and ITU (2002) shows that basic fixed-line penetration improved labor-market matching, supported small enterprises, and reduced regional disparities. However, as digital infrastructure transitions toward mobile networks, broadband, and internet-based technologies, the distributional impact of fixed-line subscriptions weakens because economic opportunities increasingly depend on newer technologies (World Bank, 2016). That is, fixed-line systems become legacy technologies disproportionately retained by low-

income or rural communities, reinforcing digital exclusion as high-income groups relatively more benefit from high-speed broadband, mobile data, and digital platforms. Thus, consistent with the digital divide literature, fixed telephone subscriptions serve as an equalizing force in the early stages of digital development, but their influence gradually diminishes—and may even contribute to widening inequality—as economies transition into more advanced technological environments.

The distributional effects of mobile cellular subscriptions can vary across stages of digital infrastructure and technological development. In the early phase of ICT development, mobile phones can reduce income inequality by providing affordable and accessible communication tools to rural and low-income populations, improving labor-market matching, financial inclusion, and micro-entrepreneurship. For example, Aker and Mbiti (2010) shows how mobile adoption facilitated market efficiency and welfare gains in developing economies. As digital systems evolve, however, the equalizing impact weakens. OECD (2020) and World Bank (2016) findings show that during the transition to more sophisticated digital ecosystems, mobile usage becomes differentiated by device quality, data affordability, and digital skills, leading to mixed distributional outcomes. In particular, mobile technologies may even worsen inequality: high-income users leverage smartphones, mobile broadband, and app-based platforms for productivity and income generation, while low-income users are confined to basic, consumption-oriented usage. This aligns with the broader literature on skill-biased technological change (e.g., Acemoglu and Autor, 2011; Goldfarb and Tucker, 2019), which finds that advanced mobile and platform-based digital services disproportionately reward high-skilled individuals. Therefore, consistent with digital divide and SBTC frameworks, mobile cellular subscriptions shift from having a broadly inclusive effect in early stages to exhibiting neutral or even inequality-enhancing associations in more technologically advanced contexts.

The relationship between internet use and income inequality can also vary with the level of digital infrastructure and technological development. In early stages of digitalization, increased internet adoption tends to reduce inequality by expanding access to information, online education, markets, and public services (see, for example, World Bank, 2016). In addition, Aker and Mbiti (2010) and Jensen (2007) show that internet access reduces information asymmetries and improves market and labor-market efficiency, disproportionately benefiting low-income populations. However, as economies transition toward more advanced digital systems, the distributional effects become mixed. OECD (2020) argues that once basic access becomes widespread,

digital divides increasingly reflect differences in digital skills, connection quality, and meaningful use. High-income users engage in productive online activities—such as digital learning, telework, financial services, and e-commerce—while low-income groups remain confined to basic or entertainment-oriented usage, weakening the equalizing effect. In advanced digital economies, internet use may even worsen inequality, as access to high-speed broadband, data-driven services, and digital platforms complements high-skilled labor and reinforces skill-biased technological change (see, for example, Acemoglu and Autor, 2011; Goldfarb and Tucker, 2019). Thus, consistent with digital divide and skill-biased technology frameworks, internet usage evolves from an equalizing force in early digitalization to a potentially inequality-enhancing factor in more technologically mature contexts.

The impact of fixed broadband subscriptions on income inequality can also vary across stages of digital development. In the early phase, broadband expansion tends to reduce inequality by providing high-quality internet access that enables online education, e-commerce participation, telemedicine, and greater integration of rural areas into national markets. For example, Czernich et al. (2011) and Hjort and Poulsen (2019) show that initial broadband rollout improves productivity and generates welfare gains that are relatively more accessible to disadvantaged groups. However, as digital ecosystems mature, the distributional effects become mixed: disparities in broadband speed, affordability, and connection quality emerge between income groups and regions, limiting the benefits for low-income households. OECD (2020) emphasizes that beyond basic access, inequality increasingly reflects gaps in digital skills and the ability to perform high-value online activities. In highly digitalized economies, fixed broadband may even contribute to increasing inequality. High-income and highly skilled individuals disproportionately benefit from broadband-enabled opportunities such as telework, data-intensive services, and digital entrepreneurship, while low-income users face constraints related to cost, device capabilities, and limited digital literacy. These patterns are consistent with the literature on digital-skill complementarities and skill-biased technological change (see, for example, Acemoglu and Autor, 2011; Goldfarb and Tucker, 2019), suggesting that fixed broadband shifts from enhancing inclusion in early stages to potentially reinforcing inequality in advanced digital contexts.

