Who Needs Cash?

The Impact Of The Digital Finance On Income Inequality

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Abstract

In regards the relevance of financial inclusion on inequality, this article analyzes the role of financial access on digital and physical ways on income inequality for a panel of 143 countries between 2001 and 2019. The results indicate that both financial institution access and digital financial institution access reduce inequality, while the effect of digital financial access is more substantial for emerging economies. We extend the work with a nonlinear analysis of digital financial access, and the results show a limit to the effect on inequality. This article contributes with a new measure of financial access that captures the impact of digital finance and it can be a guidance for policymakers looking to reduce income inequality.

Keywords: Financial Access, Income Distribution, Inequality, Digital Finance

Resumo

Tendo em vista a relevância da inclusão financeira sobre a desigualdade, este artigo analisa o papel do acesso financeiro em sua forma digital e física na desigualdade de renda em um painel de 143 países ao longo dos anos de 2001 a 2019. Os resultados sugerem que ambos os indicadores, de acesso a instituições financeiras e de acesso a instituições financeiras digitais, reduzem a desigualdade, entretanto, o efeito do acesso financeiro digital é mais relevante quando consideramos economias emergentes. Nós estendemos este trabalho com uma análise não-linear do acesso financeiro digital que sugere a existência de um limite para o seu efeito na desigualdade. Este artigo contribui com uma nova medida de acesso financeiro que captura o impacto das finanças digitais e pode ser uma orientação para os formuladores de políticas que buscam reduzir a desigualdade de renda.

Palavras-chave: Acesso Financeiro, Distribuição De Renda, Desigualdade, Finanças Digitais

1. Introduction

There are many concerns about income inequality, and much effort is being made to understand its causes and alleviate it (Cardoso & Teixeira, 2020). One of the key determinants in many inequality and poverty models is the existence of financial market imperfections (Banerjee & Newman, 1993; Greenwood & Jovanovic, 1990). As such, unequal access to finance may prevent the low-income population from investing in human capital, health, and entrepreneurial activities, becoming a critical mechanism for generating persistent income inequality and slower economic growth (Beck et al., 2007; Célerier & Matray, 2019; Inoue & Hamori, 2016; C.-C. Lee et al., 2020; Makina & Walle, 2019; Seven, 2022).

In recent years, the impact of financial inclusion on inequality has become an important topic and has driven the creation programs and recommendations for institutions like The World Bank, the G20, and the United Nations (Global Partnership for Financial Inclusion, 2016; The World Bank Group, 2018; United Nations, 2018). Because of that interest, governments and organizations need methods to measure financial access to build better policies. Several ways have been proposed in the literature to this purpose (Agarwal et al., 2018; Demirguc-kunt, A., and Klapper, 2012; Espinosa-Vega et al., 2020; Kendall et al., 2010). In this regard, the International Monetary Fund (IMF) uses a composite indicator introduced by Sahay et al. (2015) and Svirydzenka (2016) to quantify financial access - financial institution access (FIA).

The FIA tracks physical financial access to banks via bank branches and automated teller machines (ATM). However, it is important to highlight that the FIA index is extremely related to physical forms of financial access, and it is common knowledge that people's relationship with money is becoming increasingly digital. The purpose of our study is to verify whether financial access in its digital way generates the equivalent impact on inequality that traditional forms of financial access. For that, firstly we created an indicator, the Digital Financial Institution Access (DFIA), which measures the number of credit and debit cards as a proxy to capture changes in digital financial access. Secondly, we estimated the impact of this indicator on income inequality on a global panel of 119 countries and a subset of 55 emerging market economies to capture the effect for lower-income economies. Finally, we compared the results of financial access in digital way and physical access.

Through a data panel analysis of 143 countries during the period between 2001 and 2019, the results suggest that both types of financial access, digital financial access and physical financial access, reduce income inequality. In particular, the effect on emerging economies reveals that digital financial access is more relevant than physical access for inequality improvement. Finally, the nonlinear effect of digital financial access suggests that this form of access has a maximum effect on inequality. Therefore, this study contributes with a new measure of financial access that captures the impact of digital finance and it can be a guidance for policymakers looking to reduce income inequality.

The remainder of this paper is organized as follows: a review of literature, followed by details of Digital Financial Institution Access (DFIA); The date and methodology used for the estimation; Results and discussion, and the conclusions.

