A G D I Working Paper

WP/21/057

Do ICTs drive wealth inequality? Evidence from a dynamic panel analysis

Forthcoming in Telecommunications Policy

Henri Njangang[a1], Alim Beleck[b], Sosson Tadadjeu[c], Brice Kamguia[c]

[a] Faculty of economics and management, LAREFA, University of Dschang, Cameroon

[b]Higher Teacher Training College (HTTTC), University of Bamenda

[c]The Dschang School of Economics and Management, LAREFA, University of Dschang, Cameroon.

[1] Corresponding Author : ndieupahenri@gmail.com (H. Njangang); alim.belek@yahoo.fr (A. Beleck);stadadjeu@yahoo.fr (S. Tadadjeu);bricekamguiadj@yahoo.fr (B. Kamguia).

Acknowledgements: The authors would like to thank the four anonymous referees of the journal, Erik Bohlin (the editor), Edmond Noubissi and Tii Nchofoung for their helpful comments and suggestions on the earlier version of this article. However, any remaining errors are solely attributable to the authors.

2021 African Governance and Development Institute WP/21/057

Research Department

Do ICTs drive wealth inequality? Evidence from a dynamic panel analysis

Henri Njangang, Alim Beleck, Sosson Tadadjeu & Brice Kamguia

January 2021

Abstract

Surprisingly, little is known about the cross-country effect of information and communication technology (ICT) on wealth inequality. At the same time, there is some tentative evidence suggesting that information and communication technology is positively correlated with income inequality. However, whether and how ICT affects wealth inequality is less explored, particularly because of the lack of reliable data on wealth inequality. This paper, therefore, fills this gap and contributes to this new literature by investigating the effect of ICT on wealth inequality in a sample of 45 developed and developing countries over the period 2000-2017. ICT is measured with six different indicators (including internet penetration, mobile penetration, ICT service exports, the ICT index, ICT quality, and ICT quantity), while wealth inequality is measured with three different indicators (comprising billionaire wealth to GDP, the Top 1% wealth share, and the Top 10% wealth share). The empirical analysis is based on the Generalised Method of Moments, and the results show that ICT increases wealth inequality. Furthermore, we show that democracy mitigates the increasing effect of ICT on wealth inequality. This result suggests that improving democracy in both developed and developing countries is an effective mechanism for mitigating the effects of ICT on wealth inequality. Therefore, we encourage efforts to implement democratic institutions that ensure respect for citizens' freedoms, greater democratic accountability, and executive constraints that allow for a more egalitarian distribution of wealth.

Keywords: ICT; Wealth inequality; Panel data

JEL Classification: O15; O50; Q55

1. Introduction

While there is a vast literature on the relationship between information and communication technology (ICT) and economic growth (*see*, for example, Stanley et al. (2018) and Vu et al. (2020) for a literature review), less is known about the cross-country effect of ICT on wealth inequality. To the best of the author's knowledge, we are not aware of any studies on the relationship between ICT and wealth inequality. The aim of this paper is therefore to investigate, as a first attempt, the empirical effect of ICT on wealth inequality using a global panel of 45 developed and developing countries.

Wealth inequality refers to the unequal distribution of wealth, assets, or income among the countries of the world and within countries. Wealth is defined as the current market value of all assets held by households, net of all their debts (Zucman, 2016). The persistence of wealth inequalities between the rich and poor undermines the achievement of the Sustainable Development Goals (SDGs) on the one hand, and calls into question any possibility of global, sustainable, and inclusive economic growth on the other (Tadadjeu et al., 2021). The figures put forward by Oxfam (2016) are evocative. While the world's richest 1% own more than twice as much wealth as 6.9 billion people, half of humanity lives with less than $5.50 a day and 10,000 people die every day due to lack of access to affordable health care. According to Piketty (2014), wealth inequality is returning to levels not seen since the First World War. He notes with regret that the top decile in the US controls over 70% of the wealth. This increase in inequality is not unique to the United States, but concerns all countries, especially the developed ones. Moreover, Piketty and Zucman (2014) point out that over the last four decades, the ratio of wealth inequality in the eight largest developed countries to total wealth has risen from 200 to 300% in 1970 to 400 to 600% in 2010.

This accentuation of inequalities goes hand in hand with the ever-increasing number of billionaires. According to Forbes Magazine[2], during the so-called Billionaire Decade (2010-2019), the number of billionaires rose from 1,001 in 2010 to 2,153 in 2019 (an increase of more than 115%) for a total wealth that went from 3.6 trillion dollars in 2010 to more than 8.7 trillion dollars in 2019. Even the coronavirus pandemic has not slowed this progression. While the IMF expected economic growth to contract by 4.4 percent this year, pushing millions of people into poverty, billionaires are growing in number and wealth. According to a report by Swiss Bank UBS[3], billionaires increased their wealth by more than a quarter (exactly 27.5%) at the height of the COVID-19 crisis from April to July 2020.In view of this ever-increasing rise in wealth inequality, it is more than urgent to examine its determinants.

[2]https://www.forbes.com/decade-of-billionaires/
[3]https://www.theguardian.com/business/2020/oct/07/covid-19-crisis-boosts-the-fortunes-of-worlds-billionaires.

This increasing level of wealth inequality has led policymakers, particularly researchers, to examine the factors that may explain that situation.Several studies have therefore highlighted a number of important determinants of wealth inequality, including: income growth, interest rates, monetary inflation, expansionary monetary policy, financial development, financial knowledge,wars, trade openness, education, transmission of bequests, human capital, entrepreneurship, medical expense risk, labor earnings, precautionary savings, stochastic returns to wealth, inheritance, and genetic endowments(Barth et al., 2020; Hasan et al., 2020; Berisha and Meszaros, 2019; Bagchi et al., 2019; Elinder et al., 2018; Lusardi et al., 2017; De Nardi and Fella, 2017; Benhabib et al., 2017; Campanale, 2007; Balac, 2008). Despite ongoing efforts to understand the factors that may influence wealth inequality, the role of ICT has been overlooked by these earlier studies.

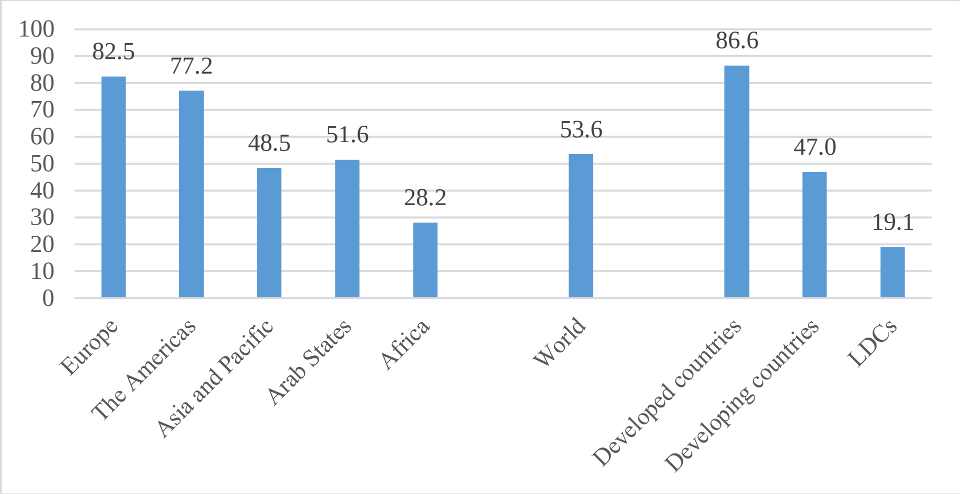
The rate of technological progress has been and continues to be impressive, with ICT growing at an exponential rate (Kurzweil, 1999; Stanley et al., 2018). In 2019, no less than 4.1 billion people have access to the internet, with a penetration rate that has risen from 16.8% in 2005 to over 53.3% in 2019 (ITU, 2019). However, this progression is not homogeneous in all regions. For example, the rate is 87% in developed countries compared to 47% in developing countries (see Figure 1). As far as mobile phones are concerned, the penetration rate is close to saturation in all regions. The mobile penetration rate is 129% in developed countries, 104% in developing countries and even nearly 75% in the least developed countries (see Figure 2).

This rapid growth in ICT adoption is due to its ability to sublimate virtually all sectors of activity. To date, several studies have highlighted the beneficial effects of ICT along several dimensions of economic life, including the productive system (Oulton, 2002; Cardona et al., 2013), trade openness (Freund and Weinhold, 2002; Choi, 2010; Rodríguez-Crespo and Martínez-Zarzoso, 2019), environment (Higón et al., 2017; Asongu et al., 2018; Avom et al., 2020),corruption (Kanyam et al., 2017;Sassi and Ali, 2017; Adam, 2020), institutional quality (Asongu and Nwachukwu, 2016; Ali, 2020), economic sophistication (Lapatinas, 2019), industrialization (Njangang and Nounamo, 2020; Müller, 2021), financial development (Edo et al., 2019; Chien et al., 2020; Owusu-Agyei, 2020), health (Dutta et al., 2019; Kouton et al., 2020), education (Hernandez, 2017), inclusive human development (Asongu and Le Roux, 2017; Asongu et al., 2017), employment (Hjort and Poulsen, 2019;Ndubuisi et al., 2021), and most importantly economic growth (Vu, 2011;Hong, 2017; Albiman and Sulong, 2017;Niebel, 2018; Sawng et al., 2021; Appiah-Otoo and Song, 2021). However, whether and how ICT affects wealth inequality is less explored. Owing to the absence of data on the distribution of wealth for enough countries, the existing literature has analysed the effect of ICT on income inequality(Flores, 2003;Jaumotte et al., 2013;Asongu, 2015;Asongu and Le Roux, 2017;Shahabadi et al.,2017;Richmond and Triplett, 2018;Bauer, 2018;Asongu and Odhiambo, 2019;Tchamyou et al., 2019; Mushtaq and Bruneau, 2019;Canh et al., 2020). Although a growing number of studies have examined the socio-economic effects of ICT, some research gaps remain. First, although some researchers have looked at the impact of ICT on income inequality, little is known about the impact of ICT on wealth inequality. Second, besides the direct impact, we assume that democracy could mitigate the effects of ICT.

