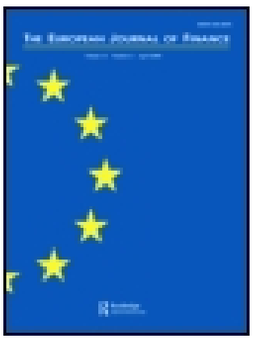

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Fintech, financial inclusion and income inequality: a quantile regression approach

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ABSTRACT

Although theory suggests that financial market imperfections – mainly information asymmetries, market segmentation and transaction costs – prevent poor people from escaping poverty by limiting their access to formal financial services, new financial technologies (FinTech) are seen as key enablers of financial inclusion. Indeed, the UN 2030 Agenda for Sustainable Development (UN-2030-ASD) and the G20 High-Level Principles for Digital Financial Inclusion (G20-HLP-DFI) highlight the importance of harnessing the potential of FinTech to reduce financial exclusion and income inequality. This paper investigates the interrelationship between FinTech, financial inclusion and income inequality for a panel of 140 countries using the Global Findex waves of survey data for 2011, 2014 and 2017. We posit that FinTech affects inequality directly and indirectly through financial inclusion. We invoke quantile regression analysis to investigate whether such effects differ across countries with different levels of income inequality. We uncover new evidence that financial inclusion is a key channel through which FinTech reduces income inequality. We also find that while financial inclusion significantly reduces inequality at all quantiles of the inequality distribution, these effects are primarily associated with higher-income countries. Overall, our results support the aspirations of the UN-2030-ASD and G20-HLP-DFI.

Highlights

- Harnessing the potential of FinTech to reduce financial exclusion and income inequality has been proposed by the UN and G20.
- We posit that FinTech affects income inequality directly and indirectly through financial inclusion.
- We invoke quantile regression analysis to investigate whether the effects of FinTech differ across countries with different levels of income inequality.
- We find that financial inclusion is a key channel through which FinTech reduces income inequality, at all quantile levels, primarily among higher-income countries.

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1. Introduction

An important underpinning in finance theory is that financial institutions and markets play a crucial role in the efficient allocation of capital resources, in the absence of asymmetric information, transaction costs and other market imperfections. The flow of funds conceptual framework builds on this theory to explain the allocation of capital resources across households and firms, ultimately driving economic growth. Indeed, the corpus of

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evidence from developed as well as developing economies suggests that there is an intimate connection between the flow of funds, interest rate and asset price determination, and hence incomes and expenditures (Murinde 2012).

However, due to market imperfections and asymmetric information, the optimal allocation of capital resources may be compromised; some firms and households may be excluded from formal financial markets, with the consequent negative impact on equitable economic growth. At the global level, it is not surprising that there are concerns between the interaction of finance and development, especially where financial exclusion and income inequality are persistent. For example, the UN 2030 Agenda for Sustainable Development recognises the crucial role of financial inclusion in achieving the Sustainable Development Goals (SDGs) and reducing inequality (SDG10) (Klapper, El-Zoghbi, and Hess 2016). Despite the significant gains made in financial inclusion in recent years, 1.7 billion adults worldwide still do not have access to formal financial services, and 760,000 of those with access still do not use them, according to the Global Findex database. Reasons often given for not having or using a financial institution account include high cost, distance, and documentation requirements (Demirgüç-Kunt et al. 2018).

Nevertheless, there seems to be much hope and aspiration that recent innovations in financial technology (FinTech) will offer unprecedented opportunities to overcome barriers to financial inclusion and close the remaining gaps in ownership and use of bank accounts (or accounts at a financial institution), by taking advantage of the increasing penetration of mobile technology (AFI 2018). Increasingly, FinTech is seen as a key enabler of financial inclusion, and mobile financial services as the type of FinTech with the greatest potential to bring the remaining under-banked into the formal financial system and, ultimately, to achieve more equitable growth (GPFI 2016; Demirgüç-Kunt et al. 2018).

What is very surprising, therefore, is that there is limited research which draws on finance theory to investigate whether FinTech can help reduce financial exclusion and how this may ultimately shed light on the intractable problem of income inequality. As noted by Demirgüç-Kunt, Klapper, and Singer (2017, 4), few studies have examined the relationship between financial inclusion and inequality at the country level and, we would add, even fewer have examined the role of FinTech in promoting financial inclusion and a more equal distribution of income. This paper seeks to rise to the challenge, by investigating the interrelationship between FinTech, financial inclusion, and income inequality in a large panel of developed and developing countries using the Global Findex waves of survey data for 2011, 2014 and 2017.

Our paper derives from two strands of the literature. The first strand relates to the relationship between finance and income inequality (e.g. Beck, Demirgüç-Kunt, and Levine 2007; Dabla-Norris et al. 2015b; De Haan and Sturm 2017; Park and Mercado 2018) and attempts to explore channels through which new changes in financial instruments, institutions and markets may address problems of income inequality. The second strand relates to the link between information and communication technology (ICT) and income inequality (e.g. Jaumotte, Lall, and Papageorgiou 2013; Asongu 2015; Dabla-Norris et al. 2015c; Richmond and Triplett 2018). By fusing together these two strands of the literature, the paper seeks to make three main contributions. First, to the best of our knowledge, this is the first study to provide evidence of a link between mobile finance, financial inclusion, and income inequality at the cross-country level. Second, unlike previous empirical studies examining inequality and the inclusiveness of financial systems, which have mostly used supply-side data on financial inclusion, we use demand-side data from the Global Findex database, the world's most comprehensive data set on how adults save, make payments, borrow, and manage risk.[1] Data collected directly from financial service users, rather than from financial service providers and regulators, provide the best insight into their financial behaviour and allow us to better identify which dimensions of financial inclusion are most critical to reducing income inequality. Finally, the paper provides a nuanced analysis of the interrelationship between FinTech, financial inclusion and inequality, showing that financial inclusion is a key channel through which FinTech reduces income inequality. We also invoke quantile regression methodology and find that while financial inclusion significantly reduces inequality at all quantiles of the inequality distribution, these effects are primarily associated with higher-income countries.

The rest of the paper is organised as follows. In section 2, we review the relevant literature on ICT (including FinTech), financial inclusion and income inequality. Section 3 describes the data and empirical methodology

used. In section 4, we present and discuss our regression results. Finally, section 5 concludes and draws policy implications.

2. Literature review

We review three interrelated strands of literature that are relevant to this paper and investigate the relationship between: financial inclusion and income inequality; FinTech and inequality; and FinTech and financial inclusion. Appendix Table A7 provides a summary of the objectives, methodology and findings of the main studies reviewed below.

2.1. Financial inclusion and income inequality

Theory suggests that financial market imperfections – such as information asymmetries and transaction costs – prevent poor people from escaping poverty by limiting their access to formal financial services (Banerjee and Newman 1993; Galor and Zeira 1993; World Bank 2014). For example, Galor and Zeira's model (1993) shows that, in the presence of imperfect credit markets, poor households cannot borrow to invest in their education. Similarly, in the model of Banerjee and Newman (1993), it is because of credit market imperfections that low-income households cannot borrow to set up their own businesses. These models suggest that broader access to finance can reduce poverty and inequality, by giving poor households access to the education and business opportunities that result in increased income.

Despite these theoretical predictions, the macro and micro empirical evidence on the financial inclusion-income inequality nexus remains largely inconclusive. A growing number of cross-country studies suggest that higher levels of financial inclusion – broadly defined as access to and use of formal financial services by households and firms (e.g. Sahay et al. 2015) – are associated with lower levels of income inequality[2] (e.g. Honohan 2007; Mookerjee and Kalipioni 2010; Hermes 2014; Sahay et al. 2015; Kim 2016; Aslan et al. 2017; Park and Mercado 2018; Turégano and Herrero 2018). Research by Mookerjee and Kalipioni (2010) shows that countries with more bank branches per capita tend to have less income inequality. Honohan (2007) also finds a significant negative relationship between household access to finance, as measured by account ownership at a bank or microfinance institution, and income disparities. A recent study by Park and Mercado (2018) suggests that increasing the 'accessibility', 'availability' and 'usage' of financial services (as measured by the number of automated teller machines and commercial bank branches per 100,000 adults; the number of borrowers from, and depositors with, commercial banks per 1,000 adults; and the ratio of domestic credit to GDP) reduces the income gap between the rich and the poor. Similarly, findings by Aslan et al. (2017) show that increasing the 'intensity of use of financial services' by a larger share of the population (proxied by the share of individuals having an account at a financial institution, saving at/borrowing from a financial institution, and making/receiving digital payments) leads to a reduction in income inequality. Using all major measures of financial inclusion – including the extent of account ownership and SME lending, as well as the financial inclusion indices developed by Sarma (2012) and Cámara and Tuesta (2014) – Turégano and Herrero (2018) provide further evidence that countries with a more inclusive financial system tend to have a less unequal income distribution. Likewise, studies with a narrower focus on the role of microfinance as a tool for financial inclusion show that the level of income inequality is lower in developing countries where the level of participation in microfinance programmes is higher (Kai and Hamori 2009; Hermes 2014; Lacalle-Calderon et al. 2019).