2. Digital Financial access and income inequality

Financial access refers to the access by companies and families' to fairly priced and acceptable formal financial services that meet their needs, and it can be defined along several dimensions, like geographic access or socio-economic access (Beck, 2016). Roodman (2012) suggest that financial inclusion have influence on poverty and income in different places around the globe. Claessens and Perotti (2007) affirms that the institutional inefficiencies in nations with historically

high inequality provide uneven access to finance, which leads to disparity in opportunities. As a result, in order to reach reduced levels of income inequality, financial access turns into a key part of financial development.

Expanding financial access through physical ways like bank branches and ATMs imposes higher costs for serving customers, and therefore digital forms gain importance in banks' growth strategies. This might allow more accessible offerings not only in terms of geographic reach but costs can be reduced with the use of technology. Therefore, focusing on digital forms of access can be an important step toward better policy development. One way to see these movements is through the payments system, not only because electronic payment methods are strictly related to access to the financial system, but also because it has its own set of benefits. To Tchamyou et al. (2019), the shift in the use of payments methods from cash to electronic payments brings advantages and can boost economic growth and productivity, and reduce inequality.

According to Humphrey, Kim, and Vale (2001), a country's payments system enhances trade and exchange, and those transactions drive the development of payment instruments. The authors also mention that as electronic payment instruments were developed, they have allowed an advance by reducing from one-third to half the costs of making payments, and while the impact of reductions might be different for each economy, the use of electronic payments can reduce total social costs (Gresvik & Haare, 2009; Hayashi & Keeton, 2012).Therefore, the incentive to use this form of payment can be considered desirable.

In term of relationship between physical and digital financial access there are different views. One strand follows the idea of a substitution effect, the use of debit cards can substitute money, and consequently impact on reduce of physical financial access (David et al., 2016; Mao & Chen, 2015; Nirmala & Widodo, 2011; Scholnick et al., 2008). The other stream, which is related to the present study, propose the complementary among all way of physical and digital financial access. Vives (2016) explains that the transactions processed over branches did not see a decline with the increase of electronic means of financial access in USA and EU.

In order to analyze the effect of digital financial access and physical financial access on inequality, we developed a new indicator that composes a measure of financial access that includes electronic means of payment. As physical financial access, the FIA was used. FIA is an index published by the IMF that represents the financial access as bank branches per 100,000 adults and ATMs per 100,000 adults (Sahay *et al*., 2015 and Svirydzenka,2016).

To construct the new indicator, the Digital Financial Institution Access Index (or DFIA), we took both *Handbook on Constructing Composite Indicators* (OECD, 2008) and Svirydzenka's (2016) work as references in order to create an index that could be easily compared to the traditional financial access measurement index. According to the OECD Handbook (2008), an indicator is a quantitative or qualitative measure that represents a series of facts revealing a position in a specific area. On the other hand, a composite indicator is made up of individual indicators that are compiled into a single measure from a model built for this purpose. These indicators can be useful in prioritizing policies and comparing them or monitoring performance.

To build an indicator that represents the digital access well, we decided to use data from debit and credit cards as proxies for the access to bank accounts and access to credit. These are important ways because they are useful for making transactions without the use of cash and can also be used in online purchases.

We constructed the indicator from five databases: three of them (IMF Financial Access Survey - FAS, Committee on Payments and Market Infrastructures – CPMI from BIS, World Bank Global Payment Systems Survey - GPSS) were sources for the number of credit and debit cards. IMF Financial Development Indicators (FDI) was used to get the Financial Institution Access, and

World Bank World Development Indicators (WDI) was used to collect country social indicators such as population to normalize card data per inhabitant and GDP growth rates.

For the years unavailable in the FAS database, a retropolation process was run in an iterative way using the extension (in years) and information similarity as a criterion to order them in the following way: % change rate from the CPMI, % change rate from the GPSS, % change rate from the FIA and % change rate from the GDP.

After the dataset was built, we continued preparing the data with an outlier removal (winsorizing) and normalization with the Min-Max procedure, which makes the index range from 0 to 1. The general techniques were the same as the ones used to build FIA in Svirydzenka (2016).

In order to keep comparability with the FIA index, the indicator was constructed using the same using Svirydzenka's (2016) methodology and form factor as presented in equation (1), where w_i is the weights obtained from the squares of the loading factors generated by the principal component analysis (PCA) and, l_i is the transformed indicator created from the number of credit and debit cards.

$$DFIA_j = \sum_{(i=1)}^{n} w_i \, l_i \tag{1}$$

After the indicator was built, we had a dataset of 143 countries from 2001 to 2019 (due to the availability of data).[1] Additionally, following De Moraes et.al (2021), we analyze emerging economies, to account for the importance of income distribution issue in those countries, and for that we created a sample of 70 emerging economies.[2]

Figure 1 presents the dynamics of financial access. For that, we use FIA and DFIA indicators with their values were converted into an index number with the base year of 2001.[3] They show a high correlation, but with a divergent trajectory after 2014. It is possible to notice that while the DFIA has been growing continuously over time, the FIA has been stagnant since 2014, which suggests the existence of different standards for both types of financial access.