This study, while drawing its theoretical foundations from the literature on the ICT -income inequality nexus, departs from the attendant literature and contributes to filling the gaps in the emerging literature on the determinants of wealth inequality on several fronts. **First**, to the best of the authors' knowledge, we are not aware of any studies that investigate the link between ICT and wealth inequality, and therefore, we provide one of the first empirical papers using the largest dataset available on wealth inequality. **Second**, due to the lack of reliable data on wealth inequality, almost all previous studies have focused on income inequality using the Gini index as a dependent variable. This study takes a fresh look at using billionaires' wealth as a percentage of GDP from Bagchi and Svejnar (2015)as the primary measure of wealth inequality. For robustness purposes, this study uses the top one percent as well as the top ten percent of wealth shares from Credit Suisse (2014) as alternative measures of wealth inequality. **Third**, in addition to the traditional measures used to measure ICT (Internet and Mobile), we use several other indicators, namely ICT service exports, and a new dataset on the quality and quantity of ICT (*see*Hilbert, 2019). This paper is therefore the first in the empirical literature to use the new dataset on ICT quality and quantity to investigate the effect of ICT on wealth inequality. **Four**, this study is the first to investigate the mitigating role of democracy in the ICT-wealth inequality nexus. **Five**, to obtain more robust results, we use the Generalised Method of Moments that accounts for potential endogeneity issues. To sum up, using a large panel of 45 developed and developing countries over the period 2000-2017, we find robust evidence that ICT increases wealth inequality and that democracy is a mitigating factor.

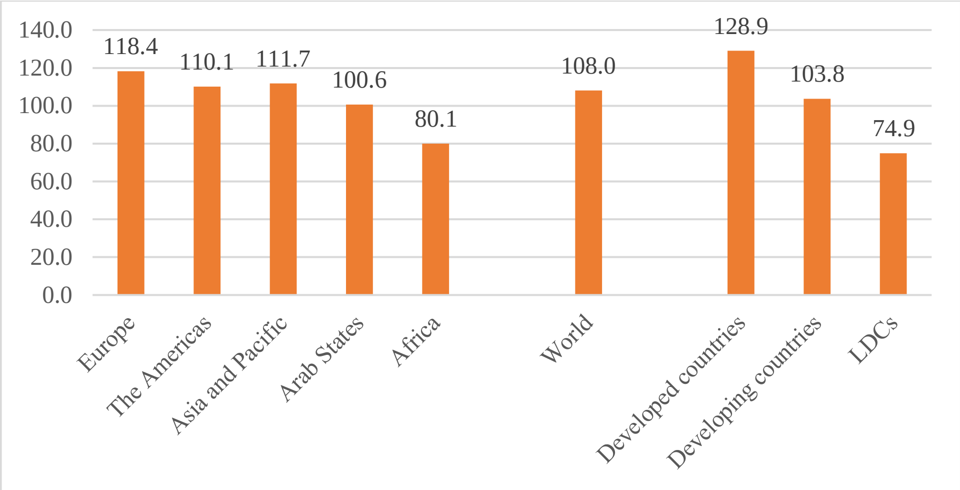
The remainder of this paper is structured as follows. Section 2 discusses the theoretical mechanism through which ICT impacts wealth inequality. Section 3 presents the data and methodology. Section 4 reports the estimation results, and Section 5 concludes.

Figure 1:Individuals unsing the internet (%) in 2019



Source: IUT (2019)

Figure 2: Mobil-cellular Suscriptions (%) in 2019



Source: IUT (2019)

2. Theoretical underpinnings

The economic literature has often explained the accumulation effect and the rise in inequality based on personal capabilities, such as entrepreneurial talent (Guiso and Rustichini, 2018). Entrepreneurship has been seen as a source of economic wealth, and is important in explaining wealth accumulation and distribution (Meh, 2005). The development of ICT has made it easy to learn about business opportunities. Several studies support this idea that ICT promotes entrepreneurship for the creation of small and medium enterprises (Francalanci and Morabito, 2008; Zhang and Li, 2017). Youssef et al. (2021) share this view by suggesting that the digitalisation of the economy affects entrepreneurial intentions. Furthermore, based on the resource-based view and social capital theory, Zhang and Li (2017) argue that the use of ICT enables the effective deployment of ICT-based and other entrepreneurial resources, which increases the success of small and medium-sized enterprises. However, a large body of research suggests that entrepreneurship can increase inequality (Hamilton, 2000; Atems and Shand, 2018). These authors argue that, while entrepreneurship increases the income of some people, most small entrepreneurs have average incomes below the population average. Theories explaining this result rely on incentive arguments, according to which borrowing constraints on entrepreneurs' investment and savings, as well as high costs of external finance, induce entrepreneurs to accumulate wealth, leading to a concentration of wealth among entrepreneurs rather than among wage earners (see, for example, Quadrini, 2000; Cagetti and DeNardi, 2006). Since access to ICT promotes entrepreneurship, this increase in entrepreneurship increases wealth inequality.

Financial development is the second mechanism by which ICT increases wealth inequality. Financial development could increase opportunities in the economy for the less privileged and reduce the intergenerational persistence of relative incomes (Becker and Tomes, 1986; Greenwood and Jovanovic, 1990; Demirgüç-Kunt and Levine, 2009). Chien et al. (2020) show that ICT has a positive impact on financial development by increasing the efficiency of financial institutions and reducing the information asymmetry in financial transactions. The authors also state that ICT can help banks improve their internal risk management and predict the likelihood of loan defaults to meet regulatory objectives for consumer protection or anti-money laundering (Chien et al., 2020). At the same time, financial development may disproportionately hit the rich, widening the inequality gap because of improved financial services for those who already have access to the financial system, which are often high-income individuals and well-established firms (Kuhn et al., 2020; Hasan et al., 2020). Financial development brings new firms into the financial market, while providing new opportunities for incumbent firms. This leads to competition within the financial market, which leads to low interest rates. Wealthier families may have the privilege of accessing enhanced financial services or assets with higher returns with increased financial development. Beck et al. (2007) show, based on a sample of 72 countries, that financial development disproportionately benefits the poor and thus improves income inequality. Roine et al. (2009) further show that financial development is pro-rich and that the effect is strongest at low stages of economic development. Rajan and Zingales (2004) further point out that financial system development is more likely to benefit the rich and well-connected, not only because they have sufficient wealth for collateral (dubbed the tyranny of collateral), but also because the rich can prevent small firms from accessing external finance and reduce the ability of the poor to improve their economic well-being. In sum, increased ICT enhances financial development, which leads to competition in the financial market.

Innovation is another mechanism by which ICT could increase wealth inequality. Several microeconomic and macroeconomic studies agree that the diffusion of ICT promotes innovation (Higón, 2012; Xu et al., 2019). Parida and Örtqvist, (2015) examine the influence of network capacity, information and communication technology (ICT) capacity, and financial margin on the innovation performance of Swedish small firms. The authors confirm that ICT use increases innovation. Xu et al. (2019) emphasize the role of internet accessibility in reducing information costs and thus stimulating regional innovation activity. Using several estimators, Xu et al. (2019) found a positive relationship between internet access and the number of patents filed in countries in the US. However, innovation, while promoting economic growth, can increase income inequality in some parts of the world. Indeed, Law et al. (2020),using panel data from 23 developed countries and the Mean Group method, show that innovation plays an important role in increasing income inequality, particularly the number of patents granted. Aghion et al. (2019) share this view and also find positive correlations between innovation measures and top income inequality in the US. The authors explain this result in part because facilitating innovation favors the share of entrepreneurs' income, leading to higher inequality. In a similar vein, Josifidis and Supic (2020) study the distributional effects of technological progress in the US over the last four decades. The results of the study reveal that the shift in R&D investment from the public to the private sector has been associated with an increase in the income share of the richest classes at the expense of the poorest income classes.

3. Data and methodology

3.1. Data

Our sample covers 45 developed and developing countries over the period 2000-2017 with data from various sources: World Bank: World Development Indicators (WDI); Polity IV project; Credit Suisse (2014), Bagchi and Svejnar (2015),Database of Political Institutions (2017), Hilbert (2019), and V-DEM, Version 11.1[4].The periodicity under investigation is chosen according to data availability constraints. Table 1 presents the descriptive statistics, while Appendix Tables A1, A2, and A3 provide the correlation matrix of the basic model, the list of countries used, and the definitions of the variables, respectively. The full description of the data is as follows.

3.1.1. Wealth Inequality measures

Drawing on the work of Bagchi and Svejnar (2015), in this paper we use billionaires' wealth as a percentage of GDP as the primary measure of wealth inequality. Data on billionaire wealth is compiled from Forbes magazine's list of billionaires. Since 1982, Forbes Magazine has published a list of the 400 richest Americans. However, beginning in 1987, the magazine expanded its list to include the wealthiest individuals and families in the world. We therefore used this list of

[4] See Coppedge et al. (2020).

billionaires worldwide to construct our variable. Billionaire's wealth as a percentage of GDP is the sum of the wealth of all billionaires in a given country divided by the country's GDP. This variable is increasingly used in the literature to measure wealth inequality (Bagchi and Svejnar, 2015; Bagchi et al., 2019; Islam and McGillivray, 2020).

Although billionaire wealth to GDP is our preferred measure of wealth inequality, it is worth nothing that it does not account for all the dimensions of wealth inequality. Therefore, this paper uses two alternative measures of wealth inequality: the top 1% wealth share and the top 10% wealth share, gathered from the Credit Suisse (2014) report. This database has the advantage of simultaneously providing information on the top one percent as well as the top ten percent of wealth shares. Three reasons have been advanced in the literature to justify the choice of the top wealth shares as a measure of wealth inequality (Islam, 2018). First, the top wealth shares are simple to understand and are rigid to wealth variations at the bottom of the wealth distribution. Second, the probability that the wealth of individuals with the highest wealth share will increase is greater than the probability that the wealth of less wealthy individuals will increase. Finally, this measure of wealth inequality is highly correlated with the Gini index that measures income inequality.

3.1.2. *Information and Communication Technology (ICT) measures*

Consistent with recent ICT literature (Asongu and Le Roux, 2017; Niebel, 2018; Asongu and Odhiambo, 2020; Appiah-Otoo and Song, 2021), three indicators are used to proxy ICT, namely: the internet penetration rate (per 100 people), the mobile phone penetration rate (per 100 people), and ICT service exports as a percentage of service exports. These variables are obtained from the World Bank: World Development Indicators (WDI).

To assess the robustness of our results, we use two alternative measures of ICT. First, we constructed an ICT index based on the three previous measures (Internet, Mobile, and ICT service exports) using principal component analysis (PCA). Second, we use a novel dataset on the quantity and quality of ICT (Hilbert, 2019). ICT quantity is measured by the number of subscriptions, and ICT quality is measured by the average quality of subscriptions (bandwidth, measured in kbps) (see, Abeliansky and Hilbert, 2017, p4. for more details on the construction of these two indicators).

3.1.3. Baseline Control variables

To substantiate this relationship and to avoid omission variable bias, we include in our baseline model, and according to the previous literature, six potential determinants of wealth inequality, namely (i) GDP per capita (US constant 2010); (ii) Democracy measured by the Polity 2 index; (iii) Trade openness expressed as the sum of exports and imports to GDP; (iv) financial development proxy by domestic credit to the private sector as a percentage of GDP; (v) natural resources measured by total natural resource rents as a percentage of GDP; and (vi) education captured by school enrolment in higher education.