Most cross-country studies thus point to a negative impact of financial inclusion on income inequality. However, there seem to be significant differences across regions of the developing world. Increased financial inclusion appears to be associated with reduced income inequality in the Middle East and North Africa (e.g. Neaime and Gaysset 2018) but not in parts of Asia (Park and Mercado 2018), Sub-Saharan Africa (Tita and Aziakpono 2017), or Latin America (e.g. Dabla-Norris et al. 2015a). This suggests that, while financial inclusion is likely to be negatively associated with income inequality, this relationship might vary across countries and depend on factors such as the level of economic development, the quality of institutions and the regulatory environment; the nature of financial institutions, markets and instruments available; and the type of financial inclusion policies pursued.[3]

Evidence from individual-country studies, both empirical and experimental, on the potential inequality-reducing effects of financial inclusion is equally mixed.[4] Some empirical studies have found a positive relationship between financial inclusion and (income or consumption) inequality (e.g. Kochar 2011; Dimova and Adebowale 2018); others, a negative relationship (e.g. Khandker 2005; Mahjabeen 2008; Zhang and Posso 2019); and still others, a changing relationship over time (e.g. Huang and Zhang 2020). For example, Kochar (2011), using household panel data from the Indian state of Uttar Pradesh, finds that not all households have benefited equally from the expansion of banking infrastructure in rural India, where increased *access* to formal financial services (*opportunity to use*) through local bank branches has not translated into increased *use* of these services (*actual use*) by poor households. More specifically, the increase in rural bank branches has improved credit availability for rich households but not for poor ones, leading to an increase in inequality. In contrast, Zhang and Posso (2019) find that in China lower-income households have benefited more from financial inclusion than high- and mid-level income ones. Using cross-sectional household data, they construct a multidimensional index of financial inclusion, which includes measures of account ownership, savings, credit, and insurance, and investigate its impact on household income. Their findings show that financial inclusion has a positive effect on income, and that this effect is larger for households at the lower quantiles of the income distribution, indicating that it reduces inequality. Reconciling these seemingly contradictory findings, other studies, like that by Huang and Zhang (2020), point to the possibility that the impact of financial inclusion varies over time. Using panel data from Chinese provinces and the index of financial inclusion developed by Sarma (2012), they examine the impact of financial inclusion on urban-rural inequality at different time horizons. They find that financial inclusion policies increase the urban-rural income gap in the short run and reduce it in the long one, as the levels of financial infrastructure and financial literacy in rural areas improve over time.

In parallel to these empirical studies, a growing number of experimental studies have been conducted to better identify the causal impact of microfinance on poverty and inequality at the micro level. They raise questions over the effectiveness of microcredit as a policy tool (e.g. Duvendack et al. 2011; Banerjee, Karlan, and Zinman 2015b).

For example, six randomised controlled trials, which were conducted in countries as different as Mexico, Mongolia, Bosnia, India, Ethiopia, and Morocco, found no robust evidence of a positive impact of household participation in microcredit programmes on household income (Angelucci, Karlan, and Zinman 2015; Attanasio et al. 2015; Augsburg et al. 2015; Crépon et al. 2015; Tarozzi, Desai, and Johnson 2015; Banerjee et al. 2015a, 2015b). Summarising their results, Banerjee, Karlan, and Zinman (2015b, 3) acknowledged 'the lack of transformative effects' of microloans on the average borrower.

Yet evidence from recent randomised controlled trials (RCTs) on the impact of (micro-)savings[5], (micro-)insurance and payments services is more consistently positive than those for microcredit (Cull, Ehrbeck, and Holle 2014; Beck 2015; Demirgüç-Kunt, Klapper, and Singer 2017). For instance, an experimental study in Malawi found that access to savings accounts helped farmers increase their agricultural output, income and expenditures (Brune et al. 2016). In Kenya, access to non-interest-bearing bank accounts allowed market vendors to increase their savings, consumption expenditures and business investment (Dupas and Robinson 2013). In Ghana, farmers provided with weather-based insurance were more likely to engage in the cultivation of higher-risk/return crops and, as a result, were able to generate higher revenues than non-insured farmers (Karlan et al. 2014). To the extent that (micro-) financial services other than (micro-) credit have been found to increase the income of the poor, they might be particularly effective in reducing inequality.

To conclude, empirical and experimental evidence from single-country studies suggests that different dimensions of financial inclusion (i.e. access and use), and different financial services (i.e. credit, savings, insurance, and payments), might have different effects on inequality. Moreover, the effects of financial inclusion on inequality might vary over time.

2.2. FinTech and inequality

Eight out of ten people in the developing world own a mobile phone. Indeed, more households own a mobile than have access to electricity or clean water (World Bank 2016). Information and communication technologies (including FinTech) can play an important role in reducing income inequality, especially in developing countries.

They can create new job and income-generating opportunities for the poor. They can also help improve tax collection and government services, while reducing corruption[6] (e.g. Aker and Mbiti 2010).

This is supported by findings from Asongu and Le Roux (2017). Using a panel of 49 Sub-Saharan countries over the period 2000–2012, they find that mobile, internet and broadband penetration have a positive impact on inclusive growth, as measured by the inequality-adjusted human development index. Asongu (2015) reports a negative relationship between mobile penetration and income inequality in a sample of 52 African countries. Similarly, more recent research by Asongu and Odhiambo (2019) finds a negative relationship between mobile, internet and broadband penetration and inequality in a panel of 48 African countries. Individual country studies provide further evidence of the positive development outcomes of information and communication technologies (ICTs). According to findings by Abor, Amidu, and Issahaku (2018), mobile ownership reduces the probability of a household falling into poverty in Ghana. Research by Beuermann, McKelvey, and Vakis (2012) in rural Peru reveals that mobile phone coverage expansion has reduced extreme poverty, while increasing household consumption. Evidence from several African countries also indicates that mobile phones have improved the delivery of agricultural, health and educational services (Aker and Mbiti 2010).

Most studies focus on ICTs other than FinTech, and very few studies have examined the distributional impact of FinTech, in general, and mobile finance, in particular. Asongu and Nwachukwu (2018) examine the relationship between mobile banking and inclusive development (quality of growth, inequality and poverty) in a cross-section of 93 countries. One of its most significant findings is that the use of mobile phones to pay bills or to send/receive money is significantly and negatively associated with income inequality but only in upper-middle income countries. A closely related study by Asongu and Odhiambo (2018) shows that mobile banking can contribute to reducing income inequality in countries where it is lowest or highest (i.e. at 10th and 90th percentile of the income inequality distribution), but that this effect is contingent on a country's level of economic development, as measured by the human development index. A common limitation of these studies, however, is that they do not address endogeneity concerns.

Recent studies illustrate some of the mechanisms through which FinTech can contribute to reducing inequality and poverty. Evidence from China shows that FinTech – measured by an index of digital financial inclusion constructed with data from Ant Financial – reduces the rural-urban income gap, by facilitating rural entrepreneurship (Zhang, Zhang, and He 2018). Research by Suri and Jack (2016) shows that mobile money lifted 2 percent of Kenyan households out of poverty and increased per capita consumption levels. These benefits were driven by changes in household financial behaviour (i.e. increased financial resilience and savings), as well as in occupational choices (i.e. individuals moving out of agriculture and into business). Evidence from Niger and India shows that digitising government payments reduces administrative costs and corruption, leaving more resources available for social spending (Aker et al. 2011; Muralidharan, Niehaus, and Sukhtankar 2014). More research needs to be conducted on the effects of FinTech on income inequality, and the channels through which these effects come about, given the scarcity of studies on these issues.

2.3. FinTech and financial inclusion

With few exceptions (Peruta 2018), most studies have found that ICT and FinTech are important drivers of financial inclusion (Jack and Suri 2011; Mbiti and Weil 2011; Ghosh 2016; Gosavi 2018; Tchamyou, Erreyger, and Cassimon 2019). There is evidence of a strong association between the level of mobile phone penetration and financial inclusion across and within countries (e.g. Andrianaivo and Kpodar 2012; Ghosh 2016). There is also evidence of a positive relationship between mobile money use, on the one hand, and household and firm financial inclusion, on the other. Households with a mobile money account tend to be banked, receive/send remittances more frequently, and accumulate more savings (Morawczynski 2009; Jack and Suri 2011; Mbiti and Weil 2011; Ouma, Odongo, and Were 2017). Mobile money has also been found to have a positive impact on SME financial inclusion, through its effects on increased access to bank credit (e.g. Gosavi 2018).