[1] Total number of countries when considering the indicator built. Estimations have smaller panels due to data availability of other indicators.
[2] List of countries available at table A6.
[3] The index number is on base 100 to improve readability.

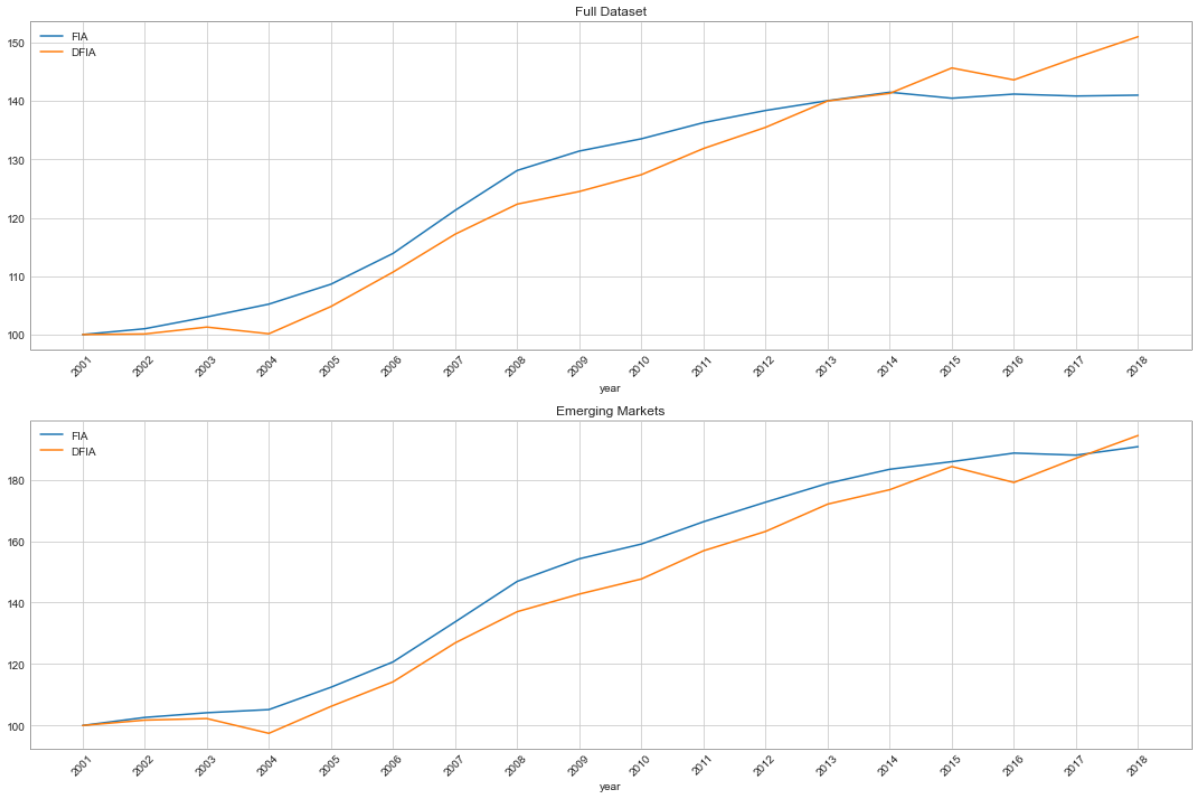

Figure 1 - Average DFIA and FIA over time and grouped by economic development as an index number using 2001 as a base for 100

3. Methodology

To analyze the effects of financial access to inequality, we built a panel of 119 countries with yearly data ranging from 2001 to 2019, which was composed of a series of databases from the International Monetary Fund, the World Income Inequality Database – UN, the World Bank, and the Bank for International Settlements. The descriptive statistics of the database are available in Tables A1 and A2 in the appendix.

In regards to measure of inequality, we used the well-known Gini variable as a dependent variable. Moreover, we chose as a control variable the most used in literature of inequality: openness to trade, Inflation, GDP growth and Government Consumption.