Table 1 : Summary statistics

Variables	Obs	Mean	Std. Dev.	Min	Max
Wealth inequality					
Billionaire wealth (%GDP)	810	6.668	8.857	0.000	79.642
Top 10% wealth Share	675	63.063	8.319	46.800	84.800
Top 1% wealth Share	675	32.320	9.541	16.900	66.200
ICT diffusion					
Internet penetration rate	805	51.520	28.029	0.528	97.298
Mobile penetration rate	808	95.807	41.982	0.339	251.765
ICT service exports	746	8.057	9.701	0.152	52.088
ICT Index	742	-2.32e-09	1.287	-2.932	3.358
ICT quality	792	5.95e+11	3.29e+12	1.21e+08	7.03e+13
ICT quantity	792	1.31e+08	3.08e+08	2.49E+06	3.39e+09
Baseline controls					
GDP per capita	810	28934.37	21221.73	826.5925	91565.73
Trade openness	809	87.455	71.558	19.798	442.620
Democracy	793	7.073	5.240	-10.000	10.000
Private credit	732	92.466	49.695	9.683	233.211
Natural resources	810	4.252	7.608	0.000	55.341
Education	638	57.643	22.797	7.590	136.603
Additional controls					
Inflation rate	810	3.984	5.954	-16.909	52.924
Foreign direct investment	810	4.963	8.409	-7.322	86.589
Urbanization	810	74.264	15.978	27.667	100.000
Executive corruption	810	0.264	0.259	0.011	0.904
Right wing party	810	0.716	0.451	0.000	1.000

One of the major determinants of wealth inequality is **economic growth,** since both theoretical and empirical literature provides strong evidence of the link between per capita GDP and wealth inequality. Empirical studies, such as Berisha and Meszaros (2019) show that economic growth is negatively correlated with wealth inequality. Therefore, to capture the general macroeconomic condition of an economy, we include per capita GDP as a control variable and we expect a negative relationship between economic growth, and wealth inequality.

Natural resources: since Sachs and Warner (1995) influential work supporting the resource curse hypothesis[5], several empirical and theoretical studies have attempted to extend the resource curse hypothesis to other macroeconomic variables (Tadadjeu et al., 2020; 2021) including income

[5]The resource curse hypothesis shows that resource-poor countries outperform resource-rich countries in economic growth.

inequality. Although there are conflicting results, the majority of studies conclude that natural resources increase income inequality (Leameret al., 1999; Gylfason and Zoega, 2003; Fum and Hodler, 2010; Carmignani, 2013). To verify the resource curse hypothesis, we included in our analysis the total natural resource rents as a percentage of GDP. A positive effect of natural resources on wealth inequality is therefore expected.

Trade openness is another important determinant of wealth redistribution. The relationship between trade openness and income inequality is a highly debated topic in the literature and remains an unresolved puzzle. While numerous empirical studies concluded a positive effect of trade openness on income inequality (Borjas et al., 1997; Zhu and Trefler, 2005), another strand of studies argued that the effect of trade openness on income inequality is negative (Chakrabarti, 2000; Xiong, 2020). We control for trade openness, measured by the total export and import of goods and services over GDP.

The literature has highlighted the role of **institutional quality** in determining countries' wealth redistribution, with democracy promoting a more egalitarian society than autocracies do (Muller, 1988; Shen and Yao, 2008). These studies argue that, because of electoral competition, democracy ensures the effectiveness of economic policies, increases the income shares of poorer portions of the population, and promotes the fair redistribution of wealth, all of which favour the reduction of wealth inequality. Our analysis captures the countries' **democracy** level by the polity2 index, and we expect a negative effect of democracy on wealth inequality.

Financial development has also been recognized as one of the important drivers of wealth inequality, and it might increase or decrease wealth inequality. The majority, if not almost all, of the countries with the greatest wealth inequalities and the largest number of billionaires, are countries with a highly developed financial system. According to Hasan et al. (2020), the relationship between finance and wealth inequality is complex. While countries with large financial markets and financial institutions are associated with greater wealth inequality, countries with a more efficient and accessible financial system exhibit less wealth inequality. In this paper, we measure financial development by private credit (which captures the size of the financial market)and we, therefore, expect a positive relationship between finance and wealth inequality.

The economic literature is replete with studies that associate **education** with greater wealth and faster wealth accumulation (Mincer, 1958; Conley and Ryvicker, 2004; Keister, 2004). For these authors, education, through its effects on the ability of educated individuals to own risky and therefore more profitable assets (Kim et al., 2012), increases their wealth. Abdullah et al. (2015) complete by stating that education affects both tails of the income distribution: education reduces the income share of higher earners and increases that of lower earners. The consequence is a reduction in wealth inequality between those who earn more and those who earn less. We, therefore, include enrolment in higher education as a measure of education and expect a negative sign.

3.1.4. Additional control variables

To verify the robustness of our basic model to the omission of some determinants of wealth inequality, we have introduced, in accordance with the literature (Pan-Long, 1995; Ha, 2012; Behrens and Robert-Nicoud, 2014; Berggren and Bjørnskov, 2020), five additional control variables. (i) Inflation; (ii) Foreign direct investment as a percentage of GDP; (iii) Urbanization measured as the proportion of the urban population to the total population; (iv) executive corruption; and (v) government ideology proxy by the right-wing party**.**

3.2. Empirical model and estimation strategy

Our study aims to investigate the effect of ICT on wealth inequality. For this purpose, we hypothesize that ICT development is positively correlated with wealth inequality. Therefore, we estimate the following dynamic model in Equation (1):

$$Wealth\_Ineq_{i,t} = \alpha + \beta_1 Wealth\_Ineq_{i,t-1} + \beta_2 ICT_{i,t} + \beta_3 X_{i,t} + \mu_i + \gamma_t + v_{i,t} \quad (1)$$

Where $Wealth_Ineq_{i,t}$is the billionaires' wealth as a percentage of GDP in country i for year t.$ICT_{i,t}$ stands for information and communication technology indicators. $X_{i,t}$ is the vector of the baseline controls, including per capita GDP, trade openness, democracy, financial development, natural resources, and education.$\mu_i$is an unobserved country-specific effect, and γ_t is time specific effect.$v_{i,t}$is the error term.

In order to efficiently estimate the dynamic model formulated above, we use the Generalized Method of Moments (GMM) initially proposed by Arellano and Bond (1991), and further improved byArellano and Bover (1995), and Blundell and Bond (1998).Several reasons motivated the choice of the GMM. First, introducing a lagged dependent variable as an explanatory variable invalidates standard static panel regression, due to "dynamic panel bias" (Nickell, 1981).This raises the endogeneity problem, and static estimation will generate biased and inconsistent results. Second, GMM also avoids simultaneity or reverse causality problems: ICTs may be endogenous and, therefore, it is more likely that there is a feedback effect from wealth inequality to ICT. Indeed, a highly unequal society results in less access to infrastructure such as ICT (internet and mobile phone use) by the poor at the expense of the rich. In other words, wealth inequalities would have hurt access to ICT.Third, variable omission bias: there are important variables (especially time-invariant variables) that may be omitted from the regression models, but are considered as important determinants of wealth inequality and are correlated with some explanatory variables

(Asongu and Nwachukwu 2016; Richmond and Triplett 2018; Tchamyou et al. 2019). Finally, measurement errors: ICT or wealth inequality measures are more likely to have measurement errors, particularly in the case of developing countries. All these reasons make the GMM the best estimator.The GMM technique is declined in two versions: the difference GMM where the lagged levels of the explanatory variables are used as instruments and system GMM where the combination of the regression in differences and the regression in levels are used. However, Bond et al. (2001) have recommended that the system GMM estimator developed by Arellano and Bover (1995) and Blundell and Bond (1998) can dramatically improve efficiency and avoid the problem of weak instruments in the first-difference GMM estimator. However, Windmeijer (2005) has shown from Monte Carlo simulations that the estimated asymptotic standard deviations of the two-step GMM estimator can be biased downwards in a finite sample. To eliminate the possibility of such a bias, we use the correction procedure proposed by Windmeijer (2005).

The consistency of the GMM estimator depends on two things: the validity of the assumption that the error term does not exhibit serial correlation (AR (2)) and the validity of the instruments (Hansen test). Too many instruments can severely weaken and bias the Hansen over-identifying restrictions test, and therefore, the rule of thumb is that the number of instruments should be less than the number of countries (Roodman, 2009).

4. Empirical results

4.1 Baseline results

Table 2 reports the estimation results of Equation (1) with Billionaires' wealth to GDP as a proxy for wealth inequality. In these estimations, we include a subset of the contemporaneous determinants of wealth inequality. In columns (1), (3) and (5), we test the bivariate relationship between ICT indicators and wealth inequality without control variables. The results provide evidence of a positive effect of ICT on wealth inequality, and these effects are significant at the 1% level. Specifically, the coefficient associated with ICT export services is positive and statistically significant, with a magnitude suggesting that 10 units of increase in ICT increase wealth inequality by 0.244 units. This result suggests that access to ICT increases wealth inequality. As access to information technology is easier for the rich, it provides them with more opportunities to increase their wealth than people in lower- income brackets. Similarly, as Acemoglu (1998) suggests, if ICT represents a type of skill-based technical change, then the benefits accrue disproportionately to those segments of the labour force that can take advantage of these opportunities. All else being equal, this is likely to increase wealth inequality.

Table 2: ICT and wealth inequality (System GMM: 45 countries, 2000-2017)

	Dependent variable: Billionaire wealth to GDP					
	(1)	(2)	(3)	(4)	(5)	(6)
L. Dependent variable	0.738***	0.408***	0.573***	0.426***	0.868***	0.447***
	(0.000724)	(0.00446)	(0.0157)	(0.00304)	(0.0119)	(0.0158)
Internet	0.0202***	0.0688***				
	(0.00127)	(0.00908)				
Mobile			0.0320***	0.0225***		
			(0.00569)	(0.00217)		
ICT service exports					0.0244***	0.0746***
					(0.00571)	(0.0197)
GDP per capita (log)		-0.871		-2.093***		-3.213***
		(0.575)		(0.469)		(0.389)
Trade openness		0.0950***		0.0835***		0.0825***
		(0.00407)		(0.00205)		(0.00334)
Democracy		-0.0159		-0.150***		-0.518***
		(0.0394)		(0.0316)		(0.0530)
Domestic credit		0.0535***		0.0677***		0.00819
		(0.00921)		(0.00762)		(0.00673)
Natural resources		0.475***		0.315***		0.0602
		(0.0312)		(0.0251)		(0.0519)
Education		-0.0849***		-0.0421***		-0.0256**
		(0.0223)		(0.0121)		(0.0123)
Constant	0.610***	-1.379	-0.562	12.49***	0.782***	35.85***
	(0.0686)	(5.597)	(0.590)	(4.397)	(0.153)	(4.173)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	757	593	763	593	710	564
Number of countries	45	40	45	40	44	38
Number of instruments	32	34	12	34	17	36
AR(1)	0.0209	0.0019	0.0020	0.0189	0.0934	0.0013
AR(2)	0.359	0.510	0.373	0.698	0.216	0.816
Hansen OIR	0.173	0.101	0.105	0.140	0.878	0.589

Notes: ***, **, * denote statistical significance at the 1%, 5%, and 10% levels respectively. Robust standard errors are reported in parentheses. The coefficients are based on the two-step GMM system estimation, using the finite sample correction of Windmeijer (2005). All explanatory variables are treated as potentially endogenous. The lags of the explanatory variables are taken as an instrument for the difference equation, while the first differences of the explanatory variables are taken as an instrument for the level equation.