III. Empirical Framework

1. The Model

This section presents the benchmark model used to estimate the effects of digitalization on income inequality and describes the variables incorporated in the empirical analysis. To account for the possibility that digitalization affects income inequality differently across stages of ICT development, we adopt a simple interaction-based approach in which each digitalization indicator is interacted with a dummy variable capturing the recent ICT development period. Accordingly, the empirical model is expressed in Equation (1) below:

$$IE_{it} = \beta_1 DT_{it} + \beta_2 D * DT_{it} + \beta_3 lny_{it} + \beta_4 (lny_{it} * lny_{it}) + X_{it} * \Gamma + \gamma X_{it} + \alpha_i + \delta_t + u_{it} \quad (1)$$

where IE_{it} includes several variables that measure income inequality of country i at year t : those variables are the Gini coefficient and income shares held by lowest 20%, second 20%, third 20%, fourth 20%, and highest 20%. The variables for measuring various income shares provide us with information about sources of income inequalities. DT_{it} includes the four variables proxying for the degree of digitalization in country i at year t as mentioned above. The dummy variable D is equal to 1 if year is greater than 2013 and to 0 otherwise.¹

Digitalization is likely to be influenced by a country's level of economic development, educational attainment, and degree of urbanization. At the same time, these structural and socio-economic factors can also directly affect income inequality. Consequently, estimates of the relationship between digitalization and income inequality may suffer from omitted variable biases if such determinants are not adequately accounted for. To mitigate this potential bias, the model incorporates a range of control variables to isolate the pure effect of digitalization on income inequality.

The model first incorporates both the linear lny_{it} and squared ($lny_{it} * lny_{it}$) terms of the log of real GDP per capita. This structure allows for mitigating the omitted variable bias. We include squared ($lny_{it} * lny_{it}$) term in the regression because the Kuznets hypothesis (Kuznets, 1955, 1963) predicts that income inequality initially

¹ We consider different threshold years and find that the results are robust across them.

increases at low stages of economic development and subsequently decreases as income levels rise: At lower stages of development, economic growth often involves structural changes in industry and labor markets, typically widening wage inequality. In contrast, higher-income economies are more likely to implement social security and redistributive policies that mitigate income inequality. The inclusion of the quadratic term controls for the potentially non-linear relationship between average income and income inequality across different stages of economic development.

The vector of other control variables (X_{it}) is also included in the model in order to isolate the effect of digitalization on income inequality. In particular, domestic income inequality is mainly related to wage gap between skilled and unskilled workers and the relative price change between capital and labor. And these channels are likely related to the development of digitalization. We include several variables that potentially capture these two channels. Although these variables mainly function to mitigate potential omitted variable bias, we also describe how these variables are related to income inequality.

“Openness” is defined as the ratio of the sum of exports and imports to gross domestic product (GDP), expressed as a percentage. The Stolper-Samuelson theory suggests that increased foreign trade leads to the expansion of industries where the country has a comparative advantage and the contraction of industries with a comparative disadvantage. This process of industrial restructuring can cause income inequality. “Foreign direct investment (FDI) inflows”, measured as a share of GDP, may influence domestic income distribution through several mechanisms such as skill-biased technology transfer (Feenstra and Hanson, 1997), capital deepening and productivity gains, and sectoral composition effects. “FDI outflows” also may influence the income distribution within a country through various channels such as offshoring, job relocation, and global value chain. “R&D expenditure” (% of GDP) may also influence the income inequality by creating and disseminating new technologies, which can significantly influence the skill premium in the labor market.