Openness to trade, which is present in several works on income inequality (Aslan et al., 2017; Beck et al., 2007; Cihak & Sahay, 2020; Hamori & Hashiguchi, 2012; Lo Prete, 2013; Omar & Inaba, 2020; Roine et al., 2009) and presents negative effects on inequality (Bayar & Sezgin, 2017; Daumal, 2013; Franco & Gerussi, 2013), specially by the entrance of technological differential embodied in goods (Franco & Gerussi, 2013).

Inflation, that is even more frequent, (Aslan et al., 2017; Beck et al., 2007; Cihak & Sahay, 2020; Hamori & Hashiguchi, 2012; Lo Prete, 2013; Omar & Inaba, 2020; Ratnawati, 2020) and is known as affecting negatively inequality, because mainly of the capacity of rich to hedge against inflation (Li & Zou, 2002).

GDP growth and Government Consumption, which has mixed expected results in the literature. Expenditure is used as proxy for fiscal action on inequality with some suggesting a negative relationship (H. S. Lee, 2021) or mixed effects depending on form and economic structure (Rehman et al., 2008). All variables are described in Table A3 in the appendix.

In considering the persistence effect identified by the literature on inequality (Christopoulos & Mcadam, 2017; Tiberto et al., 2020), we use a dynamic panel analysis, so the model contains a lagged dependent variable. This creates bias for OLS fixed effect estimation, as mentioned by Nickell (1981). For that, it is appropriate to estimate the dynamic panel through the System Generalized Method of Moments (S-GMM). Our general specification is as follows:

$$\mathrm{GINI}_{i,t} = \beta_0 + \beta_1\, \mathrm{GINI}_{i,t-1} + \beta_2\, \mathrm{DFIA}_{i,t-1} + \beta_3\, \mathrm{FIA}_{i,t-1} + \beta_4\, \mathrm{Z}_{i,t-1} + \epsilon_{i,t} \qquad (2)$$

where *i* = 1,2, …, 116 represents the countries used in this study; t = 2001, 2007, …, 2019 represents the time period in years; the dependent variable GINI is the Gini Index, DFIA is the composite index of the number of debit cards and the number of credit cards, FIA is an index composed by bank branches per 100,000 adults and ATMs per 100,000 adults; Z represents the control variables (Inflation, Government Consumption, Trade Openness, and GDP Growth), an $\epsilon_{i,t} = \eta_i + \omega_{i,t}$, η_i is the unobserved time-invariant country-specific fixed effects and $\omega_{i,t}$ is an i.i.d. random term with $E(\omega_{i,t}) = 0$ and $\mathrm{Var}(\omega_{i,t}) = \sigma^2$.

According to Arellano & Bond (1991), using S-GMM, it is possible to eliminate the effects of non-observed variables and create reliable estimates even in the presence of omitted variables. The use of instruments permits the estimation of parameters more consistently, even in the case of endogeneity in explanatory variables and in the presence of measurement errors (Bond et al., 2001). The S-GMM estimation is made by using instruments at different lagged levels mitigating the risks of bias, poor accuracy, and weak instruments (Arellano & Bover, 1995; Blundell & Bond, 1998).

The instruments were constructed in order to satisfy the conditions proposed by Roodman (2009). to confirm the validity of the instruments used in the models, the test of overidentification restrictions (J-test), as suggested by Arellano (2003). Finally, tests of first-order (AR1) and second-order (AR2) serial correlation are also performed.

4. Results

As a preliminary results, Table 3 shows the correlation of variables used for the entire sample of countries, which indicates an important and strong negative correlation between both FIA and DFIA to the Gini index. The same happens in Table 4 on the emerging markets sample. The negative sign of DFIA and FIA in relation Gini suggests that financial access reduces inequality.

Table 1 - Correlation of variables for the full sample

Full Sample

	FIA	DFIA	GDP growth	Inflation	trade openness	gov. consumption	education secondary	Gini
FIA	1	0.716293	-0.263937	-0.2175	0.205101	0.423565	0.68949	-0.546212
DFIA	0.716293	1	-0.207809	-0.182062	0.277011	0.280148	0.700396	-0.552041
GDP growth	-0.263937	-0.207809	1	0.02797	0.009627	-0.225191	-0.297578	0.103716
Inflation	-0.2175	-0.182062	0.02797	1	-0.101442	-0.146283	-0.315873	0.163392
trade openness	0.205101	0.277011	0.009627	-0.101442	1	0.098452	0.221914	-0.241167
gov. consumption	0.423565	0.280148	-0.225191	-0.146283	0.098452	1	0.456185	-0.257911
education secondary	0.68949	0.700396	-0.297578	-0.315873	0.221914	0.456185	1	-0.609028
Gini	-0.546212	-0.552041	0.103716	0.163392	-0.241167	-0.257911	-0.609028	1