The results presented in columns (2), (4) and (6) include the control variables. All the coefficients associated with ICT indicators remain positive and statistically significant at the 1% level, suggesting that the development of ICT has favoured the emergence of billionaires and therefore increased wealth inequality. These results are consistent with the existing literature, which shows that ICT is associated with an increase in income inequality (Jaumotte et al., 2013).Our results are explained by the effects of ICT on entrepreneurship, financial development, and innovation. The availability of infrastructure such as ICT can quickly create entrepreneurial opportunities. However, the borrowing constraints of entrepreneurs and the high cost of external finance create incentives for entrepreneurs to accumulate wealth, which leads to a concentration of wealth among entrepreneurs compared to wage earners. In addition, ICT can help banks to improve their internal risk management and predict the probability of loan default. At the same time, financial development can disproportionately affect the rich, widening the inequality gap through improved financial services for those who already have access to the financial system. Regarding entrepreneurship, as Xu et al. (2019) point out, internet accessibility reduces information costs and thus stimulates innovation activity. Innovation favors the income share of entrepreneurs, which leads to greater inequality.

Regarding our control variables, we find that GDP per capita, democracy and education reduce wealth inequality. These results are in line with the work of Hasan et al. (2020),who show that per capita income, democracy and education reduce wealth inequality. Furthermore, we show that trade openness, financial development, and natural resources all increase wealth inequality. These results are similar to work showing that financial development, trade openness, and natural resource dependence increase income inequality (Carmignani, 2013).

Overall, the results of the diagnostic tests show that our models are well specified. The Hansen test does not reject the validity of the instruments, and the absence of second-order serial correlation is not rejected. A high number of instruments may bias the Hansen test of over-identification restrictions, and therefore, the rule of thumb is that the number of instruments should be less than the number of countries (Roodman, 2009). The results of the system GMM estimates generated a maximum of 36 instruments, which is less than the number of countries, so our results are valid.

4.2 Robustness check

To test the robustness of our main results, we conducted in this sub-section sensitivity analyses along several dimensions: additional control variables, alternative measures of the key variables (ICT and wealth inequality), and alternative samples. Overall, in all robustness checks, we find results from the specifications equivalent to those in Tables 2.

4.2.1 Additional control variables

The results in Table 3 show the estimation of the model by introducing five additional control variables. In each specification, we find that the coefficient associated with the different ICT measures is positive and statistically significant at the 1% level. This indicates that the results are robust to the use of additional control variables. Regarding these variables, we find that inflation (Cysne et al., 2005), urbanisation (Adams and Klobodu, 2019), and corruption (Dincer and Gunalp, 2012; Apergis et al., 2010) increase wealth inequality.

Table 3: ICT and wealth inequality (System GMM with Additional controls: 45 countries, 2000-2017)

	Dependent variable: Billionaire wealth (GDP)					
	(1)	(2)	(3)	(4)	(5)	(6)
L.Dependent variable	0.381***	0.377***	0.403***	0.405***	0.337***	0.335***
	(0.00444)	(0.00508)	(0.00308)	(0.00527)	(0.00538)	(0.00553)
Internet	0.0830***	0.0601***				
	(0.00985)	(0.0122)				
Mobile			0.0304***	0.0277***		
			(0.00234)	(0.00239)		
ICT service exports					0.233***	0.214***
					(0.0303)	(0.0296)
GDP per capita (log)	-7.137***	-5.985***	-7.480***	-7.530***	-5.875***	-5.662***
	(1.456)	(1.707)	(0.974)	(1.015)	(1.018)	(1.320)
Trade openness	0.0727***	0.0754***	0.0607***	0.0629***	0.0753***	0.0781***
	(0.00422)	(0.00418)	(0.00541)	(0.00535)	(0.00635)	(0.00677)
Democracy	-0.272***	-0.270**	-0.253***	-0.218**	-0.0744	-0.0199
	(0.0913)	(0.108)	(0.0661)	(0.0811)	(0.0858)	(0.108)
Domestic credit	0.00132	0.00482	0.0393***	0.0258***	0.0447***	0.0320***
	(0.00845)	(0.00706)	(0.00836)	(0.00812)	(0.00798)	(0.00973)
Natural resources	0.0754	0.102	0.00391	0.0330	0.280***	0.181***
	(0.0907)	(0.0840)	(0.0202)	(0.0201)	(0.0299)	(0.0291)
Education	-0.0662***	-0.0370	-0.0277**	-0.00187	-0.0506***	-0.0661***
	(0.0180)	(0.0298)	(0.0113)	(0.0118)	(0.0182)	(0.0214)
Inflation	0.342***	0.313***	0.309***	0.302***	0.280***	0.306***
	(0.0343)	(0.0436)	(0.0308)	(0.0448)	(0.0558)	(0.0556)
FDI	-0.0409***	-0.0343***	-0.0676***	-0.0523***	-0.0480***	-0.0295***
	(0.00518)	(0.00498)	(0.00935)	(0.00993)	(0.00429)	(0.00802)
Urbanization	0.403***	0.379***	0.435***	0.414***	0.455***	0.472***
	(0.0924)	(0.0999)	(0.0791)	(0.0856)	(0.0591)	(0.0628)
Executive corruption		7.222***		11.77***		10.86***
		(1.885)		(4.215)		(2.782)
Right wing party		0.447		0.519		0.0585
		(0.614)		(0.640)		(0.949)
Constant	41.46***	30.26**	39.39***	40.59***	14.00*	9.573
	(11.91)	(13.06)	(6.744)	(8.396)	(7.930)	(12.65)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	593	593	593	593	564	564
Number of countries	39	39	39	39	39	39
Number of instruments	37	37	38	38	36	34
AR(1)	0.0185	0.0018	0.0108	0.0018	0.0084	0.0115
AR(2)	0.411	0.430	0.610	0.631	0.426	0.452
Hansen OIR	0.973	0.998	0.539	0.924	0.784	0.959

Notes: ***, **, * denote statistical significance at the 1%, 5%, and 10% levels respectively. Robust standard errors are reported in parentheses. The coefficients are based on the two-step GMM system estimation, using the finite sample correction of Windmeijer (2005). All explanatory variables are treated as potentially endogenous. The lags of the explanatory variables are taken as an instrument for the difference equation, while the first differences of the explanatory variables are taken as an instrument for the level equation. The largest number of instruments used is 38. Hansen's test checks the validity of the instruments when the null hypothesis is that the instruments are uncorrelated with the residuals. The null hypothesis of the AR test (2) is that the error terms in the first difference regression exhibit no second-order serial correlation. All regressions also satisfy the AR (2) test for second-order serial correlation. Thus, the estimated coefficients are valid.

4.2.2 Alternative measures of wealth inequality

Table 4 summarizes the estimation results using two alternative measures of wealth inequality, namely the top percentile (top 1% wealth share) and top decile (top 10% wealth share)of wealth. From column (1) to column (3), we find that the use of ICT has a positive and significant effect on the top 1% wealth share. Similarly, from column (4) to column (6), we find similar results showing that ICT increases wealth inequality measured by the top 10% wealth share. Thus, the use of ICT creates more opportunities for a certain segment of the population that benefits from it, which allows them to earn more income and leads to an increase in wealth inequality. We can therefore conclude that the results are robust to alternative measures of wealth inequality.

Table 4: ICT and wealth inequality (System GMM with alternative wealth inequality measures: 45 countries, 2000-2017)

	Top 1% wealth Share			Top 10% wealth Share		
	(1)	(2)	(3)	(4)	(5)	(6)
L. Dependent variables	0.988***	0.988***	0.967***	0.977***	0.997***	0.997***
	(0.00398)	(0.00626)	(0.00720)	(0.0125)	(0.00518)	(0.00730)
Internet	0.0225***			0.0247***		
	(0.00153)			(0.00337)		
Mobile		0.00966***			0.00609***	
		(0.00123)			(0.000929)	
ICT service exports			0.0208***			0.0121***
			(0.00484)			(0.00275)
GDP per capita (log)	-0.411***	-0.277***	0.995***	-0.287	-0.387***	0.393***
	(0.0494)	(0.0869)	(0.221)	(0.187)	(0.0623)	(0.0883)
Trade openness	0.00447***	0.00459***	0.00267**	0.00499***	0.00238**	0.00419***
	(0.000990)	(0.000771)	(0.00124)	(0.000995)	(0.000929)	(0.000837)
Democracy	-0.0328**	-0.0737***	-0.199***	-0.113***	-0.0172	-0.153***
	(0.0134)	(0.0189)	(0.0213)	(0.0288)	(0.0211)	(0.0193)
Domestic credit	0.00113	0.00679***	0.0129***	0.00485***	0.00295**	0.0105***
	(0.000863)	(0.00165)	(0.00427)	(0.00166)	(0.00110)	(0.00273)
Natural resources	0.0581***	0.0480***	0.00101	0.0193***	0.0427***	0.00426
	(0.0105)	(0.0104)	(0.00792)	(0.00473)	(0.00728)	(0.00687)
Education	-0.00652**	-0.00461	-0.0217***	-0.00848	-0.00459**	-0.0276***
	(0.00320)	(0.00291)	(0.00745)	(0.00617)	(0.00205)	(0.00428)
Constant	3.190***	0.584	-14.35***	-4.679**	2.678***	-8.865***
	(0.452)	(0.803)	(1.523)	(2.010)	(0.776)	(0.517)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	476	476	449	476	476	449

Number of countries	40	40	40	40	40	40
Number of instruments	37	37	34	38	37	34
AR(1)	0.0006	0.0006	0.0064	0.0270	0.0239	0.0358
AR(2)	0.251	0.443	0.209	0.304	0.322	0.994
Hansen OIR	0.999	0.998	0.793	0.982	0.985	0.728

Notes: ***, **, * denote statistical significance at the 1%, 5%, and 10% levels respectively. Robust standard errors are reported in parentheses. The coefficients are based on the two-step GMM system estimation, using the finite sample correction of Windmeijer (2005). All explanatory variables are treated as potentially endogenous. The lags of the explanatory variables are taken as an instrument for the difference equation, while the first differences of the explanatory variables are taken as an instrument for the level equation. The largest number of instruments used is 38. Hansen's test checks the validity of the instruments when the null hypothesis is that the instruments are uncorrelated with the residuals. The null hypothesis of the AR test (2) is that the error terms in the first difference regression exhibit no second-order serial correlation. All regressions also satisfy the AR (2) test for second-order serial correlation. Thus, the estimated coefficients are valid.