These studies suggest that mobile technology has great potential for extending the outreach of the formal banking system in countries where most of the population remains unbanked (or informally banked) but owns a mobile phone. A major limitation of this literature, however, is its narrow focus on certain financial products and countries, such as the M-Pesa mobile money system and eastern Sub-Saharan African countries, which

raises questions about the generalisability of their findings. More research is needed on the FinTech-financial inclusion nexus that goes beyond the current focus on certain technologies and regions.

2.4. Implications of the literature

Several research implications can be drawn from our review of the relevant literature. First, the relationship between financial inclusion and income inequality might vary by dimensions of financial inclusion (access versus use), as well as by type of financial service (payments, savings, credit and insurance). This suggests the need to incorporate different measures of financial inclusion in our econometric model. Second, existing studies look at either the relationship between financial inclusion and inequality or that between FinTech and inequality but fail to look at their interrelationship. FinTech might affect income inequality indirectly through its effects on financial inclusion. Finally, the relationship between FinTech, financial inclusion and inequality might vary across countries with different levels of income inequality and be influenced by a country's economic development and institutional environment.

3. Data and econometric strategy

3.1. Model

To determine the impact of FinTech and financial inclusion on within-country income inequality, we develop the following model:

$$Inequality_{i,t} = \alpha_0 + \alpha_1 Fintech_{i,t} + \alpha_2 Financial\_inclusion_{i,t} + \sum_{k=1}^{K} \rho_k X_{k,i,t} + u_{i,t} \quad (1)$$

where *inequality* refers to income inequality; *FinTech* denotes mobile financial technology; *financial_inclusion* refers to access and use of formal financial services; and X represents a set of control variables that are commonly used in the recent finance-inequality and technology-inequality literature (e.g. Beck, Demirgüç-Kunt, and Levine 2007; Jaumotte, Lall, and Papageorgiou 2013; Dabla-Norris et al. 2015c; Neaime and Gaysset 2018; Park and Mercado 2018; Asongu and Odhiambo 2019). These variables are: GDP per capita growth (Beck, Demirgüç-Kunt, and Levine 2007; Neaime and Gaysset 2018; Park and Mercado 2018; Lacalle-Calderon et al. 2019); trade openness (Beck, Demirgüç-Kunt, and Levine 2007; Jaumotte, Lall, and Papageorgiou 2013; Hermes 2014; Dabla-Norris et al. 2015c; Aslan et al. 2017; Neaime and Gaysset 2018; Turégano and Herrero 2018; Lacalle-Calderon et al. 2019); inflation (Beck, Demirgüç-Kunt, and Levine 2007; Hermes 2014; Aslan et al. 2017; Neaime and Gaysset 2018; Park and Mercado 2018; Lacalle-Calderon et al. 2019); government spending (Dabla-Norris et al. 2015c; Turégano and Herrero 2018; Lacalle-Calderon et al. 2019); education (Beck, Demirgüç-Kunt, and Levine 2007; Jaumotte, Lall, and Papageorgiou 2013; Hermes 2014; Aslan et al. 2017; Park and Mercado 2018; Lacalle-Calderon et al. 2019); and population growth (Beck, Demirgüç-Kunt, and Levine 2007; Hermes 2014; Lacalle-Calderon et al. 2019). Finally, u_i is the error term, which is assumed to have mean zero and variance equal to one.

The specification of our model follows that of Altunbaş and Thornton (2019), who examine the effect of financial development on income inequality using quantile regression. In our case, however, the focus of analysis is on the potential inequality-reducing effect of financial inclusion.

3.2. Data

For our empirical analysis, we collected data from three main sources, namely: the Standardised World Income Inequality Database (SWIID) for the income inequality measure[7]; the Global Financial Inclusion Database (Findex) for our FinTech and financial inclusion variables; and the World Development Indicators Database for the control variables. The data was collected for 140 countries and the years 2011, 2014 and 2017.[8]

In order to explore the heterogeneity of the sample countries, we use the World Bank's classification scheme for 2015, where low-income economies are defined as those with a GNI per capita of $1,025 or less in 2015; lower

middle-income economies are those with a GNI per capita between $1,026 and $4,035; upper middle-income economies are those with a GNI per capita between $4,036 and $12,475; and high-income economies are those with a GNI per capita of $12,476 or more.

3.2.1. Dependent variable

Income inequality is measured by the Gini coefficient of disposable income, which ranges from 0 (perfect equality) to 100 (perfect inequality). This is the most widely used measure of income inequality in the literature on the relationship between finance and inequality (e.g. Beck, Demirgüç-Kunt, and Levine 2007; Jauch and Watzka 2016; De Haan and Sturm 2017).

3.2.2. Main variables of interest

In line with Asongu and Odhiambo (2018) and Asongu and Nwachukwu (2018), FinTech is proxied by the use of mobile phones to pay bills. Following Allen et al. (2016), we use various measures of financial inclusion to capture access to and use of different types of formal financial services, namely: the share of the adult population (aged 15+) owning an account at a formal financial institution; the proportion of adults saving at a formal financial institution; and the share of the adult population borrowing from a formal financial institution.

Existing cross-country studies have found a negative relationship between FinTech and inequality (Asongu and Nwachukwu 2018; Asongu and Odhiambo 2018), as well as between financial inclusion and inequality although not for all regions (e.g. Honohan 2007; Park and Mercado 2018). This raises the question of whether the inequality-reducing impact of FinTech and financial inclusion vary across countries depending on their level of income inequality and economic development. Another question that existing studies have not fully addressed is related to the relationship between FinTech and financial inclusion and, in particular, to the possibility that the impact of FinTech on income inequality is mediated by its effects on financial inclusion.

To control for the potential endogeneity of financial inclusion and FinTech, we regress our measures of these variables on a set of instruments identified in the finance-inequality and ICT-inequality literatures, and use the predicted values in our estimations. In line with previous studies, we instrument for financial inclusion using a country's legal origins and quality of institutions (e.g. Mookerjee and Kalipioni 2010; Hermes 2014; Lacalle-Calderon et al. 2019). The instruments used for FinTech (mobile finance) are mobile phone penetration and fixed broadband penetration (Andrianaivo and Kpodar 2012; Ghosh 2016; Demirgüç-Kunt et al. 2018). The definition, summary statistics and correlation matrix of these instruments and our FinTech, financial inclusion and income inequality variables are provided in Appendix Tables A3–A6.

3.2.3. Control variables

Our control variables include: *growth*[9], measured as the annual percentage change in per capita GDP; *trade*, measured by the sum of exports and imports as a share of GDP; *inflation,* measured by the consumer price index; *redistributive policies*, proxied by government spending over GDP; *education*, proxied by the secondary school enrolment rate; and *population growth*, which is measured by the annual percentage change in population. We use lagged values of the control variables to avoid potential endogeneity problems.

Per capita GDP growth can reduce inequality, by increasing the income share of the poor. However, it can increase it, if low-income households do not reap the benefits of growth (e.g. Beck, Demirgüç-Kunt, and Levine 2007). Trade and government spending have been found to reduce income inequality (e.g. Jaumotte, Lall, and Papageorgiou 2013; Dabla-Norris et al. 2015c; Turégano and Herrero 2018). In contrast, increases in inflation and population growth rates tend to be associated with increases in inequality (e.g. Jaumotte, Lall, and Papageorgiou 2013; Dabla-Norris et al. 2015c; Neaime and Gaysset 2018). Finally, the evidence on the inequality-reducing impact of education is mixed and seems to depend on the evolution of rates of return to education i.e. the skill premium (e.g. Beck, Demirgüç-Kunt, and Levine 2007; Jaumotte, Lall, and Papageorgiou 2013; Dabla-Norris et al. 2015c; Neaime and Gaysset 2018; Park and Mercado 2018). Table 1 describes the variables to be used in the empirical analysis and specifies the data sources used.

The summary statistics of the variables used in estimation and testing are reported in Table 2. Income inequality, as measured by the Gini coefficient, was found to be lowest in Belarus in 2014 and was highest in South Africa

Table 1. Description of the variables.