Population structure may also influence domestic income inequality. “Crude birth rate per 100 people” may increase income inequality: A higher birth rate is generally associated with a lower average educational level among women. Women with higher education face a greater opportunity cost (higher market wages) for the time spent raising children, leading to a lower birth rate (see, for example, Kremer and Chen, 2002). Therefore, economies with high birth rates are likely to have lower female education and wages, which ultimately contributes to the expansion of income inequality.

“Female labor force participation rate” may influence domestic income inequality. Thurow (1987) argued that an increase in the participation rate could worsen inequality for two reasons: i) women’s relatively lower wages; and ii) increased probability of assortative mating (high-wage women marrying high-wage men). “Population ages 65 and above” (measured as a percentage of GDP) proxies the degree of ageing in a country and is likely to affect income inequality. According to the life-cycle income hypothesis, household income peaks in middle age and declines as individuals get older. Therefore, an economy with a rapidly increasing share of the elderly population is likely to experience an increase in overall income inequality.

“Urbanization” is measured by “population in urban area (% of total population)” and generally tends to increase inequality. Urban areas often concentrate high-skill, high-wage industries such as R&D, finance, and IT. This drives up the demand and wage premium for skilled workers, widening the income gap between skilled and unskilled labor. Urbanization also leads to soaring real estate and housing costs, deepening wealth inequality between those who own assets and those who do not. Furthermore, it can create disparities in access to high-quality education and health services, leading to unequal human capital accumulation.

“ICT Openness” is defined by the share of total ICT Trade (Exports + Imports) in GDP and may influence income inequality. An increase in the ICT trade share reflects a country's digital economic openness and level of global integration. High ICT trade exposure subjects the domestic market to global competition. This benefits on the high ICT technology firms and workers who quickly adapt to technological change and drive innovation, while other sectors struggle, potentially worsening the overall income distribution of the country.

“Human capital level” (measured by a human capital index from the Penn World Table) may affect in income inequality. Countries with higher human capital accumulation generally have higher average levels of education. This widespread high educational attainment is expected to reduce income inequality. “Price of Capital Goods” may affect income inequality. If the price of capital goods falls (while the price of labor is held constant), this encourages firms to substitute capital for labor. This substitution effect leads to a reduction in average labor income. Since most households rely on supplying labor rather than owning capital, this decrease in labor income is expected to worsen income inequality.

Finally, we control country specific fixed effects and year fixed effects which captures overall technological progress.

2. Data

We obtain data from the World Bank's World Development Indicators (WDI)² database and Penn World Table 11³ for our empirical analysis. By merging these datasets, we construct an unbalanced OECD panel covering the period from 1996 to 2023. Table 1 reports the summary statistics for all variables included in the analysis. The Gini coefficient has an average value of 33.8, with observations ranging from 23.2 to 58.5, indicating that our sample includes countries with both relatively equal and highly unequal income distributions. The income-share variables display similar cross-country and over-time variation: on average, the bottom 20 percent receive 7.4 percent of total income, whereas the top 20 percent capture 41.4 percent, with the highest value exceeding 62 percent. This substantial heterogeneity provides a rich empirical setting for examining the relationship between digitalization and income inequality.

Table 1. Summary Statistics

Variables	Obs	Mean	SD	Min	Max
Gini coefficient	821	33.8	6.9	23.2	58.5
Income share held by lowest 20%	821	7.4	1.7	2.1	10.6
Income share held by second 20%	821	12.4	1.8	6.5	15.4
Income share held by third 20%	821	16.6	1.6	10.9	19.6
Income share held by fourth 20%	821	22.3	1.0	18.0	24.1
Income share held by highest 20%	821	41.4	5.6	32.4	62.3
Fixed telephone subscriptions	1,062	38.4	16.0	2.7	74.5
Mobile cellular subscriptions	1,063	93.4	41.5	0.5	179.9
Individuals using the Internet	1,061	60.0	30.6	0.2	99.8
Fixed broadband subscriptions	909	22.8	13.6	0.0	48.7
ln income per capita	1,064	10.6	0.5	9.3	11.8
Openness	1,064	92.2	55.0	18.1	412.2
FDI, net inflows (% of GDP)	1,058	4.2	17.7	-391.6	234.3
FDI, net outflows (% of GDP)	1,053	4.3	16.2	-238.2	253.0
R&D expenditure (% of GDP)	937	1.7	1.0	0.1	6.0
ln crude birth rate	1,064	1.2	0.3	0.5	2.6
Female Labor force participation rate	1,050	44.0	15.4	18.8	83.5
Population ages 65 and above	1,064	15.1	4.5	4.3	29.6
ICT openness	870	790.7	770.8	148.4	6361.7
Urbanization	1,064	76.4	11.1	50.6	98.2
ln price of capital	1,064	-0.5	0.3	-1.3	0.3
ln human capital index	1,064	1.2	0.1	0.6	1.4