4.2.3 Alternative measures of ICT

The previous results show that ICT (Internet penetration, Mobile penetration, and ICT service exports) has a positive and significant effect on wealth inequality. We now test the robustness of the results using two alternative measures of ICT. First, we use a composite ICT index constructed from the three previous ICT measures (Internet, Mobile, and ICT service exports). This composite index is constructed using Principal Component Analysis (PCA). The estimation results are summarised in Table 5. In column (1), we again find that ICT increases wealth inequality, as measured by billionaires' wealth as a percentage of GDP. Similarly, in columns (2) and (3), where we use the top percentile and top decile wealth respectively, we find that ICT increases wealth inequality. Thus, our hypothesis that ICT increases wealth inequality is robust to the use of this alternative measure of ICT.

Table 5: ICT and wealth inequality (System GMM with ICT index: 45 countries, 2000-2017)

	Billionaire wealth (GDP)	Top 1% wealth share	Top 10% wealth share
	(1)	(2)	(3)
L.Dependent variables	0.257***	0.962***	0.969***
	(0.0249)	(0.0236)	(0.0197)
ICT index	4.511***	1.511***	0.986***
	(0.384)	(0.226)	(0.181)
GDP per capita (log)	-3.857***	-0.573	-0.805***
	(0.566)	(0.416)	(0.288)
Trade openness	0.0791***	0.00170	0.00283*
	(0.00417)	(0.00351)	(0.00142)
Democracy	-0.478***	-0.0804	-0.0904***
	(0.0851)	(0.0482)	(0.0293)
Domestic credit	0.0463**	0.0133***	0.00686**
	(0.0171)	(0.00470)	(0.00333)
Natural resources	0.106***	0.0487***	0.0134
	(0.0283)	(0.0118)	(0.00920)
Education	-0.225***	-0.0905***	-0.0465***
	(0.0226)	(0.0137)	(0.0133)

Constant	54.64***	-0.667	-3.884
	(6.597)	(3.444)	(2.460)
Time fixed effect	Yes	Yes	Yes
Observations	563	262	262
Number of countries	38	38	38
Number of instruments	34	34	34
AR(1)	0.0176	0.0174	0.0281
AR(2)	0.680	0.615	0.570
Hansen OIR	0.145	0.426	0.432

Notes: ***, **, * denote statistical significance at the 1%, 5%, and 10% levels respectively. Robuststandard errors are reported in parentheses. The coefficients are based on the two-step GMM system estimation, using the finite sample correction of Windmeijer (2005). All explanatory variables are treated as potentially endogenous. The lags of the explanatory variables are taken as an instrument for the difference equation, while the first differences of the explanatory variables are taken as an instrument for the level equation. The largest number of instruments used is 34. Hansen's test checks the validity of the instruments when the null hypothesis is that the instruments are uncorrelated with the residuals. The null hypothesis of the AR test (2) is that the error terms in the first difference regression exhibit no second-order serial correlation. All regressions also satisfy the AR (2) test for second-order serial correlation. Thus, the estimated coefficients are valid.

Table 6: ICT and wealth inequality (System GMM with ICT quality and quantity: 45 countries, 2000-2017)

	Billionaire wealth (%GDP)		Top 1% wealth share		Top 10% wealth share	
	(1)	(2)	(3)	(4)	(5)	(6)
L.Dependent variables	0.468***	0.449***	0.951***	0.939***	0.980***	0.965***
	(0.00319)	(0.00327)	(0.00496)	(0.00901)	(0.0189)	(0.0184)
ICT quality	0.614***		0.226***		0.150***	
	(0.0638)		(0.0186)		(0.0221)	
ICT quantity		1.185***		0.158**		0.105*
		(0.175)		(0.0742)		(0.0533)
GDP per capita (log)	-2.416***	-0.739	-0.537***	-0.587***	-0.0819	-0.458***
	(0.422)	(0.491)	(0.127)	(0.132)	(0.158)	(0.148)
Trade openness	0.0601***	0.0836***	0.0270***	0.0453***	0.0211***	0.0360***
	(0.00820)	(0.00955)	(0.00239)	(0.00450)	(0.00293)	(0.00508)
Democracy	-0.123**	-0.260***	0.122***	-0.0929***	-0.0669*	-0.0547***
	(0.0524)	(0.0395)	(0.0221)	(0.0149)	(0.0361)	(0.0181)
Domestic credit	0.00329	0.0437***	0.0159***	0.0189***	0.0105***	0.0160***
	(0.00477)	(0.00928)	(0.00119)	(0.00445)	(0.00319)	(0.00363)
Natural resources	0.370***	0.424***	0.0106***	0.0247***	0.00573	0.0120
	(0.0311)	(0.0271)	(0.00284)	(0.00536)	(0.00680)	(0.0132)
Education	-0.188***	-0.123***	-0.0161***	-0.0159***	-0.00792	-0.0162***
	(0.0166)	(0.0172)	(0.00258)	(0.00339)	(0.00495)	(0.00501)
Constant	-29.06***	-25.93***	-13.29***	2.638	-6.137**	2.773
	(4.253)	(6.378)	(1.908)	(2.252)	(2.812)	(2.160)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	580	580	464	464	464	464
Number of countries	39	39	39	39	39	39
Number of instruments	34	34	35	35	34	34
AR(1)	0.0238	0.0241	0.0007	0.0013	0.0181	0.0203
AR(2)	0.556	0.572	0.109	0.121	0.461	0.537
Hansen OIR	0.273	0.262	0.452	0.755	0.357	0.344

Notes: ***, **, * denote statistical significance at the 1%, 5%, and 10% levels respectively. Robust standard errors are reported in parentheses. The coefficients are based on the two-step GMM system estimation, using the finite sample correction of Windmeijer (2005). All explanatory variables are treated as potentially endogenous. The lags of the explanatory variables are taken as an instrument for the difference equation, while the first differences of the explanatory variables are taken as an instrument for the level equation. The largest number of instruments used is 35. Hansen's test checks the validity of the instruments when the null hypothesis is that the instruments are uncorrelated with the residuals. The null hypothesis of the AR test (2) is that the error terms in the first difference regression exhibit no second-order serial correlation. All regressions also satisfy the AR (2) test for second-order serial correlation. Thus, the estimated coefficients are valid.

Next, we use a novel dataset on the quantity and quality of ICT (Hilbert, 2019). ICT quantity is measured by the number of subscriptions (per capita), and ICT quality is measured by the average quality of subscriptions (bandwidth, measured in kbps). The results using these novel ICT measures are reported in Table 6. As it can be seen, both ICT quality and ICT quantity have a positive and statistically significant coefficient, suggesting that ICT increases wealth inequality. Overall, our baseline results are not influenced by these novel measures of ICT.

4.2.4 Alternative sample

Forbes Magazine's 2017[6] data shows that the United States and China are the largest contributors to our sample in terms of the number of billionaires and billionaires' wealth. The US has no less than 566 billionaires with a total wealth of $2.8 trillion, which represents more than 27% of billionaires and 36% of global wealth. China comes second with 319 billionaires with a total wealth of 808.6 billion dollars. This line of argument sheds a concern about whether our previously established results may have been biased due to over-representation. This issue is addressed here by excluding the US and China. The estimation results of these exercises are reported in Table 7. The results in Table7 show that all the coefficients associated with ICT indicators remain positive and statistically significant at the conventional level, suggesting that ICT is positively correlated with wealth inequality. Overall, we reveal that our previous findings are unbiased by the over-representation concern of some countries in the sample.

[6] https://www.forbes.com/decade-of-billionaires/

Table 7: ICT and wealth inequality (System GMM without outliers: 43 countries, 2000-2017)

	Dependent variable: Billionaire wealth (%GDP)					
	(1)	(2)	(3)	(4)	(5)	(6)
L.Dependent variable	0.737***	0.403***	0.574***	0.423***	0.866***	0.440***
	(0.000715)	(0.00402)	(0.0158)	(0.00342)	(0.0122)	(0.0186)
Internet	0.0190***	0.0497***				
	(0.00125)	(0.0107)				
Mobile			0.0327***	0.0216***		
			(0.00592)	(0.00184)		
ICT service exports					0.0270***	0.0717***
					(0.00564)	(0.0199)
GDP per capita (log)		-0.799		-2.707***		-3.343***
		(0.485)		(0.423)		(0.482)
Trade openness		0.102***		0.0870***		0.0821***
		(0.00354)		(0.00326)		(0.00301)
Democracy		-0.0730		-0.0104		-0.567***
		(0.0433)		(0.0385)		(0.0877)
Domestic credit		0.0417***		0.0805***		0.00433
		(0.00850)		(0.00921)		(0.00788)
Natural resources		0.459***		0.332***		0.0957
		(0.0346)		(0.0250)		(0.0823)
Education		-0.0518**		-0.0143		0.0132
		(0.0203)		(0.0135)		(0.0153)
Constant	0.691***	-3.605	-0.673	13.08***	0.763***	35.71***
	(0.0647)	(4.685)	(0.619)	(4.055)	(0.152)	(5.963)
Time fixed effect	Yes	Yes	Yes	Yes	Yes	Yes
Observations	723	559	729	559	676	530
Number of countries	43	38	43	38	42	36
Number of instruments	32	34	12	34	17	35
AR(1)	0.0021	0.0089	0.0004	0.0001	0.0063	0.0002
AR(2)	0.357	0.520	0.370	0.729	0.216	0.430
Hansen OIR	0.183	0.116	0.113	0.150	0.156	0.892

Notes: ***, **, * denote statistical significance at the 1%, 5%, and 10% levels respectively. Robust standard errors are reported in parentheses. The coefficients are based on the two-step GMM system estimation, using the finite sample correction of Windmeijer (2005). All explanatory variables are treated as potentially endogenous. The lags of the explanatory variables are taken as an instrument for the difference equation, while the first differences of the explanatory variables are taken as an instrument for the level equation. The largest number of instruments used is 35. Hansen's test checks the validity of the instruments when the null hypothesis is that the instruments are uncorrelated with the residuals. The null hypothesis of the AR test (2) is that the error terms in the first difference regression exhibit no second-order serial correlation. All regressions also satisfy the AR (2) test for second-order serial correlation. Thus, the estimated coefficients are valid.