Table 2 - Correlation of variables for the emerging markets sample

Emerging Markets

	FIA	DFIA	GDP growth	Inflation	trade openness	gov. consumption	education secondary	Gini
FIA	1	0.48569	-0.258337	-0.187631	0.189078	0.373169	0.469981	-0.177459
DFIA	0.48569	1	-0.129066	-0.078225	0.031106	0.051655	0.529418	-0.236556
GDP growth	-0.258337	-0.129066	1	0.058027	0.029913	-0.191494	-0.259802	-0.00745
Inflation	-0.187631	-0.078225	0.058027	1	-0.017713	-0.051392	-0.212096	0.050985
trade openness	0.189078	0.031106	0.029913	-0.017713	1	0.24859	0.100615	-0.136403
gov. consumption	0.373169	0.051655	-0.191494	-0.051392	0.24859	1	0.271535	0.02504
education secondary	0.469981	0.529418	-0.259802	-0.212096	0.100615	0.271535	1	-0.259921
Gini	-0.177459	-0.236556	-0.00745	0.050985	-0.136403	0.02504	-0.259921	1

4.1. Main results

Table 5 presents the results of the estimated effect of the FIA and DFIA index on the Gini index for the full dataset. For all estimations by S-GMM accept the null hypothesis in the Sargan tests (J statistic) and, therefore, the over-identifying restrictions are valid, while both autocorrelation tests, AR (1) and AR (2), do not denote serial autocorrelation.

The FIA is statistically significant in all models, and a negative sign also suggests that an increase in the offering of bank branches and ATMs can help reduce inequality and might be related as a sign of increased competitiveness within the financial sector leading to lower costs (de Moraes et al., 2021). Moreover, the statistical significance and negative sign of DFIA also suggests that an increase in financial access through digital forms can decrease inequality as measured by Gini. This result suggests that any form of financial access decease inequality, therefore, from these results there is absence of substitute effect between physical and digital access.

In order to evaluate if there are different impacts of both forms of financial access, we executed the Wald test. The Wald test shows statistical significance for the difference between the estimated coefficients of FIA and DFIA, as shown in Table A4 (Appendix). Consequently, this result allows us to investigate the economic coefficient of DFIA and FIA. From this point of view, for the full sample countries, the effect of DFIA on inequality is smaller than FIA. The smaller effect is likely to be due to the advanced economies included in the sample that have lower inequality indexes and, therefore, fewer necessity for improvement.

Inflation and Government consumption present statistically significant coefficients and a positive sign for all samples suggesting that an increase in either would lead to an increase in inequality. Inflation worsens the signaling of price information, making it harder to make proper consumption decisions, and the government consumption effect can be attributed to inefficiencies in government resource allocation. Trade Openness presents a statistically significant coefficient and a negative sign suggesting that the trade openness of the market can reduce inequality. GDP Growth presented a statistically significant coefficient and a negative sign indicating that GDP Growth could reduce inequality and could be related to the resulting constraints on the access of the poor to financial markets. Lagged Gini index presented a statistically significant and positive sign which suggests that there is some degree of persistence in inequality, which increases itself if no countermeasures are taken.

In Table 6, the same models were estimated for the Emerging Markets Economies (EME). The test statistics of Sargan tests (J statistic) indicate the over-identifying restrictions are valid, while both autocorrelation tests, AR (1) and AR (2), do not denote serial autocorrelation.

The statistically significant and negative sign of DFIA for the EME sample suggests that an increase in financial access through digital forms can decrease inequality, as measured by Gini. The coefficient of the FIA index is statistically significant on all models, and a negative sign also suggests that an increase in access might reduce inequality. A noticeable aspect is the difference between FIA and DFIA coefficients on emerging markets compared to the full sample suggesting a greater effect on those markets. As shown in Table A4, the Wald test shows that DFIA and FIA index are different with statistical significance, suggesting that the effect on inequality DFIA is larger than FIA but only for emerging markets.

As it is possible to observe in Table 5, Inflation and Government consumption present statistically significant coefficients and a positive sign for all samples suggesting that an increase in either would lead to an increase in inequality in a consistent way with the complete dataset. Trade Openness also presents a statistically significant coefficient and a negative sign suggesting that the trade openness of the market can reduce inequality. GDP Growth was not statistically significant.