Variable	Source	Definition and measurement
Panel A: Dependent Variables		
Gini	The Standardized World Income Inequality Database (SWIID)	Net Inequality
Panel B: Financial Inclusion Indicators		
Account	Global Findex	Having an account at a formal financial institution (% age 15+),
Saving	Global Findex	Saving at a formal financial institution (% age 15+),
Borrowing	Global Findex	Borrowing from a formal financial institution (% age 15+)
Panel C: FinTech Indicators		
FinTech	Global Findex	Mobile phone used to pay bills (% age 15+)
Panel E: Control Variables		
Financial Development	International Money Fund	Financial development index
Education	World Development Indicators 2017 (World Bank)	School enrolment, secondary (% gross)
Redistributive policies	World Development Indicators 2017 (World Bank)	General government final consumption expenditure (% of GDP)
Trade	World Development Indicators 2017 (World Bank)	Trade (% of GDP)
Population growth	World Development Indicators 2017 (World Bank)	Population growth (annual %)
Growth	Author's calculations using data from World Development Indicators 2017 (World Bank)	Author's calculations
GDP	World Development Indicators 2017 (World Bank)	GDP (constant 2010 US$)
Institutional quality	World Governance Indicators 2017 (WGI) (World Bank)	Author's calculations using data from World Governance Indicators 2017 (WGI) (World Bank)

Note: This table presents the variables used in the paper, their definitions and/or measurement, and the sources of raw data.

Table 2. Summary statistics.

Variable	Obs	Mean	Std. dev.	Min	Max
Inequality	383	37.680	7.723	24.002	59.879
Account	405	53.021	31.238	1.520	100
Savings	405	22.207	18.904	0.690	79.330
Borrowing	405	11.453	7.113	0.419	40.510
FinTech	332	4.558	5.904	0.030	37.100
School	404	101.281	15.965	17.546	145.249
Ins. quality	420	−0.003	0.900	−1.978	1.861
Trade	402	89.417	50.561	23.702	286
Gov exp	399	15.720	5.171	4.371	36.604
Inflation	411	6.682	9.748	0.054	62.169
Population	417	16.473	1.479	11.299	21.060
GDP	411	8.600	1.518	5.363	11.589
GDPgr	366	3.601	3.477	−20.490	25.560
Fin dev	363	48.280	22.147	11.739	99.278

Notes**:** This table presents the summary statistics of the variables used in the estimations. Obs. stands for the number of observations. Std. Dev. is the standard deviation of each variable for a panel of 140 countries for years 2011, 2014 and 2017. Mean is the arithmetic average of each variable in our sample; Min is the minimum value of each variable in the sample; Max is the maximum value of each variable in our sample. Inequality denotes income inequality, measured by the Gini coefficient. Account is the percentage of adults having an account at a formal financial institution. Savings is the percentage of adults saving at a formal financial institution. Borrowing is the percentage of adults that borrow from a formal financial institution. Accounts, Savings and Borrowing are used as measures of financial inclusion. FinTech is a proxy for financial technologies and is measured by the percentage of adults that use of their mobile phone to pay bills. School denotes secondary school completion rate and is used as a proxy for human capital. Ins. quality stands for the quality of institutions. Trade denotes international trade and is measured by the sum of exports and imports as a percentage of GDP; Gov exp refers to government expenditure as a percentage of GDP. Inflation is the inflation rate and is measured by the rate of change of the consumer price index. Population refers to the population growth rate. GDPgr refers to the GDP growth rate. Financial development denotes an index of financial development.

also in 2014. Account ownership was lowest in Niger in 2017 and highest in Denmark in 2011. Saving at a formal financial institution was lowest in Egypt in 2014 and highest in Norway in 2011. Borrowing from a formal financial institution was lowest in Yemen in 2017 and highest in Israel in 2011. Using a mobile phone to pay bills was lowest in Madagascar in 2011 and highest in Kenya in 2014. These results show that the financial systems of

Scandinavian countries are more inclusive while those of African countries are less so. Yet, in terms of FinTech, as proxied by mobile phone used to pay bills, Kenya is well ahead other countries, reflecting that it has become one of the fastest growing mobile money markets in Sub-Saharan Africa and the world.

3.3. Econometric strategy

Our empirical strategy seeks to: (1) test whether financial inclusion is one of the channels through which FinTech affects inequality; (2) test how different dimensions of financial inclusion affect income inequality across countries which have different levels of income inequality and are at different stages of economic development; and (3) address potential endogeneity concerns.

Specifically, our econometric strategy consists of a four-step procedure. First, we examine how FinTech affects financial inclusion. We do so by running a set of pooled OLS regressions using different measures of both FinTech and financial inclusion. We regress financial inclusion on FinTech and other determinants identified in the relevant literature (e.g. Allen et al. 2016).

In the second step, we examine whether and how FinTech affects income inequality. We start with a parsimonious model regression of income inequality on FinTech. We then include in the model control variables that have been found to affect income inequality and check if the coefficient on FinTech changes significantly. Finally, we add a measure of financial inclusion to the model and examine how the coefficient on FinTech is affected.

In the third step, we run quantile regressions to examine the potentially differential effects of FinTech and financial inclusion on income inequality across countries with different levels of inequality. The quantile estimator can be obtained by solving the following optimisation problem (Altunbaş and Thornton 2019):

$$\min \sum_{i\in\{i:y_i\geq x'_i\alpha\}} \alpha|y_i - x'_i\Omega| + \sum_{i\in\{i:y_i<x'_i\alpha\}} 1-\alpha|y_i - x'_i\Omega|$$

for the α-th quantile ($0 < \alpha < 1$), where y_i is the dependent variable and x_i is a k by 1 vector of explanatory variables.

In the fourth step, we re-run the quantile regressions for four different sub-samples of countries, namely: high-income countries, upper middle-income countries, lower middle-income countries and low-income countries. This allows to assess if the impact of FinTech and financial inclusion varies across different country income groups.

One possible problem with our empirical model that needs to be addressed is the presence of endogeneity. One important source of potential endogeneity is reverse causality between, on the one hand, FinTech and financial inclusion and, on the other, income inequality, although Honohan (2007) has pointed out that endogeneity is not likely to be as serious a problem when we are trying to explain income inequality, as it would be if we were trying to explain income levels or growth. Another possible source of endogeneity comes from the presence of common unobserved factors affecting both the dependent and the main explanatory variables.

As previously pointed out, to address potential endogeneity concerns, we regress our measures of FinTech and financial inclusion variables on a set of instruments identified in the finance-inequality and ICT-inequality literatures, and use the predicted values in our estimations. In line with previous studies, we instrument for financial inclusion using a country's legal origins and quality of institutions (e.g. Mookerjee and Kalipioni 2010; Hermes 2014; Lacalle-Calderon et al. 2019).[10] As some of our control variables may also be endogenous, we use lagged values for all of them.

4. Econometric results

4.1. Main results

Table 3 reports regression results with three alternative measures of financial inclusion as the dependent variable, namely: 'account ownership', 'saving at a formal financial institution', and 'borrowing from a formal financial

Table 3. The impact of FinTech on financial inclusion.

VARIABLES	(1) Account	(2) Savings	(3) Borrowing
FinTech	0.673**	0.727**	0.285**
	(0.097)	(0.116)	(0.065)
GDP	10.616***	2.848***	1.104
	(0.248)	(0.261)	(0.392)
School	−0.019	−0.029	0.031*
	(0.017)	(0.011)	(0.010)
Population	0.881*	1.190***	−0.433
	(0.274)	(0.078)	(0.167)
Ins. quality	12.211***	11.352***	1.393*
	(0.183)	(0.113)	(0.382)
Constant	−54.128***	−22.386**	4.776**
	(3.754)	(3.134)	(0.897)
Observations	263	263	263
R-squared	0.769	0.726	0.326

Note: This table reports the regression results for the impact of FinTech on financial inclusion. The dependent variables are Account, Savings and Borrowing, where: Account = % of adults having an account at a formal financial institution; Savings = % of adults saving at a formal financial institution; and Borrowing = % of adults borrowing from a formal financial institution. The explanatory variables are: FinTech = % of adults using their mobile phone to pay bills; GDP = real Gross Domestic Product; School = secondary school completion rate; Population = population growth rate; Ins. quality = Institutional quality. These variables are further described, with sources of data indicated, in Table 1.

Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

institution'. The findings confirm that FinTech has a significant positive effect on all measures of financial inclusion. The size of the FinTech coefficient is largest when using 'savings' as the dependent variable, and smallest when using 'borrowing'. Our cross-country results are consistent with previous single-country studies that have found a positive relationship between FinTech and financial inclusion in African countries (e.g. Mbiti and Weil 2011; Gosavi 2018).

Table 4 presents the results of the regression analysis for income inequality. In the first two columns, inequality is regressed on FinTech only, and then regressed on FinTech and a series of control variables, respectively. In both cases, FinTech is strongly correlated with inequality. Moreover, the coefficient of FinTech is significantly negative, indicating that FinTech reduces income inequality. The estimated coefficient suggests that a one-point increase in FinTech adoption in a country results in an 18–23% reduction in income inequality.