4.3 Is democracy a mitigating factor

The previous results have highlighted the positive and significant relationship between ICT and wealth inequality. However, a fairly extensive literature has shown that better quality institutions reduce inequality. For example, Acemoglu et al. (2015) provide several theoretical arguments for why democracy is supposed to increase redistribution and reduce inequality. By improving the protection of civil liberties, democracy enhances workers' bargaining power and increases the number of workers covered by collective wage bargaining. Moreover, in a meta-analysis, Gradstein and Milanovic (2004) argue that by reducing inequalities in the distribution of political power, democracy helps reduce inequalities in wealth and status. Thus, given all these arguments, it is reasonable to assume that democracy could help mitigate the positive effect of ICT on wealth inequality. In order to test this hypothesis, we formulated and estimated the following interactive model:

$$Wealth\_Ineq_{i,t} = \alpha + \beta_1 Wealth\_Ineq_{i,t-1} + \beta_2 ICT_{i,t} + \beta_3 Demo_{i,t} + \beta_4 (ICT_{i,t} \times Demo_{i,t}) + \beta_5 X_{i,t} + \mu_i + \gamma_t + v_{i,t} \quad (2)$$

Where $Demo_{i,t}$ represents democracy in countries i in time t.We include the interaction term between ICT and democracy$(ICT_{i,t} \times Demo_{i,t})$. We are interested in β_2 and β_4, which provide information on the marginal effect of ICT on wealth inequality according to the level of democracy. A negative coefficient on the interaction term would imply that democracy mitigates the positive effect of ICT on wealth inequality. The results of this exercise are displayed in Table 8.

In line with our expectations, the coefficients associated with the interaction variable are negative and statistically significant, regardless of the ICT indicators. This result implies that democracy mitigates the increasing effect of ICT on wealth inequality. It follows that, in light of the negative interactive effects, the corresponding democracy thresholds needed to reverse the positive effect of ICT on wealth inequality are: (i) 4.28 for internet penetration, (ii) 3.04 for mobile penetration, (iii) 5.825 for the ICT quality, (iv) 5.16 for ICT quantity, and (v) 5.288 for ICT index. These negative interactive effects are evidence of the potential for democracy policy thresholds that are relevant to reducing the positive role of ICT in increasing wealth inequality.

Table 8: ICT and wealth inequality: influence of democracy (System GMM: 45 countries, 2000-2017)

	Dependent variable: Billionaire wealth (%GDP)					
	(1)	(2)	(3)	(4)	(5)	(6)
L.Dependent variable	0.487***	0.360***	0.528***	0.457***	0.479***	0.460***
	(0.00902)	(0.00555)	(0.0269)	(0.0141)	(0.00211)	(0.00451)
Democracy	-1.491***	-1.117***	-0.716***	-2.501***	-4.657***	-0.629***
	(0.314)	(0.106)	(0.122)	(0.591)	(0.369)	(0.208)
Internet	0.0162***					
	(0.00509)					
Internet*Democracy	0.00378***					
	(0.000814)					
Mobile		0.00990***				
		(0.00175)				
Mobile*Democracy		0.00325***				
		(0.000504)				
ICT Cap Services			0.0196***			
			(0.00430)			
(ICT Cap Services)*Democracy			0.00318			
			(0.00802)			
ICT quality				0.0699*		
				(0.0398)		
(ICT quality)*Democracy				0.0120***		
				(0.00422)		
ICT quantity					0.183***	
					(0.0321)	
(ICT quantity)*Democracy					-0.0354***	
					(0.00717)	
ICT Index						0.229*
						(0.121)
(ICT Index)*Democracy						-0.0433***
						(0.00322)
Baseline controls	Yes	Yes	Yes	Yes	Yes	Yes
Time fixed efects	Yes	Yes	Yes	Yes	Yes	Yes
Constant	78.74**	34.54***	20.45*	85.39***	29.90***	99.68***
	(33.31)	(6.078)	(11.69)	(20.71)	(3.984)	(11.59)
Observations	465	465	248	464	464	438
Number of countries	40	40	38	39	39	40
Number of Instruments	29	37	39	29	38	38
AR(2)	0.724	0.738	0.150	0.826	0.432	0.728
Hansen OIR	0.798	0.712	0.782	0.334	0.294	0.477
Democracy thresholds	4.28	3.04	na	5.825	5.16	5.288

Notes: ***, **, * denote statistical significance at the 1%, 5%, and 10% levels respectively. Robust standard errors are reported in parentheses. na: not applicable because at least one estimated coefficient needed for the computation of the threshold is not significant.

5 Conclusion

A large body of studies has examined the effects of information and communication technology (ICT) on various macroeconomic variables. Surprisingly, little is known about the effects of ICT on wealth inequality. Due to the lack of reliable data on wealth inequality, previous studies have used the Gini index to measure wealth inequality. Moreover, previous studies have analyzed the link between ICT and income inequality without focusing on the effect of ICT on wealth inequality. The aim of this study is therefore to fill the gap in the empirical literature by analyzing as a first attempt, the effect of ICT on wealth inequality. Using data from 45 developed and developing countries spanning the period 2000 to 2017, and applying the system Generalized Method of Moments (GMM), we show that ICT(measured by internet penetration, mobile penetration, and ICT service exports)has on average a positive and significant effect on wealth inequality (measured by billionaire wealth to GDP). This result is robust to the use of additional control variables, alternative measures of ICT (ICT index, ICT quality, and ICT quantity), alternative measures of wealth inequality (top 10% wealth share and top 1% wealth share) as well as to the exclusion of outliers. Further analysis shows that democracy mitigates the positive effect of ICT on wealth inequality. This result suggests that improving democracy in both developed and developing countries is an effective mechanism for mitigating the effects of ICT on wealth inequality. Therefore, we encourage efforts to implement democratic institutions that ensure respect for citizens' freedoms, greater democratic accountability, and executive constraints that allow for a more egalitarian distribution of wealth.

Two directions for future work emerge. On the one hand, it would be interesting to examine the effect of ICT on wealth inequality using non-parametric estimation methods, including quantile regression. Such an approach would allow a more detailed examination of the relationship between ICT and wealth inequality, considering the heterogeneity of the wealth distribution. On the other hand, future studies can analyze the role of governance in the relationship between wealth inequality and ICT by using more appropriate estimation techniques, such as the panel smooth transmission regression (PSTR) or the buffered panel approach. These methods have the advantage of proposing more appropriate thresholds.

References

Abdullah, A., Doucouliagos, H., & Manning, E. (2015). Does education reduce income inequality? A meta‐regression analysis. *Journal of Economic Surveys*, *29*(2), 301-316.

Abeliansky, A. L., & Hilbert, M. (2017). Digital technology and international trade: Is it the quantity of subscriptions or the quality of data speed that matters?. *Telecommunications Policy*, *41*(1), 35-48.

Acemoglu, D. (1998). Why do new technologies complement skills? Directed technical change and wage inequality. *The Quarterly Journal of Economics*, *113*(4), 1055-1089.

Acemoglu, D., Naidu, S., Restrepo, P., & Robinson, J. A. (2015). Democracy, redistribution, and inequality. In *Handbook of income distribution* (Vol. 2, pp. 1885-1966). Elsevier.

Adam, I. O. (2020). Examining E-Government development effects on corruption in Africa: the mediating effects of ICT development and institutional quality. *Technology in Society*, *61*, 101245.

Adams, S., & Klobodu, E. K. M. (2019). Urbanization, economic structure, political regime, and income inequality. *Social Indicators Research*, *142*(3), 971-995.

Aghion, P., Akcigit, U., Bergeaud, A., Blundell, R., & Hémous, D. (2019). Innovation and top income inequality. *The Review of Economic Studies*, *86*(1), 1-45.

Albiman, M. M., & Sulong, Z. (2017). The linear and non-linear impacts of ICT on economic growth, of disaggregate income groups within SSA region. *Telecommunications Policy, 41*(7-8), 555-572.

Ali, M. S. B. (2020). Does ICT promote democracy similarily in developed and developing countries? A linear and nonlinear panel threshold framework. *Telematics and Informatics*, *50,* 101382.

Apergis, N., Dincer, O. C., & Payne, J. E. (2010). The relationship between corruption and income inequality in US states: evidence from a panel cointegration and error correction model. *Public choice*, *145*(1-2), 125-135.

Appiah-Otoo, I., & Song, N. (2021). The impact of ICT on economic growth-Comparing rich and poor countries. *Telecommunications Policy*, *45*(2), 102082.

Arellano, M., & Bond, S. (1991). Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The review of economic studies*, *58*(2), 277-297.

Arellano, M., &Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of econometrics*, *68*(1), 29-51.

Asongu, S. (2015). The impact of mobile phone penetration on African inequality. *International Journal of Social Economics*, 42 (8), 706–716.

Asongu, S. A., & Le Roux, S. (2017). Enhancing ICT for inclusive human development in Sub-Saharan Africa. *Technological Forecasting and Social Change*, *118*, 44-54.

Asongu, S. A., & Nwachukwu, J. C. (2016). The mobile phone in the diffusion of knowledge for institutional quality in sub-Saharan Africa. *World Development*, *86*, 133-147.