Source: WDI and Penn World Table 11.

² <https://databank.worldbank.org/source/world-development-indicators>

³ <https://www.rug.nl/ggdc/productivity/pwt/?lang=en>

Digitalization indicators also show substantial variation across countries and over time. Fixed telephone subscriptions average 38.4 per 100 people, but the distribution ranges widely—from just 2.7 to 74.5—highlighting divergent historical trajectories in traditional telecommunication infrastructure. Mobile cellular subscriptions display even greater dispersion, with a mean of 93.4 and values extending from nearly zero to close to 180 per 100 people, signaling the coexistence of both early- and fully mature mobile markets. Internet use averages 60 percent of the population but spans an extremely wide range, from virtually no usage (0.2 percent) to almost universal adoption (99.8 percent). Fixed broadband subscriptions similarly vary from zero to nearly 50 per 100 people, reflecting substantial differences in the development and diffusion of high-speed internet services. Collectively, these indicators illustrate the evolving nature of digitalization across the OECD sample and provide a solid basis for examining how its effects on income inequality may differ across stages of ICT advancement.

The control variables also exhibit considerable variation, reflecting the economic, demographic, and structural differences that accompany digital transformation across countries. Income per capita shows substantial dispersion, with log values ranging from 9.3 to 11.8, capturing the coexistence of both lower-income and highly developed economies within the sample. Indicators related to globalization and investment—such as trade openness and FDI inflows and outflows—likewise vary widely, indicating differing degrees of integration into global markets. Measures of human capital, labor-force participation, population structure, and urbanization also differ markedly, underscoring the institutional and developmental diversity across OECD countries.

IV. Empirical Results

1. Results without Considering the Different Stages of ICT Development

We begin with the estimation results using the model without considering the different stages of digitalization development. Table 2 reports the estimation results on how various dimensions of digitalization affect income inequality, measured by the Gini coefficient, using the data of OECD countries. Four separate regressions are presented, each including one main ICT indicator: fixed telephone subscriptions, mobile cellular subscriptions, individuals using the Internet, and fixed broadband subscriptions.

Overall, we find that those indicators are negatively related to the Gini coefficient. Of them, only the estimated coefficient for fixed telephone subscriptions is -1.462 and statistically significant, interpreting that 1% increase in fixed-line telephone subscriptions reduces 1.462% of the Gini coefficient. That is, an increase in fixed-line telephone subscriptions is associated with a reduction in income inequality. On the other hand, the other three estimates are not statistically significant.

Considering that our main objective of including various control variables in the regression is to mitigate omitted variable biases, we briefly discuss the effects of the control variables on income inequality. First, FDI inflows tend to reduce income inequality. The estimates for FDI inflows are negative and statistically significant in all models, suggesting that foreign direct investment inflows consistently reduce income inequality, likely through job creation and technology spillovers in domestic economies. Second, FDI outflows tend to widen income inequality. Its estimates are positive and significant across all models, suggesting that outward FDI increases inequality, likely because foreign investment negatively affects domestic labor markets, in particular unskilled workers. Third, the estimates for the price of capital goods are negative but statistically insignificant in all models. Finally, population structures, urbanization, and human capital indexes do not significantly affect income equality in that those estimates are not statistically significant.