An interesting result appears in columns 3–5. In those columns, we complement the set of regressors by entering the variables 'account', 'savings', and 'borrowing' individually. Column 3 displays the results of the estimation when 'account' is added to column 2. The coefficient of 'account' is negative and significant. However, the coefficient of FinTech, though negative, shrinks and loses significance, which suggests that in previous estimations it partly captured the indirect effect of FinTech on income inequality through account ownership at a formal financial institution. Column 4 displays the regression results after adding 'savings' to column 2 as an explanatory variable of income inequality. The sign of the coefficient of 'savings' is negative and significant, implying that an increase in the share of the population that saves at a formal financial institution reduces income inequality. The coefficient of FinTech loses significance and shrinks with respect to column 2. We again consider this finding as evidence that the impact of FinTech on inequality is mediated by financial inclusion, in this case, saving at a formal financial institution. Column 5 reports the estimation results when 'borrowing' is added to column 2. Here, borrowing is negatively associated with income inequality at the 1% significance level and the coefficient of FinTech becomes insignificant. This finding again indicates that financial inclusion is a key channel through which FinTech affects income inequality. This implies that accounting for the impact of financial inclusion on income inequality leaves little scope for the effects of FinTech to be observed directly.

An equally important finding is that financial inclusion reduces income inequality. This is consistent with the results obtained by other recent cross-country studies which, unlike ours, are based on supply-side data on

Table 4. The impact of FinTech on income inequality.

VARIABLES	(1) Inequality	(2) Inequality	(3) Inequality	(4) Inequality	(5) Inequality
FinTech	−0.237***	−0.175***	−0.063	−0.050	−0.071
	(0.015)	(0.047)	(0.045)	(0.048)	(0.052)
Account			−0.087***		
			(0.015)		
Saving				−0.122***	
				(0.026)	
Borrowing					−0.480***
					(0.125)
GDPgr		0.387***	0.293**	0.327**	0.372***
		(0.122)	(0.133)	(0.130)	(0.139)
School		0.041*	0.046**	0.047**	0.045**
		(0.021)	(0.020)	(0.020)	(0.021)
Trade		−0.046***	−0.032***	−0.038***	−0.039***
		(0.009)	(0.010)	(0.010)	(0.011)
Gov exp		−0.481***	−0.327***	−0.343***	−0.251*
		(0.104)	(0.110)	(0.113)	(0.132)
Inflation		0.006	−0.062	−0.046	−0.033
		(0.056)	(0.058)	(0.059)	(0.059)
Population		−0.073	0.201	0.085	−0.077
		(0.276)	(0.275)	(0.274)	(0.281)
Constant	38.821***	45.318***	41.609***	41.976***	46.273***
	(0.342)	(5.635)	(5.629)	(5.637)	(5.849)
Observations	270	259	256	256	258
R-squared	0.035	0.312	0.361	0.347	0.298

Note**:** Table 4 reports regression results for the impact of FinTech and financial inclusion on income inequality. The dependent variable is income inequality, measured by the Gini coefficient. FinTech is measured by the percentage of adults who use their mobile phone to pay bills. Financial inclusion is measured in three ways, by Account (the percentage of adults that have an account at a formal financial institution), Savings (the percentage of adults that save at a formal financial institution), and Borrowing (the percentage of adults that borrow from a formal financial institution). GDPgr = denotes the GDP growth rate. School refers to the secondary school completion rate. Trade denotes international trade and is measured by the sum exports and imports over GDP. Gov exp denotes government expenditure as a percentage of GDP. Inflation is the inflation rate and is measured by the rate of change of the consumer price index. Population refers to the population growth rate.
Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

financial inclusion (Mookerjee and Kalipioni 2010; Kim 2016; Park and Mercado 2018; Turégano and Herrero 2018) or microfinance (Kai and Hamori 2009; Hermes 2014; Lacalle-Calderon et al. 2019). Our results are also in line with those of single-country studies that have found a negative relationship between household financial inclusion and (income or consumption) inequality in developing countries, such as Bangladesh (Khandker 2005; Mahjabeen 2008) and China (Zhang and Posso 2019).

As can be seen in Table 4, the magnitude of the coefficients of the financial inclusion variables suggest that, for financial inclusion to reduce inequality most effectively, increased 'access' to formal financial services (i.e. 'account') must be followed by increased 'use' of these services (i.e. 'savings' and 'borrowing'). A 1-percentage-point increase in formal account ownership results in a 0.087-percentage-point reduction in the Gini coefficient, while the same increase in formal savings and formal borrowing leads to a 0.12- and 0.48-percentage-point reduction in the Gini, respectively.

Regarding the control variables, they behave largely as expected. Like previous studies, we find that, together with financial inclusion, government redistribution (Turégano and Herrero 2018) and trade openness (Mookerjee and Kalipioni 2010; Turégano and Herrero 2018) play a significant role in reducing income disparities.

In sum, our results indicate that FinTech affects inequality through financial inclusion, and that financial inclusion – whether proxied by formal account ownership, savings, or borrowing – plays a crucial role in reducing income inequality. They also suggest that different dimensions of financial inclusion have a differential impact on inequality reduction.

Next, we examine whether the inequality-reducing impact of financial inclusion varies across countries with different income inequality levels – a question that, to the best of our knowledge, has not been fully addressed in

Table 5. The impact of FinTech and financial inclusion on income inequality: Quantile regression results.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)
	(0.10)	(.25)	(.50)	(.75)	(.90)	(0.10)	(.25)	(.50)	(.75)	(.90)	(0.10)	(.25)	(.50)	(.75)	(.90)
VARIABLES	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality
FinTech	−0.090	−0.063	−0.059	−0.067	−0.071	−0.023	−0.002	−0.021	−0.094	−0.090	−0.066	0.004	−0.088	−0.121	−0.101
	(0.114)	(0.057)	(0.063)	(0.076)	(0.163)	(0.105)	(0.070)	(0.067)	(0.066)	(0.183)	(0.089)	(0.082)	(0.065)	(0.084)	(0.172)
Account	−0.067**	−0.084***	−0.097***	−0.111***	−0.149***										
	(0.033)	(0.016)	(0.018)	(0.022)	(0.047)										
Savings						−0.138***	−0.137***	−0.141***	−0.141***	−0.191**					
						(0.048)	(0.032)	(0.031)	(0.030)	(0.084)					
Borrowing											−0.380**	−0.562***	−0.416***	−0.349**	−0.696**
											(0.162)	(0.149)	(0.118)	(0.152)	(0.313)
GDPgr	0.161	0.142	0.458***	0.439***	0.504*	0.196	0.257**	0.423***	0.452***	0.597*	0.196	0.339**	0.466***	0.427***	0.274
	(0.202)	(0.101)	(0.111)	(0.135)	(0.289)	(0.176)	(0.116)	(0.112)	(0.110)	(0.305)	(0.153)	(0.141)	(0.112)	(0.144)	(0.296)
School	0.036	0.029	0.024	0.059**	0.057	0.040	0.048*	0.035	0.050**	0.043	0.050	0.055*	0.033	0.027	0.074
	(0.044)	(0.022)	(0.024)	(0.030)	(0.063)	(0.039)	(0.026)	(0.025)	(0.024)	(0.068)	(0.034)	(0.031)	(0.025)	(0.032)	(0.065)
Trade	−0.045***	−0.045***	−0.033***	−0.019*	0.006	−0.061***	−0.060***	−0.040***	−0.028***	0.006	−0.056***	−0.058***	−0.042***	−0.044***	0.001
	(0.017)	(0.008)	(0.009)	(0.011)	(0.024)	(0.014)	(0.009)	(0.009)	(0.009)	(0.025)	(0.012)	(0.011)	(0.009)	(0.012)	(0.024)
Gov exp	−0.113	−0.434***	−0.460***	−0.544***	−0.032	−0.047	−0.354***	−0.504***	−0.538***	0.018	−0.101	−0.316***	−0.571***	−0.638***	−0.250
	(0.154)	(0.077)	(0.085)	(0.103)	(0.220)	(0.136)	(0.090)	(0.087)	(0.086)	(0.237)	(0.114)	(0.105)	(0.083)	(0.108)	(0.221)
Inflation	−0.149	−0.155***	−0.126**	0.061	−0.133	−0.191**	−0.144***	−0.113**	0.079	−0.123	−0.070	−0.132**	−0.104**	0.102*	−0.010
	(0.092)	(0.046)	(0.051)	(0.062)	(0.132)	(0.081)	(0.053)	(0.051)	(0.051)	(0.140)	(0.070)	(0.064)	(0.051)	(0.065)	(0.134)
Population	−0.323	0.156	0.382	0.359	0.205	−0.164	−0.240	0.014	0.291	0.177	−0.399	−0.563	−0.051	−0.131	0.104
	(0.552)	(0.276)	(0.303)	(0.370)	(0.791)	(0.480)	(0.317)	(0.307)	(0.301)	(0.835)	(0.413)	(0.379)	(0.301)	(0.389)	(0.798)
Constant	42.615***	44.460***	43.086***	43.200***	43.204**	39.108***	46.760***	47.024***	43.041***	40.449**	42.860***	53.506***	51.498***	56.248***	47.368***
	(11.734)	(5.861)	(6.447)	(7.861)	(16.805)	(10.305)	(6.814)	(6.587)	(6.469)	(17.925)	(8.921)	(8.188)	(6.508)	(8.398)	(17.238)
Equality test					(account)4.41					(saving)5.12					(borrowing)3.93
					$p = 0.009$					$p = 0.008$					$p = 0.010$
R-squared	0.342	0.354	0.412	0.431	0.455	0.201	0.221	0.302	0.325	0.345	0.301	0.339	0.358	0.412	0.447
Observations	248	248	248	248	248	248	248	248	248	248	248	248	248	248	248