Asongu, S. A., & Nwachukwu, J. C. (2016). The role of governance in mobile phones for inclusive human development in Sub-Saharan Africa. *Technovation*, *55*, 1-13.
Asongu, S. A., & Odhiambo, N. M. (2019). How enhancing information and communication technology has affected inequality in Africa for sustainable development: An empirical investigation. *Sustainable Development*, *27*(4), 647-656.
Asongu, S. A., & Odhiambo, N. M. (2020). Inequality and gender inclusion: Minimum ICT policy thresholds for promoting female employment in Sub-Saharan Africa. *Telecommunications Policy*, *44*(4), 101900.
Asongu, S. A., Le Roux, S., & Biekpe, N. (2017). Environmental degradation, ICT and inclusive development in Sub-Saharan Africa. *Energy Policy*, *111*, 353-361.
Asongu, S. A., Le Roux, S., & Biekpe, N. (2018). Enhancing ICT for environmental sustainability in sub-Saharan Africa. *Technological Forecasting and Social Change*, *127*, 209-216.
Atems, B., &Shand, G. (2018). An empirical analysis of the relationship between entrepreneurship and income inequality. *Small Business Economics*, *51*(4), 905-922.
Avom, D., Nkengfack, H., Fotio, H. K., & Totouom, A. (2020). ICT and environmental quality in Sub-Saharan Africa: Effects and transmission channels. *Technological Forecasting and Social Change*, *155*, 120028.
Bagchi, S., & Svejnar, J. (2015). Does wealth inequality matter for growth? The effect of billionaire wealth, income distribution, and poverty. *Journal of Comparative Economics*, *43*(3), 505-530.
Bagchi, S., Curran, M., & Fagerstrom, M. J. (2019). Monetary growth and wealth inequality. *Economics Letters*, *182*, 23-25.
Balac, Z. (2008). Monetary inflation's effect on wealth inequality: An Austrian analysis. *The Quarterly Journal of Austrian Economics*, *11*(1), 1-17.
Barth, D., Papageorge, N. W., & Thom, K. (2020). Genetic endowments and wealth inequality. *Journal of Political Economy*, *128*(4), 1474-1522.
Bauer, J. M. (2018). The Internet and income inequality: Socio-economic challenges in a hyperconnected society. *Telecommunications Policy*, *42*(4), 333-343.
Beck, T., Demirgüç-Kunt, A., & Levine, R. (2007). Finance, inequality and the poor. *Journal of economic growth*, *12*(1), 27-49.
Becker, G. S., & Tomes, N. (1986). Human capital and the rise and fall of families. *Journal of labor economics*, *4*(3, Part 2), S1-S39.
Behrens, K., & Robert-Nicoud, F. (2014). Survival of the fittest in cities: Urbanisation and inequality. *The Economic Journal*, *124*(581), 1371-1400.
Benhabib, J., Bisin, A., & Luo, M. (2017). Earnings inequality and other determinants of wealth inequality. *American Economic Review*, *107*(5), 593-97.
Berggren, N., & Bjørnskov, C. (2020). Corruption, judicial accountability and inequality: Unfair procedures may benefit the worst-off. *Journal of Economic Behavior & Organization*, *170*, 341-354.
Berisha, E., &Meszaros, J. (2019). Macroeconomic determinants of wealth inequality dynamics. *Economic Modelling*.
Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of econometrics*, *87*(1), 115-143.
Bond, S., Bowsher, C., & Windmeijer, F. (2001). Criterion-based inference for GMM in autoregressive panel data models. *Economics Letters*, *73*(3), 379-388.

Borjas, G. J., Freeman, R. B., Katz, L. F., DiNardo, J., & Abowd, J. M. (1997). How much do immigration and trade affect labor market outcomes?. *Brookings papers on economic activity*, *1997*(1), 1-90.

Cagetti, M., & De Nardi, M. (2006). Entrepreneurship, frictions, and wealth. *Journal of political Economy*, *114*(5), 835-870.

Campanale, C. (2007). Increasing returns to savings and wealth inequality. *Review of Economic Dynamics*, *10*(4), 646-675.

Canh, N. P., Schinckus, C., Thanh, S. D., & Ling, F. C. H. (2020). Effects of the internet, mobile, and land phones on income inequality and The Kuznets curve: Cross country analysis. *Telecommunications Policy*, *44*(10), 102041.

Cardona, M., Kretschmer, T., & Strobel, T. (2013). ICT and productivity: conclusions from the empirical literature. *Information Economics and Policy*, *25*(3), 109-125.

Carmignani, F. (2013). Development outcomes, resource abundance, and the transmission through inequality. *Resource and Energy Economics*, *35*(3), 412-428.

Chakrabarti, A. (2000). Does trade cause inequality?. *Journal of Economic Development*, *25*(2), 1-22.

Chien, M. S., Cheng, C. Y., & Kurniawati, M. A. (2020). The non-linear relationship between ICT diffusion and financial development. *Telecommunications Policy*, *44*(9), 102023.

Choi, C. (2010). The effect of the Internet on service trade. *Economics Letters*, *109*(2), 102-104.

Conley, D., & Ryvicker, M. (2004). The price of female headship: Gender, inheritance, and wealth accumulation in the United States. *Journal of Income Distribution*, *13*(3/4), 41.

Coppedge, M., Gerring, J., Knutsen, C. H., Lindberg, S. I., Teorell, J., Altman, D., ... & Ziblatt, D. (2020). V-Dem Dataset V10. https://www.v-dem.net/en/data/data/v-dem-dataset-v111/

Credit Suisse. (2014). Global wealth report 2014. *Zurich: Crédit Suisse. https://www.credit-suisse.com/about-us/en/reports-research/global-wealthreport.html*

Cysne, R. P., Maldonado, W. L., & Monteiro, P. K. (2005). Inflation and income inequality: A shopping-time approach. *Journal of Development Economics*, *78*(2), 516-528.

De Nardi, M., & Fella, G. (2017). Saving and wealth inequality. *Review of Economic Dynamics*, *26*, 280-300.

Demirgüç-Kunt, A., & Levine, R. (2009). Finance and inequality: Theory and evidence. *Annu. Rev. Financ. Econ.*, *1*(1), 287-318.

Dincer, O. C., & Gunalp, B. (2012). Corruption and income inequality in the United States. *Contemporary Economic Policy*, *30*(2), 283-292.

DPI (2017). https://mydata.iadb.org/idb/dataset/938i-s2bw/about.

Dutta, U. P., Gupta, H., & Sengupta, P. P. (2019). ICT and health outcome nexus in 30 selected Asian countries: Fresh evidence from panel data analysis. *Technology in Society*, *59*, 101184.

Edo, S., Okodua, H., & Odebiyi, J. (2019). Internet adoption and financial development in Sub-Saharan Africa: Evidence from Nigeria and Kenya. *African Development Review*, *31*(1), 144-160.

Elinder, M., Erixson, O., &Waldenström, D. (2018). Inheritance and wealth inequality: Evidence from population registers. *Journal of Public Economics*, *165*, 17-30.

Flores, C. (2003). Measuring the relationship between ICT use and income inequality in Chile. *University of Texas Inequality Project, Working Paper*, *26*.

Forbes Magazine, List of Billionaires, 2000-2018 issues. http://stats.areppim.com/listes/list_billionairesx10xwor.htm

Francalanci, C., & Morabito, V. (2008). IS integration and business performance: The mediation effect of organizational absorptive capacity in SMEs. *Journal of Information technology*, *23*(4), 297-312.

Freund, C., & Weinhold, D. (2002). The Internet and international trade in services. *American Economic Review*, *92*(2), 236-240.

Fum, R. M., & Hodler, R. (2010). Natural resources and income inequality: The role of ethnic divisions. *Economics Letters*, *107*(3), 360-363.

Gradstein, M., & Milanovic, B. (2004). Does liberté= égalité? A survey of the empirical links between democracy and inequality with some evidence on the transition economies. *Journal of Economic Surveys*, *18*(4), 515-537.

Greenwood J, Jovanovic B. (1990). Financial development, growth, and the distribution of income. J. Polit. Econ. 98(5):1076–107.

Guiso, L., & Rustichini, A. (2018). Understanding the size and profitability of firms: The role of a biological factor. *Research in Economics*, *72*(1), 65-85.

Gylfason, T., & Zoega, G. (2003). Inequality and economic growth: Do natural resources matter?. *Inequality and growth: Theory and policy implications*, *1*, 255.

Ha, E. (2012). Globalization, government ideology, and income inequality in developing countries. *The journal of Politics*, *74*(2), 541-557.

Hamilton, B. H. (2000). Does entrepreneurship pay? An empirical analysis of the returns to self-employment. *Journal of Political economy*, *108*(3), 604-631.

Hasan, I., Horvath, R., & Mares, J. (2020). Finance and wealth inequality. *Journal of International Money and Finance*, 102161.

Hernandez, R. M. (2017). Impact of ICT on Education: Challenges and Perspectives. *Journal of Educational Psychology-Propositos y Representaciones*, *5*(1), 337-347.

Higón, D. A. (2012). The impact of ICT on innovation activities: Evidence for UK SMEs. *International Small Business Journal*, *30*(6), 684-699.

Higón, D. A., Gholami, R., & Shirazi, F. (2017). ICT and environmental sustainability: A global perspective. *Telematics and Informatics*, *34*(4), 85-95.

Hilbert, M. (2019). Digital Data Divide Database. *Available at SSRN 3345756*. Rochester, NY: Social Science Research Network. https://osf.io/qyagv/.

Hjort, J., & Poulsen, J. (2019). The arrival of fast internet and employment in Africa. *American Economic Review*, *109*(3), 1032-79.

Hong, J. P. (2017). Causal relationship between ICT R&D investment and economic growth in Korea. *Technological Forecasting and Social Change*, *116*, 70-75.

International Telecommunication Union (ITU). (2019). Measuring digital development: Facts and figures 2019.

Islam, M. R. (2018). Wealth inequality, democracy and economic freedom. *Journal of Comparative Economics*, *46*(4), 920-935.

Islam, M. R., & McGillivray, M. (2020). Wealth inequality, governance and economic growth. *Economic Modelling*, *88*, 1-13.

Jaumotte, F., Lall, S., & Papageorgiou, C. (2013). Rising income inequality: technology, or trade and financial globalization?. *IMF Economic Review*, *61*(2), 271-309.

Josifidis, K., & Supic, N. (2020). Innovation and Income Inequality in the USA: Ceremonial versus Institutional Changes. *Journal of Economic Issues*, *54*(2), 486-494.

Kanyam, D. A., Kostandini, G., & Ferreira, S. (2017). The mobile phone revolution: have mobile phones and the internet reduced corruption in Sub-Saharan Africa?. *World Development, 99*, 271-284.

Keister, L. A. (2004). Race, family structure, and wealth: The effect of childhood family on adult asset ownership. *Sociological Perspectives, 47*(2), 161-187.

Kim, E. J., Hanna, S. D., Chatterjee, S., & Lindamood, S. (2012). Who among the elderly owns stocks? The role of cognitive ability and bequest motive. *Journal of Family and Economic Issues*, *33*(3), 338-352.

Kouton, J., Bétila, R. R., & Lawin, M. (2020). The Impact of ICT Development on Health Outcomes in Africa: Does Economic Freedom Matter?. *Journal of the Knowledge Economy*, 1-40.

Kuhn, M., Schularick, M., & Steins, U. I. (2020). Income and wealth inequality in America, 1949–2016. *Journal of Political Economy*, *128*(9), 3469-3519.

Kurzweil, R. (1999). The Age of Spiritual Machines. Viking.

Lapatinas, A. (2019). The effect of the Internet on economic sophistication: An empirical analysis. *Economics Letters*, *174*, 35-38.

Law, S. H., Naseem, N. A. M., Lau, W. T., & Trinugroho, I. (2020). Can innovation improve income inequality? Evidence from panel data. *Economic Systems*, *44*(4), 100815.