We now examine how digitalization influences the distribution of income. Table 3 presents the fixed-effects estimation results using five income-share measures—the shares held by the lowest, second, third, fourth, and highest 20% of the income distribution as dependent variables. Across specifications, we observe a broadly similar pattern for all four digitalization indicators: higher levels of digitalization tend to be positively associated with the income shares of the bottom four quintiles, while exhibiting a negative association with the income share of the top quintile. This pattern suggests a potentially equalizing effect of digitalization, insofar as it shifts relative income shares away from the richest segment toward lower- and middle-income groups.

Among the digitalization indicators examined, fixed telephone subscriptions stand out as the only variable with statistically significant coefficients. Specifically, increases in fixed-line telephone penetration are associated with higher income shares for the lowest, second, third, and fourth quintiles, alongside a reduction in the income share captured by the richest 20%. This implies that, during the period under study, fixed-line telephony served as a meaningful channel through which lower-income households

Table 2. Impacts of Digitalization on Gini Coefficients

	(1)	(2)	(3)	(4)
ln fixed telephone subscriptions	-1.462** (0.556)			
ln mobile cellular subscriptions		-0.545 (0.753)		
ln individuals using the Internet			-1.096 (0.920)	
ln fixed broadband subscriptions				-0.306 (0.322)
ln income per capita	-8.084 (27.108)	7.572 (31.661)	11.269 (28.206)	-0.890 (30.373)
Square of ln income per capita	0.299 (1.277)	-0.398 (1.483)	-0.565 (1.317)	-0.005 (1.424)
Openness	-0.000 (0.012)	-0.007 (0.013)	-0.005 (0.011)	-0.007 (0.012)
FDI, net inflows (% of GDP)	-0.010** (0.004)	-0.011** (0.004)	-0.010** (0.004)	-0.011** (0.004)
FDI, net outflows (% of GDP)	0.013** (0.006)	0.014** (0.006)	0.014** (0.006)	0.015** (0.006)
R&D expenditure (% of GDP)	0.115 (0.498)	-0.327 (0.476)	-0.256 (0.481)	-0.233 (0.489)
ln crude birth rate	1.251 (1.791)	0.660 (1.795)	0.651 (1.788)	1.165 (1.840)
Female Labor force participation rate	0.016 (0.036)	0.011 (0.036)	0.004 (0.038)	0.010 (0.036)
Population ages 65 and above (% of total pop)	-0.196 (0.220)	-0.123 (0.242)	-0.167 (0.226)	-0.159 (0.235)
ICT openness	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)	0.000 (0.000)
Urbanization	0.123 (0.112)	0.116 (0.133)	0.118 (0.125)	0.113 (0.133)
ln price of capital	-1.082 (1.114)	-1.218 (1.110)	-1.361 (1.051)	-1.510 (1.177)
ln human capital index	8.609 (10.817)	1.824 (10.946)	9.270 (12.152)	5.641 (11.905)
Observations	691	691	690	686
R-squared	0.154	0.111	0.122	0.123
Number of countries	37	37	37	37

Notes: Openness is the percentage of the sum of export and import to GDP. ICT openness is the percentage of the sum of ICT export and import to GDP. Urbanization is the percentage of urban population to total population.

Source: WDI and Penn World Table 11.

Table 3. Impacts of Digitalization on Income Distribution

	(1)	(2)	(3)	(4)
Panel A. Income share held by lowest 20%				
In fixed telephone subscriptions	0.366*** (0.133)			
In mobile cellular subscriptions		-0.027 (0.201)		
In individuals using the Internet			0.191 (0.241)	
In fixed broadband subscriptions				0.016 (0.073)
Panel B. Income share held by second 20%				
In fixed telephone subscriptions	0.311** (0.133)			
In mobile cellular subscriptions		0.213 (0.195)		
In individuals using the Internet			0.344 (0.235)	
In fixed broadband subscriptions				0.082 (0.078)
Panel C. Income share held by third 20%				
In fixed telephone subscriptions	0.323** (0.141)			
In mobile cellular subscriptions		0.272 (0.200)		
In individuals using the Internet			0.325 (0.202)	
In fixed broadband subscriptions				0.120 (0.081)
Panel D. Income share held by fourth 20%				
In fixed telephone subscriptions	0.214* (0.119)			
In mobile cellular subscriptions		0.204 (0.161)		
In individuals using the Internet			0.088 (0.180)	
In fixed broadband subscriptions				0.087 (0.068)
Panel E. Income share held by highest 20%				
In fixed telephone subscriptions	-1.218** (0.464)			
In mobile cellular subscriptions		-0.640 (0.641)		
In individuals using the Internet			-0.927 (0.735)	
In fixed broadband subscriptions				-0.299 (0.274)