Note: This table reports quantile regression results for the impact of FinTech and financial inclusion on income inequality. The dependent variable is income inequality, measured by the Gini coefficient. FinTech is a proxy for FinTech, measured as the percentage of adults that use a mobile phone to pay bills. Financial inclusion is measured using three proxies, namely: Account (the % of adults having an account at a formal financial institution), Savings (the % of adults saving at a formal financial institution), and Borrowing (the % of adults borrowing from a financial institution). GDPgr denotes the GDP growth rate. School denotes the secondary school completion rate and is used as a measure of human capital. Trade refers to foreign trade and is measured by exports plus imports as a percentage of GDP. Gov exp denotes government expenditure as a percentage of GDP. Inflation is a measure of inflation, which is measured as the rate of change of the Consumer Price Index. Population denotes the population growth rate. The equality test applied is the F-test where the null hypothesis purports that the estimated slope coefficients for financial inclusion variables (account, saving and borrowing) are not statistically different across all the quantile estimates.

Standard errors in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 6. The impact of FinTech and financial inclusion on income inequality in high-income, upper-middle income, lower-middle income and low-income countries.

VARIABLES	(1) Inequality	(2) Inequality	(5) Inequality	(6) Inequality	(7) Inequality
High-Income Countries					
FinTech	−0.143**	−0.009*	0.014	0.027	0.021
	(0.066)	(0.012)	(0.018)	(0.055)	(0.016)
Account			−0.121***		
			(0.010)		
Savings				−0.071**	
				(0.033)	
Borrowing					−0.125**
					(0.063)
Observations	114	114	100	100	111
R-squared	0.040	0.322	0.425	0.652	0.544
Upper-Middle Income Countries					
FinTech	−0.026*	−0.041	−0.066	−0.147**	−0.031**
	(0.015)	(0.074)	(0.150)	(0.069)	(0.013)
Account			0.214***		
			(0.074)		
Saving				0.379***	
				(0.078)	
Borrowing					−0.325***
					(0.084)
Observations	90	75	79	79	79
R-squared	0.055	0.321	0.432	0.543	0.602
Lower-Middle Income Countries					
FinTech	0.143***	0.044	0.047	0.123	0.008
	(0.048)	(0.058)	(0.051)	(0.129)	(0.042)
Account			0.070***		
			(0.024)		
Saving				0.195*	
				(0.097)	
Borrowing					0.397**
					(0.169)
Observations	88	79	66	65	74
R-squared	0.045	0.201	0.234	0.240	0.321
Low Income Countries					
FinTech	0.236**	0.562***	0.464***	0.455***	0.244**
	(0.098)	(0.151)	(0.145)	(0.150)	(0.119)
Account			0.146***		
			(0.054)		
Saving				0.226**	
				(0.098)	
Borrowing					1.316***
					(0.296)
Observations	58	46	46	46	46
R-squared	0.182	0.356	0.465	0.501	0.582

Note**:** This table reports regression results for the impact of FinTech and financial inclusion on income inequality in countries with varying income levels. The dependent variable is income inequality measured by the Gini coefficient. FinTech is a proxy for FinTech, measured by the percentage of adults using a mobile phone to pay bills. Financial inclusion is measured using three proxies: Account (the percentage of adults having an account at a formal financial institution), Savings (the percentage of adults saving at a formal financial institution), Borrowing (the percentage of adults borrowing from a financial institution). GDPgr denotes the GDP growth rate. School refers to the secondary school completion rate. Trade refers to foreign trade and is measured by the sum of exports and imports over GDP; Gov exp denotes government expenditure as a percentage of GDP. Inflation is a measure of inflation and is calculated as the rate of change of the Consumer Price Index; Population denotes the population growth rate.

Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

the existing literature.[11] Table 5 presents the results of our quantile regressions for the full sample of countries using different measures of financial inclusion. The first five columns report the regression results for the 10, 25, 50, 75 and 90 percent quantiles when 'account' is used as the financial inclusion indicator. The signs of the quantile regression coefficients for 'account' in columns (1) to (5) are consistent with the results in Table 4,

Table 7. The impact of FinTech and financial inclusion on income inequality, where the IMF financial development index is used as a proxy for financial inclusion.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
				(0.10)	**(.25)**	**(.50)**	**(.75)**	**(.90)**
VARIABLES	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality	Inequality
FinTech	−0.237***	−0.175***	−0.090	−0.121**	−0.084	−0.098**	−0.111*	−0.126
	(0.015)	(0.059)	(0.063)	(0.053)	(0.066)	(0.046)	(0.056)	(0.090)
Fin Dev			−0.078***	−0.027	−0.070***	−0.083***	−0.113***	−0.068**
			(0.020)	(0.022)	(0.018)	(0.016)	(0.026)	(0.034)
GDPgr		0.387***	0.311***	0.270*	0.203**	0.219***	0.236*	0.443***
		(0.110)	(0.115)	(0.158)	(0.086)	(0.073)	(0.140)	(0.155)
School		0.041*	0.044*	0.048	0.043	0.023	0.023	0.064**
		(0.024)	(0.025)	(0.039)	(0.032)	(0.024)	(0.022)	(0.032)
Trade		−0.046***	−0.033***	−0.051***	−0.044***	−0.040***	−0.057***	−0.012
		(0.009)	(0.009)	(0.010)	(0.010)	(0.011)	(0.011)	(0.011)
Gov exp		−0.481***	−0.294***	−0.329***	−0.524***	−0.455***	−0.432***	−0.503***
		(0.086)	(0.090)	(0.072)	(0.078)	(0.052)	(0.124)	(0.192)
Inflation		0.006	−0.047	−0.340	−0.106	−0.077	−0.069	0.004
		(0.045)	(0.048)	(0.217)	(0.124)	(0.063)	(0.084)	(0.079)
Population		−0.073	0.519	0.228	0.460	0.316	0.564	0.200
		(0.300)	(0.342)	(0.399)	(0.366)	(0.329)	(0.349)	(0.353)
Constant	38.821***	45.318***	34.147***	32.983***	36.749***	43.489***	44.035***	44.382***
	(0.342)	(6.469)	(7.041)	(8.632)	(7.254)	(6.476)	(6.942)	(7.499)
Equality Test								(Fin Dev) 4.43 $p = 0.008$
Observations	270	249	248	239	259	233	251	239
R-squared	0.035	0.312	0.412	0.375	0.389	0.399	0.423	0.456

Note**:** This table reports regression results for the impact of FinTech and financial inclusion on income inequality, where financial inclusion is proxied by the IMF financial development index (Fin Dev). The dependent variable is income inequality measured by the Gini coefficient. FinTech is a proxy for FinTech and is measured by the percentage of adults using a mobile phone to pay bills. GDPgr refers to the GDP growth rate. School denotes the secondary school completion rate. Trade refers to the sum of exports and imports over GDP; Gov exp denotes government expenditure as a percentage of GDP. Inflation is the rate of change of the Consumer Price Index; Population refers to the population growth rate.
Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

indicating that an increase in the proportion of the population with an account at a formal financial institution is associated with a reduction in income inequality at all quantiles of the income distribution. Importantly, while 'account' reduces inequality at all quantile levels, its inequality-reducing impact is larger in countries with higher inequality. The equality test results for 'account' allow us to reject the null hypothesis that all regression quantile coefficients are equal (see lower part of Table 5).