Leamer, E. E., Maul, H., Rodriguez, S., & Schott, P. K. (1999). Does natural resource abundance increase Latin American income inequality?.*Journal of development Economics*, *59*(1), 3-42.

Lusardi, A., Michaud, P. C., & Mitchell, O. S. (2017). Optimal financial knowledge and wealth inequality. *Journal of Political Economy*, *125*(2), 431-477.

Meh, C. A. (2005). Entrepreneurship, wealth inequality, and taxation. *Review of Economic Dynamics*, *8*(3), 688-719.

Mincer, J. (1958). Investment in human capital and personal income distribution. *Journal of political economy*, *66*(4), 281-302.

Muller, E. N. (1988). Democracy, economic development, and income inequality. *American Sociological Review*, 50-68.

Müller, P. (2021). Impacts of inward FDIs and ICT penetration on the industrialisation of Sub-Saharan African countries. *Structural Change and Economic Dynamics*, *56*, 265-279.

Mushtaq, R., & Bruneau, C. (2019). Microfinance, financial inclusion and ICT: Implications for poverty and inequality. *Technology in Society*, *59*, 101154.

Ndubuisi, G., Otioma, C., & Tetteh, G. K. (2021). Digital infrastructure and employment in services: Evidence from Sub-Saharan African countries. *Telecommunications Policy*, 102153.

Nickell, S. (1981). Biases in dynamic models with fixed effects. *Econometrica: Journal of the econometric society*, 1417-1426.

Niebel, T. (2018). ICT and economic growth–Comparing developing, emerging and developed countries. *World Development*, *104*, 197-211.

Njangang, H., & Nounamo, Y. (2020). Is information and communication technology a driver of industrialization process in African countries?. *Economics Bulletin*, *40*(4), 2654-2662.

Oulton, N. (2002). ICT and productivity growth in the United Kingdom. *Oxford Review of Economic Policy*, *18*(3), 363-379.

Owusu-Agyei, S., Okafor, G., Chijoke-Mgbame, A. M., Ohalehi, P., & Hasan, F. (2020). Internet adoption and financial development in sub-Saharan Africa. *Technological Forecasting and Social Change*, *161*, 120293.

Oxfam, A. (2016). Economy for the 1%. *Oxfam Briefing Paper*, *210*, 44.

Pan-Long, T. (1995). Foreign direct investment and income inequality: Further evidence. *World Development*, *23*(3), 469-483.

Parida, V., & Örtqvist, D. (2015). Interactive effects of network capability, ICT capability, and financial slack on Technology-Based small firm innovation performance. *Journal of Small Business Management*, *53*, 278-298.

Piketty, T. (2014). Capital in the Twenty-first Century (Cambridge, Massachusetts and London, England, The Belknap Press of Harvard University Press).

Piketty, T., &Zucman, G. (2014). Capital is back: Wealth-income ratios in rich countries 1700–2010. *The Quarterly Journal of Economics*, *129*(3), 1255-1310.

Quadrini, V. (2000). Entrepreneurship, saving, and social mobility. *Review of economic dynamics*, *3*(1), 1-40.

Rajan, R. G., & Zingales, L. (2004). *Saving capitalism from the capitalists: Unleashing the power of financial markets to create wealth and spread opportunity*. Princeton University Press.

Richmond, K., & Triplett, R. E. (2018). ICT and income inequality: a cross-national perspective. *International Review of Applied Economics*, *32*(2), 195-214.

Richmond, K., & Triplett, R. E. (2018). ICT and income inequality: a cross-national perspective. *International Review of Applied Economics*, *32*(2), 195-214.

Rodríguez-Crespo, E., & Martínez-Zarzoso, I. (2019). The effect of ICT on trade: Does product complexity matter?. *Telematics and Informatics*, *41*, 182-196.

Roine, J., Vlachos, J., & Waldenström, D. (2009). The long-run determinants of inequality: What can we learn from top income data?. *Journal of public economics*, *93*(7-8), 974-988.

Roodman, D. (2009). A note on the theme of too many instruments. *Oxford Bulletin of Economics and statistics*, *71*(1), 135-158.

Sachs, J. D., & Warner, A. M. (1995). *Natural resource abundance and economic growth* (No. w5398). National Bureau of Economic Research.

Sassi, S., & Ali, M. S. B. (2017). Corruption in Africa: What role does ICT diffusion play. *Telecommunications Policy*, *41*(7-8), 662-669.

Sawng, Y. W., Kim, P. R., & Park, J. (2021). ICT investment and GDP growth: Causality analysis for the case of Korea. *Telecommunications Policy*, *45*(7), 102157.

Shahabadi, A., Nemati, M., & Hosseinidoust, S. E. (2017). The effect of knowledge economy factors on income inequality in the selected Islamic Countries. *Journal of the knowledge economy*, *8*(4), 1174-1188.

Shen, Y., & Yao, Y. (2008). Does grassroots democracy reduce income inequality in China?. *Journal of Public Economics*, *92*(10-11), 2182-2198.

Stanley, T. D., Doucouliagos, H., & Steel, P. (2018). Does ICT generate economic growth? A meta-regression analysis. *Journal of Economic Surveys*, *32*(3), 705-726.

Tadadjeu, S., Njangang, H., Asongu, S., & Nounamo, Y. (2021). Natural resources and wealth inequality: a cross-country analysis. *Journal of Economic and Administrative Sciences*. https://doi.org/10.1108/JEAS-05-2021-0099

Tadadjeu, S., Njangang, H., Ningaye, P., & Nourou, M. (2020). Linking natural resource dependence and access to water and sanitation in African countries. *Resources Policy*, *69*, 101880.

Tchamyou, V. S., Erreygers, G., & Cassimon, D. (2019). Inequality, ICT and financial access in Africa. *Technological Forecasting and Social Change*, *139*, 169-184.

Tchamyou, V. S., Erreygers, G., & Cassimon, D. (2019). Inequality, ICT and financial access in Africa. *Technological Forecasting and Social Change*, *139*, 169-184.

Vu, K. M. (2011). ICT as a source of economic growth in the information age: Empirical evidence from the 1996–2005 period. *Telecommunications Policy*, *35*(4), 357-372.

Vu, K., Hanafizadeh, P., & Bohlin, E. (2020). ICT as a driver of economic growth: A survey of the literature and directions for future research. *Telecommunications Policy*, *44*(2), 101922.

Windmeijer, F. (2005). A finite sample correction for the variance of linear efficient two-step GMM estimators. *Journal of econometrics*, *126*(1), 25-51.

Xiong, Y. (2020). International Trade, Factor Endowments, and Income Inequality: Evidence from Chinese Regional Data. *Emerging Markets Finance and Trade*, *56*(14), 3405-3424.

Xu, X., Watts, A., & Reed, M. (2019). Does access to internet promote innovation? A look at the US broadband industry. *Growth and Change*, *50*(4), 1423-1440.

Youssef, A. B., Boubaker, S., Dedaj, B., & Carabregu-Vokshi, M. (2021). Digitalization of the economy and entrepreneurship intention. *Technological Forecasting and Social Change*, *164*, 120043.

Zhang, F., & Li, D. (2018). Regional ICT access and entrepreneurship: Evidence from China. *Information & Management*, *55*(2), 188-198.

Zhu, S. C., & Trefler, D. (2005). Trade and inequality in developing countries: a general equilibrium analysis. *Journal of international Economics*, *65*(1), 21-48.

Zucman, G. (2016). Wealth inequality. *The Poverty and Inequality Report*, 39-44.

Appendix

Table A1: Correlation matrix (Baseline model)

	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]
[1] Wealth/GDP	1.0000									
[2] Internet	0.0143	1.0000								
[3] Mobile	0.0470	0.6620	1.0000							
[4] ICT service exports	0.1176	0.0586	-0.0110	1.0000						
[5] GDP per capita	-0.0398	0.7589	0.3898	0.0681	1.0000					
[6] Trade	0.1766	0.3621	0.2785	0.0773	0.2642	1.0000				
[7] Polity2	-0.1167	0.3445	0.1294	0.1603	0.4060	0.0091	1.0000			
[8] Private credit	0.0161	0.6126	0.3332	-0.0513	0.5817	0.3347	0.1468	1.0000		
[9] Natural resources	0.2423	-0.2035	0.0583	-0.2009	-0.2265	-0.0361	-0.6112	-0.2531	1.0000	
[10] Higher education	-0.0289	0.6812	0.5304	-0.0865	0.5308	0.1095	0.4215	0.3619	-0.2274	1.0000

Table A2: List of 45 countries

Argentina	Denmark	Israel	Poland	Thailand
Australia	Egypt, Arab Rep	Italy	Portugal	Turkey
Austria	Finland	Japan	Russia	United Arab Emirates
Belgium	France	Malaysia	Saudi Arabia	United Kingdom
Brazil	Germany	Mexico	Singapore	United States
Canada	Greece	Netherlands	South Africa	
Chile	Hong Kong	New Zealand	South Korea	
China	India	Norway	Spain	
Colombia	Indonesia	Peru	Sweden	
Czech Republic	Ireland	Philippines	Switzerland	

Table A3: Variable descriptions and data sources

Variables	Short definitions	Sources
Billionaire wealth	Billionaire wealth as a percentage of GDP	Bagchi and Svejnar (2015)
Top 10% wealth Share	The share of wealth of the richest 10% of the population	Credit Suisse (2014)
Top 1% wealth Share	The share of wealth of the richest 1% of the population	Credit Suisse (2014)
Internet penetration rate	Internet user (per 100 people)	WDI
Mobile penetration rate	Mobile cellular subscriptions (per 100 people)	WDI
ICT service exports	ICT service exports (% of service exports, BoP)	WDI
ICT Index	First component of internet, mobile and ICT service exports	PCA
ICT quality	The average quality of subscriptions (bandwidth, measured in kbps)	Hilbert (2019)
ICT quantity	Measured by the number of subscriptions	Hilbert (2019)
GDP per capita (log)	GDP per capita (constant 2010 US$)	WDI
Trade openness	Sum of exports and imports as a percentage of GDP	WDI
Democracy		Polity IV project
Private credit	Domestic credit to private sector (% of GDP)	WDI
Natural resources	Total natural resources rents (% of GDP)	WDI
Education	School enrollment, tertiary (% gross)	WDI
Inflation rate	Inflation, consumer prices (annual %)	WDI
Foreign direct investment	Foreign direct investment, net inflows (% of GDP)	WDI
Urbanization	Urban population (% of total population)	WDI
Executive corruption	Embezzlement or misuse of public funds for personal purposes by members of the executive	V-DEM, Version 11.1
Right wing party	Parties that are defined as conservative or Christian democratic	DPI (2017)