Note: See note in Table 2. We omit the results for control variables.

benefited relatively more from improvements in basic ICT access. Taken together, the results indicate that the decline in the Gini coefficient associated with digitalization—when proxied by increased fixed-line subscriptions—is driven mainly by the reduced concentration of income at the top of the distribution.

2. Results Considering the Different Stages of ICT Development

We now discuss our main results on the effects of digitalization indicators on income inequality by controlling for the different stages of ICT development. Table 4 reports the estimation results on how differently the four digitalization indicators affect income inequality, measured by the Gini coefficient, across the different stages of ICT development.

The baseline estimated coefficients (without interaction) generally show that digitalization—proxied by fixed telephone subscriptions, mobile subscriptions, internet use, and fixed broadband subscriptions—is associated with a reduction in income inequality in the earlier period of ICT development. For example, the coefficient on fixed telephone subscriptions is negative and statistically significant, indicating that increases in basic telecommunication infrastructure were linked to lower Gini coefficients when ICT diffusion was still in its initial stages. Similar negative but statistically insignificant coefficients for mobile subscriptions, internet use, and broadband subscriptions point toward an overall tendency of early digitalization to play an equalizing role, even if the effects are not statistically significant.

In contrast, the interaction terms—constructed by interacting each digitalization indicator with a post-2013 dummy variable—reveal a markedly different pattern for the later period characterized by more advanced ICT development. For all four indicators, the interaction coefficients are positive, and several of them are statistical significance (notably for fixed telephone subscriptions, internet use, and fixed broadband subscriptions). This implies that, after 2013, digitalization tends to contribute to expanding inequality. These results suggest that as economies transition to a more mature digital environment characterized by advanced broadband, widespread smartphone adoption, and platform-based digital services, further increases in digitalization are associated with higher Gini coefficients. This stands in contrast to the earlier phase and points to a shift in the distributional consequences of digitalization over time.

Table 4. Impacts of Digitalization on Gini Coefficients

	(1)	(2)	(3)	(4)
In fixed telephone subscriptions	-2.690*** (0.840)			
D*In fixed telephone subscriptions	1.307** (0.528)			
In mobile cellular subscriptions		-0.624 (0.737)		
D*In mobile cellular subscriptions		1.012 (1.476)		
In individuals using the Internet			-0.883 (0.881)	
D*In individuals using the Internet			2.366* (1.298)	
In fixed broadband subscriptions				-0.299 (0.327)
D*In fixed broadband subscriptions				1.803** (0.781)
Observations	691	691	690	686
R-squared	0.175	0.113	0.131	0.146
Number of countries	37	37	37	37

Note: See note in Table 2. We omit the results for control variables.

Taken together, the estimates indicate a stage-dependent effect of digitalization on income inequality: digital technologies appear to reduce inequality in the early period—consistent with theories emphasizing improved access to information, markets, and communication—while in the more recent, advanced ICT period, digitalization tends to contribute to widening inequality, likely due to unequal returns to digital capabilities and increasing digital-economic concentration. Thus, the interaction results show that digitalization has become increasing inequality in the advanced ICT era, whereas it reduced inequality in the earlier stage of ICT development.