The signs of the coefficients for 'savings' in columns (6) to (10) are also consistent with the results in Table 4, revealing a significant negative relationship between the share of the population with savings at a formal financial institution and income inequality at all quantiles. The inequality-reducing effects of financial inclusion, when measured by 'savings', also increase in the upper part of the inequality distribution. The equality test results for 'savings' also reject the null hypothesis that all regression quantile coefficients are equal. Finally, the signs of the coefficients on 'borrowing' in columns (11) to (15) are also in line with the results in Table 4. The higher the proportion of adults borrowing from a formal institution, the lower the level of income inequality in a country. Also in this case, a consistent negative sign is found at all quantiles, and the coefficient increases in magnitude in the upper part of the inequality distribution. The equality test results for 'borrowing' allow us to reject the null hypothesis that all regression quantile coefficients are equal.

In short, our quantile regression results show that an increase in *financial inclusion* is associated with a decrease in income inequality at all quantile levels. Furthermore, the inequality-reducing effect of financial inclusion increases as inequality increases. As can be seen in Table 5, our results indicate that a 1-percentage-point increase in formal account ownership results in a 0.067-percentage-point reduction in the Gini coefficient in countries at the 10th percentile of the income inequality distribution, and a 0.149-percentage-point reduction in countries at the 90th percentile. The same increase in formal savings and formal borrowing leads to a 0.138- and 0.38-percentage-point reduction in the Gini coefficient in the least unequal countries (at the 10th percentile

Table 8. The impact of FinTech and financial inclusion on income inequality for countries with different income levels- the IMF financial development index is used as a proxy for financial inclusion.

	(1) High Income	(2) Upper middle-income	(3) Lower middle-income	(4) Low Income
VARIABLES	Inequality	Inequality	Inequality	Inequality
FinTech	0.010	−0.052*	0.047	0.547***
	(0.009)	(0.030)	(0.054)	(0.150)
Fin Dev	−0.047**	−0.079**	0.119***	−0.212
	(0.019)	(0.036)	(0.035)	(0.172)
GDPgr	0.031	−0.020	0.224*	0.069
	(0.021)	(0.050)	(0.115)	(0.190)
School	−0.018***	−0.024**	0.100***	0.067***
	(0.007)	(0.012)	(0.033)	(0.020)
Trade	0.005	−0.006	−0.073***	0.024
	(0.005)	(0.013)	(0.008)	(0.029)
Gov exp	−0.170***	−0.173	−0.758***	0.093
	(0.054)	(0.123)	(0.086)	(0.123)
Inflation	0.050	−0.006	−0.079	−0.014
	(0.032)	(0.015)	(0.078)	(0.063)
Population	1.051**	1.753	−1.739***	−0.569
	(0.435)	(1.177)	(0.397)	(1.174)
Constant	21.568***	17.664	73.415***	40.980*
	(7.222)	(20.594)	(7.869)	(21.941)
Observations	114	70	68	44
R-squared	0.065	0.212	0.321	0.326

Note**:** This table reports regression results for the impact of FinTech and financial inclusion on income inequality for countries with different levels of income. The IMF financial development index (Fin Dev) is used as a proxy for financial inclusion. The dependent variable is income inequality measured by the Gini coefficient. FinTech is a proxy for FinTech and is measured by the percentage of adults using a mobile phone to pay bills. GDPgr denotes the GDP growth rate. School refers to the secondary school completion rate. Trade refers to foreign trade and is measured exports plus imports as a percentage of GDP. Gov exp denotes government expenditure as a percentage of GDP. Inflation is the rate of change of the Consumer Price Index. Population refers to the population growth rate.
Robust standard errors in parentheses: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

of the income inequality distribution), and to a 0.191- and 0.696-percentage-point decrease in the Gini index in the most unequal ones (at the 90th percentile), respectively.

These findings complement those of Altunbaş and Thornton (2019), according to which an increase in *financial development* is associated with an increase in income inequality at all quantile levels. While more research is needed, these results may be interpreted as evidence that financial inclusion and financial development have very different distributional effects.

Next, we examine whether the inequality-reducing impact of financial inclusion varies across countries with different income levels. In order to examine whether the significant negative relationship between FinTech-driven financial inclusion and income inequality holds for countries with different income levels, we re-estimate the pooled OLS model (Table 4) for 4 sub-samples of countries that are classified based on their income levels (Table 6).[12] Our results suggest that, while financial inclusion reduces inequality, these effects are primarily driven by higher-income countries. Only in high-income countries do the three dimensions of financial inclusion (i.e. account, savings, and borrowing at a formal financial institution) reduce income inequality. Financial inclusion, however, appears to have the opposite effect in lower-middle- and low-income countries. These results are consistent with those of Asongu and Nwachukwu (2018), which suggest that mobile banking tends to reduce income inequality in relatively higher income countries.

4.2. Robustness test results

We test for the robustness of our results in four ways: first, we re-run the pooled OLS and quantile regressions using a composite measure of financial inclusion; secondly, we estimate our model using panel fixed effects; thirdly, we estimate the model for each year separately using OLS; and, finally, we re-estimate our model using 2SLS and IV quantile with time and country fixed effects.

Table 9. Re-estimation of Table 4 with panel country and time fixed effects.

VARIABLES	(1) Inequality	(2) Inequality	(3) Inequality	(4) Inequality	(5) Inequality
Gini(−1)	0.121**	0.114**	0.113**	0.113**	0.114**
	(0.055)	(0.050)	(0.055)	(0.048)	(0.049)
FinTech	−0.037**	−0.031**	−0.010	−0.011	−0.013
	(0.018)	(0.015)	(0.022)	(0.022)	(0.021)
Account			−0.009**		
			(0.004)		
Saving				−0.009**	
				(0.004)	
Borrowing					−0.003**
					(0.001)
GDPgr		0.017	0.012	0.013	0.014
		(0.013)	(0.013)	(0.013)	(0.012)
School		−0.005	−0.004	−0.004	−0.005
		(0.003)	(0.003)	(0.003)	(0.003)
Trade		0.001	0.001	0.001	0.001
		(0.004)	(0.004)	(0.004)	(0.004)
Gov exp		−0.055*	−0.061**	−0.060**	−0.062**
		(0.030)	(0.030)	(0.030)	(0.030)
Inflation		−0.006	−0.005	−0.006	−0.005
		(0.008)	(0.008)	(0.008)	(0.008)
Population		−0.289	−0.241	−0.276	−0.253
		(0.797)	(0.781)	(0.783)	(0.775)
Constant	37.763***	43.330***	43.132***	43.400***	43.971***
	(0.086)	(13.378)	(13.082)	(13.134)	(12.995)
Observations	269	222	219	219	219
R-squared	0.121	0.135	0.146	0.139	0.160
Number of id	132	113	112	112	112

Note**:** This table reports the panel fixed effects results for the impact of FinTech and financial inclusion on income inequality. The dependent variable is income inequality measured by the Gini coefficient. FinTech is measured by percentage of adults using a mobile phone to pay bills. Financial inclusion is measured in three ways, by Account (the % of adults having an account at a formal financial institution), Savings (the % of adults saving at a formal financial institution), and Borrowing (the % of adults borrowing from a formal financial institution). GDPgr = denotes the GDP growth rate. School is the secondary school completion rate. trade denotes international trade and is measured by exports and imports over GDP. Gov exp denotes government expenditure as a percentage of GDP. Inflation is the rate of change of the consumer price index. Population is the population growth rate.

Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

As a first robustness test, we replace our individual measures of financial inclusion with a composite index. Specifically, we use the IMF financial development index, which encompasses three core dimensions of financial systems, namely: access, efficiency, and depth (see Svirydzenka 2016). The results of the pooled OLS and quantile regressions are reported in Table 7. Table 8 reports the pooled OLS estimates for four sub-samples of countries based on their income levels.

Columns (1) to (3) in Table 7 suggest that financial inclusion, as measured by the IMF's financial development index, is a key channel through which FinTech reduces income inequality. Likewise, columns (4) to (8) show that financial inclusion reduces income inequality at all quantiles except for the 10th quantile, and that such inequality-reducing effects are larger in countries with higher levels of inequality. Our results in Table 8 further suggest that financial inclusion reduces inequality in high- and upper-middle income countries but not in lower-middle and low-income countries.

As a second robustness test, we re-estimate Table 4 using panel fixed effects. Table 9 shows the panel fixed effects estimation of Table 4. The results suggest that inequality is significantly influenced by its past values.

The results with respect to FinTech and financial inclusion are in line with those provided in Table 4, which suggest that financial inclusion plays a key role in mediating the negative impact of FinTech on income inequality.