We now examine how differently digitalization influences the distribution of income across the different stages of digitalization development. Table 5 provides a detailed assessment of how digitalization affects the distribution of income across all five quintiles, and the results reveal a striking contrast between the early and advanced stages of ICT development. In the baseline period most digitalization indicators (fixed telephone subscriptions, mobile cellular subscriptions, internet use, and fixed broadband subscriptions) are positively associated with the income shares of the lowest, second,

Table 5. Impacts of Digitalization on Income Distribution

	(1)	(2)	(3)	(4)
Panel A. Income share held by lowest 20%				
In fixed telephone subscriptions	0.727*** (0.212)			
D*ln fixed telephone subscriptions	-0.384** (0.148)			
In mobile cellular subscriptions		0.030 (0.208)		
D*ln mobile cellular subscriptions		-0.737** (0.363)		
In individuals using the Internet			0.116 (0.223)	
D*ln individuals using the Internet			-0.838** (0.350)	
In fixed broadband subscriptions				0.014 (0.071)
D*ln fixed broadband subscriptions				-0.560** (0.215)
Panel B. Income share held by second 20%				
In fixed telephone subscriptions	0.569** (0.213)			
D*ln fixed telephone subscriptions	-0.275* (0.155)			
In mobile cellular subscriptions		0.242 (0.191)		
D*ln mobile cellular subscriptions		-0.369 (0.393)		
In individuals using the Internet			0.296 (0.226)	
D*ln individuals using the Internet			-0.534 (0.369)	
In fixed broadband subscriptions				0.081 (0.080)
D*ln fixed broadband subscriptions				-0.454** (0.220)
Panel C. Income share held by third 20%				
In fixed telephone subscriptions	0.505** (0.199)			
D*ln fixed telephone subscriptions	-0.194 (0.139)			
In mobile cellular subscriptions		0.261 (0.195)		
D*ln mobile cellular subscriptions		0.151 (0.380)		

Table 5. Continued

	(1)	(2)	(3)	(4)
In individuals using the Internet			0.307 (0.202)	
D*In individuals using the Internet			-0.197 (0.361)	
In fixed broadband subscriptions				0.119 (0.083)
D*In fixed broadband subscriptions				-0.229 (0.186)
Panel D. Income share held by fourth 20%				
In fixed telephone subscriptions	0.340* (0.182)			
D*In fixed telephone subscriptions	-0.134 (0.117)			
In mobile cellular subscriptions		0.141 (0.155)		
D*In mobile cellular subscriptions		0.816** (0.315)		
In individuals using the Internet			0.094 (0.181)	
D*In individuals using the Internet			0.072 (0.296)	
In fixed broadband subscriptions				0.087 (0.068)
D*In fixed broadband subscriptions				0.014 (0.128)
Panel E. Income share held by highest 20%				
In fixed telephone subscriptions	-2.144*** (0.691)			
D*In fixed telephone subscriptions	0.986** (0.437)			
In mobile cellular subscriptions		-0.653 (0.623)		
D*In mobile cellular subscriptions		0.159 (1.235)		
In individuals using the Internet			-0.793 (0.716)	
D*In individuals using the Internet			1.491 (1.086)	
In fixed broadband subscriptions				-0.295 (0.279)
D*In fixed broadband subscriptions				1.224* (0.616)

Note: See note in Table 2. We omit the results for control variables

third, and fourth quintiles. These positive coefficients suggest that digitalization in its earlier phase tended to support more equitable income distribution. The strongest effects appear for fixed-line telephony, which shows significant increases in income shares for the bottom three quintiles, reinforcing the view that ICT infrastructure historically played an inclusive economic role.

The interaction terms—representing the period after 2013, when ICT infrastructure became more advanced—consistently change the direction of these effects for the lower-income quintiles. For the bottom 20 percent and the second 20 percent, the interaction coefficients are negative and statistically significant across most digitalization measures, indicating that the equalizing effects observed in the earlier period either weaken or reverse in the later period. For instance, the income share of the lowest 20 percent increases with mobile-cellular telephony in the early period but decreases once the post-2013 dummy is activated. Similar patterns emerge for fixed telephone subscriptions, internet use, and broadband subscriptions: a technology that once expanded opportunities for low-income populations seems to provide diminished or even adverse distributional effects in the advanced ICT stage. This shift is consistent with the broader literature on the digital divide and capability gaps, which emphasizes that once basic access is universal, the returns to digitalization depend increasingly on digital skills, broadband quality, and the ability to use digital tools productively—dimensions in which low-income groups often lag.