As an additional check, we re-estimate Table 4 for each survey year, that is, 2011, 2014 and 2017 (Table 10). As can be seen in Table 10, the results for our main variables of interest are in line with those provided in Table 4. They further suggest that the negative effect of FinTech on income inequality is indirect and mediated by

Table 10. Re-estimation of Table 4 for each of the years 2011, 2014 and 2017.

VARIABLES	(1) Inequality	(2) Inequality	(3) Inequality	(4) Inequality	(5) Inequality
Estimation of Table 4 for 2011					
FinTech	−1.028***	−0.783**	−0.381	−0.480	−0.519
	(0.251)	(0.321)	(0.370)	(0.367)	(0.355)
Account			−0.079**		
			(0.036)		
Saving				−0.097*	
				(0.056)	
Borrowing					−0.394*
					(0.217)
Observations	131	112	111	111	111
R-squared	0.115	0.272	0.305	0.293	0.295
Estimation of Table 4 for 2014					
FinTech	−1.096***	−0.453**	0.038	0.032	0.044
	(0.282)	(0.217)	(0.321)	(0.332)	(0.352)
Account			−0.128***		
			(0.031)		
Saving				−0.180***	
				(0.049)	
Borrowing					−0.638***
					(0.210)
Observations	121	107	106	106	106
R-squared	0.112	0.262	0.379	0.355	0.330
Estimation of Table 4 for 2017					
FinTech	−1.204***	−0.445**	0.112	0.077	−0.078
	(0.341)	(0.215)	(0.385)	(0.396)	(0.396)
Account			−0.104***		
			(0.030)		
Saving				−0.141***	
				(0.048)	
Borrowing					−0.415**
					(0.187)
Observations	117	103	102	102	102
R-squared	0.098	0.362	0.436	0.417	0.395

Note: This table reports the OLS regression results for the impact of FinTech and financial inclusion on income inequality for the years 2011, 2014 and 2017. The dependent variable is income inequality measured by the Gini coefficient. FinTech is measured by the percentage of adults using a mobile phone to pay bills. Financial inclusion is measured in three ways, by Account (the % of adults having an account at a formal financial institution), Savings (the % of adults saving at a formal financial institution), and Borrowing (the % of adults borrowing from a formal financial institution). GDPgr refers to the GDP growth rate. School denotes the secondary school completion rate. Trade denotes international trade and is measured as the sum of exports and imports over GDP. Gov exp denotes government expenditure as a percentage of GDP. Inflation is the rate of change of the consumer price index. Population refers to the population growth rate.

Robust standard errors in parentheses: ***$p < 0.01$, **$p < 0.05$, *$p < 0.1$.

financial inclusion. They also confirm that financial inclusion, regardless of how it is measured, has a significant negative effect on income inequality.

As a final check, we re-estimate Tables 4 and 5 using 2SLS and IV quantile methods with time and country fixed effects. The results are reported in Tables A8 and A9, respectively. They are consistent with those reported in Table 4 and Table 5. Overall, we can conclude that our main results for the whole sample are robust to using alternative measures of financial inclusion and alternative methodologies.

5. Conclusion

Theory suggests that financial market imperfections, such as information asymmetries and transaction costs, prevent poor people from escaping poverty, by limiting their access to formal financial services. But, with recent developments, FinTech is seen as a key enabler of financial inclusion; and mobile financial services, as the type of FinTech with the greatest potential to bring the unbanked into the formal financial system.

In this paper, we investigate the interrelationship between FinTech, financial inclusion, and income inequality for a panel of 140 countries using three waves of survey data from the Global Findex database, which cover the years 2011, 2014 and 2017. Specifically, we examine how FinTech affects inequality directly and indirectly through financial inclusion. We also investigate whether such effects differ across countries with different levels of income inequality using quantile regression analysis. To the best of our knowledge, this is the first study to investigate the link between mobile finance, financial inclusion, and income inequality at the cross-country level, using Global Findex data and quantile regression.

Three main conclusions can be drawn from our findings. First, FinTech reduces income inequality indirectly through its effects on financial inclusion. Second, financial inclusion reduces inequality at all quantiles of the inequality distribution, and its effects are larger in the upper quantiles. Last but not least, while we find that financial inclusion has significant negative effects on inequality, these effects are primarily driven by higher-income countries.

These findings contribute to a small but growing cross-country literature on the role of FinTech and financial inclusion in promoting inclusive development. In line with recent studies, we find that FinTech is an important driver of financial inclusion (e.g. Mbiti and Weil 2011; Gosavi 2018). Also consistent with previous research is our finding that financial inclusion – proxied by formal account ownership, formal savings and formal borrowing – reduces inequality (Mookerjee and Kalipioni 2010; Kim 2016; Park and Mercado 2018; Turégano and Herrero 2018). However, we extend the findings of these studies by showing that, while an increase in financial inclusion is associated with a decrease in income inequality at all levels of inequality, these effects are primarily driven by higher-income countries.

Our research results provide important policy implications. First, financial sector policies aimed at reducing income inequality should place emphasis on building more inclusive financial systems that benefit the poor and low-income groups directly through increased access to appropriate financial services. Second, for financial inclusion to reduce inequality most effectively, increased 'access' to formal financial services (i.e. 'account ownership') must be followed by increased 'use' of these services (i.e. 'savings' and 'borrowing'). FinTech can play a key role in this regard, by expanding account ownership among the unbanked, and account use among the banked. Third, our results suggest that FinTech-driven financial inclusion is an effective policy option for reducing income inequality, but less so in low-income countries. This might be the case because the absence of good infrastructure, appropriate (consumer protection) regulations, and basic financial literacy prevent low-income households from benefiting from the increased availability of financial services in these countries. If so, policy efforts should be directed to creating an enabling environment for FinTech and financial inclusion to serve low-income groups. Finally, financial policies alone are not enough to address the problem of income inequality. Our results point to the crucial role of fiscal policies in reducing income disparities. In this sense, financial inclusion should be accompanied by fiscal redistribution.

Notes

1. See Beck (2016) on the measurement problems associated with the use of supply-side indicators of financial inclusion. As he points out, the indicators give 'a rather blurred picture of the ultimate metric we are interested in: the share of population in a country that uses different types of financial services' (Beck 2016, 12).
2. There is a parallel and closely related strand of literature on the relationship between financial development and income inequality. See, for example, Beck, Demirgüç-Kunt, and Levine 2007; Claessens and Perotti 2007; Demirgüç-Kunt and Levine 2009; De Haan and Sturm 2017.
3. For instance, Dabla-Norris et al. (2015b, 2015a) indicate that different financial inclusion strategies may imply a trade-off between growth and inequality. They develop a model in which an increase in financial inclusion may lead to a reduction in inequality, if it is achieved through policies focused on increasing access (reducing participation costs) for people who have been left out of the formal financial system (e.g., reducing documentation requirements to open an account or obtain a loan). In contrast, inequality may increase if the policy focus is on relaxing the borrowing constrains faced by people who already have access to credit and other services from formal financial institutions (e.g., reducing collateral requirements).
4. See Demirgüç-Kunt, Klapper, and Singer (2017), Beck (2015) and Cull, Ehrbeck, and Holle (2014) for excellent reviews of this literature.
5. Results from a meta-analysis of 27 randomised controlled trials show that saving promotion interventions in Sub-Saharan Africa have helped households increase their savings and have had significant 'trickle-down' effects in terms of increasing household incomes and expenditures as well as food security and returns from family businesses (Steinert et al. 2018).

6. As a skill-biased technological change, the ICT revolution can also contribute to increasing wage disparities between skilled and unskilled labour (e.g., Jaumotte, Lall, and Papageorgiou 2013; Richmond and Triplett 2018). However, recent findings by Dabla-Norris et al. (2015c) indicate that the effects of skill-biased technological change vary across countries at different levels of economic development, and that an increase in the skill premium is strongly associated with widening disparities in advanced economies but not in emerging and developing economies.
7. The standardised income inequality measures are fully discussed in Solt (2009).
8. Description of variables are provided in Appendix, Table A1
9. We did not include GDP per capita in the estimations due to the high correlation between this variable and our measures of financial inclusion.
10. The instruments used for FinTech (mobile finance) are mobile phone penetration and fixed broadband penetration (Ghosh 2016; Andrianaivo and Kpodar 2012; Demirgüç-Kunt et al. 2018). The definition, summary statistics and correlation matrix of these instruments and our FinTech, financial inclusion and income inequality variables are provided in Appendix Tables A3–A6.
11. Asongu and Odhiambo (2018) investigate the relationship between mobile banking and income inequalitybut only for a cross-section of developing countries in 2011. Furthermore, they do not explore the interrelationship between Fintech, financial inclusion and income inequality.
12. To this end, we use the World Bank's income classification of countries discussed in Section 3.2.

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