Moving toward the middle quintiles, the pattern becomes more varied, but the stage-dependent dynamics remain evident. In the third and fourth quintiles, early-period coefficients for most ICT indicators are positive but many lose significance or change direction in the later period. In particular, mobile subscriptions show a strong positive effect on the fourth quintile in the advanced ICT era, suggesting that mid-income groups may gain disproportionately from mobile-based economic opportunities such as digital services, app-based work, and platform participation. Meanwhile, the interaction effects for internet use and broadband remain mostly insignificant for these middle quintiles.

For the highest 20 percent, the results show the mirror image of the lower groups. In the early period, several digitalization indicators—especially fixed telephone subscriptions—are associated with a reduction in the top income share, consistent with the broadly inclusive nature of early ICT development. However, the interaction terms for the post-2013 period are positive for all indicators, and some are statistically significant (notably for fixed telephony and broadband), indicating that the top quintile

gains a larger share of income in the more advanced ICT environment.⁴ This finding highlights an important structural shift: after digitalization becomes more skill-intensive and platform-driven, high-income individuals capture disproportionate returns possibly through superior digital skills, access to high-quality broadband, or greater ability to leverage digital platforms. Taken together, the results underscore that digitalization is inequality-reducing in its early stage but becomes inequality-increasing in more technologically advanced periods.

V. Conclusion and Implications

This study examines how digitalization influences income inequality in OECD countries and, in particular, whether its effects vary depending on the stage of ICT development. Using four widely recognized indicators—fixed telephone subscriptions, mobile cellular subscriptions, individuals using the Internet, and fixed broadband subscriptions—we estimate fixed-effects models that separately capture the period before and after 2013, marking the transition to a more advanced phase of ICT infrastructure and usage. The results reveal a consistent and robust pattern: the relationship between digitalization and income inequality is not constant over time, but instead changes significantly across stages of technological development.

In the earlier period of ICT diffusion, digitalization appears to exert an equalizing effect. During the foundational stages of ICT expansion—when basic access to telecommunications, mobile services, and the internet was still uneven—digitalization tended to support more equitable income distribution by broadening access to information, communication, and economic opportunities. However, digitalization becomes inequality-increasing in the more advanced ICT period. Once ICT infrastructure becomes sufficiently developed, the economic returns from digitalization may increasingly favor individuals and groups with higher levels of digital skills, higher-quality broadband access, and stronger capacity to participate in digitally enabled markets.

⁴ Fixed telephone subscriptions are included as a conventional indicator of early ICT diffusion. In the post-2013 period, this variable should be interpreted not as a measure of technological progress per se, but rather as reflecting the persistence of legacy communication infrastructure or its complementary relationship with higher-quality digital networks.

This dynamic perspective helps explain why prior research has produced mixed evidence regarding the relationship between digitalization and inequality. Our findings highlight the importance of designing digital policies that are sensitive to a country's stage of ICT development. In early stages, expanding access remains crucial, but in more advanced stages, policies must increasingly focus on digital skill formation, inclusive broadband quality, and reducing disparities in the ability to utilize advanced digital tools. As economies continue to transition into more sophisticated digital ecosystems, the challenge for policymakers is to ensure that the benefits of digital transformation are broadly shared rather than concentrated among those already equipped to thrive in a digital economy.

Despite providing a dynamic perspective on the relationship between ICT development and income inequality, this study remains subject to several limitations. First, the classification of ICT development stages using a single cutoff year—2013—represents a simplifying assumption adopted for analytical clarity. OECD countries exhibit substantial heterogeneity in the timing, pace, and depth of digital transformation, and applying a uniform temporal threshold may not fully capture differences in national ICT development trajectories. Second, although the fixed-effects framework controls for time-invariant country characteristics and common time trends, the possibility of reverse causality between digitalization and income inequality cannot be fully ruled out. Income inequality may itself shape the diffusion and direction of ICT development by constraining digital access and skill accumulation among lower-income groups, while simultaneously reinforcing demand for advanced digital technologies among higher-income households and firms. As a result, the observed associations may partly reflect bidirectional interactions rather than a purely one-way causal relationship. Addressing these identification challenges in a more rigorous manner is left for future research.

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