Table 3 - Effect of DFIA in the Gini Index for the full dataset

Dependent variable: GINI				
Sample:	Full dataset			
Equation	(1)	(2)	(3)	(4)
GINI t-1	0.8642***	0.8517***	0.8496***	0.8591***
	(0.0035)	(0.0041)	(0.0040)	(0.0054)
DFIA t-1	-0.2548***	-0.2404***	-0.1947**	-0.2901***
	(0.0776)	(0.0780)	(0.0772)	(0.0942)
FIA t-1	-0.0461	-0.2037***	-0.3152***	-0.4734***
	(0.0483)	(0.0577)	(0.0618)	(0.0648)
Inflation t-1	0.0075***	0.0145***	0.0156***	0.0099***
	(0.0012)	(0.0013)	(0.0013)	(0.0016)
Gov. Consumption t-1		0.0208***	0.0206***	0.0172***
		(0.0040)	(0.0053)	(0.0054)
Trade Openness t-1			-0.0040***	-0.0016**
			(0.0005)	(0.0007)
GDP Growth t-1				-0.0200***
				(0.0025)
Observations	1189	1186	1186	1186
Countries	116	115	115	115
J-Statistic	90.6656	89.8789	89.1865	85.6555
p-value	0.2401	0.2341	0.2259	0.2850
AR (1)	-0.4966	-0.3840	-0.4957	-0.4973
p-value	0.0000	0.0000	0.0000	0.0000
AR (2)	0.0484	-0.0513	0.0477	0.0443
p-value	0.1391	0.1354	0.1454	0.1764

Note: *Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. Standard errors between parentheses.*

Table 4 - Effect of DFIA on the Gini Index for the emerging market sample

Dependent variable: GINI				
Sample:	Emerging Markets			
Equation	(5)	(6)	(7)	(8)
GINI $_{t-1}$	0.9047***	0.9119***	0.9143***	0.9142***
	(0.0012)	(0.0028)	(0.0030)	(0.0040)
DFIA $_{t-1}$	-0.9062***	-0.8413***	-0.9609***	-0.9852***
	(0.0559)	(0.0619)	(0.0781)	(0.1137)
FIA $_{t-1}$	-0.3232***	-0.4447***	-0.2842***	-0.2784***
	(0.0314)	(0.0406)	(0.0444)	(0.0859)
Inflation $_{t-1}$	0.0085***	0.0142***	0.0163***	0.0163***
	(0.0007)	(0.0011)	(0.0012)	(0.0025)
Gov.Consumption$_{t-1}$		0.0725***	0.0592***	0.0610***
		(0.0058)	(0.0072)	(0.0074)
Trade Openness t-1			-0.0037***	-0.0035*
			(0.0012)	(0.0019)
GDP Growth t-1				0.0008
				(0.0033)
Observations	576	574	574	574
Countries	55	55	55	55
J-Statistic	46.9636	44.6006	43.7736	43.5651
p-value	0.4328	0.4888	0.4813	0.4473
AR (1)	-0.4035	-0.4080	-0.4078	-0.4079
p-value	0.0000	0.0000	0.0000	0.0000
AR (2)	0.0542	0.0551	0.0554	0.0554
p-value	0.2268	0.2202	0.2176	0.2180

Note: *Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. Standard errors between parentheses.*

4.2. The Nonlinear effect

In the previous subsection, the results indicated that countries with higher usage of electronic payment systems lead to a reduction in inequality, controlled by physical access, and the use of bank branches and ATMs (physical access), controlled by digital access, also reduce inequality. In short, these results indicate complementarity in both form of financial access. In order to investigate whether there is a limit to the effect on the inequality, the quadratic term of the DFIA variable was added to the original specification, Eq. (2), in the following way:

$$GINI_{i,t} = \gamma_0 + \gamma_1 GINI_{i,t-1} + \gamma_2 DFIA_{i,t-1} + \gamma_3 DFIA^2_{i,t-1} + \gamma_4 FIA_{i,t-1} + \gamma_5 Z_{i,t-1} + \mu_{i,t} \qquad (3)$$

In general, the results presented in Table 7 kept consistent with previous results. With that, the statistically significant DFIA quadratic term with a positive sign presented in all models suggests a limit to the effect of financial access on inequality. This result corroborates with results seen by De Moraes Et Al.(2021) for physical financial access on interest rate spreads. Other control variables kept consistent with earlier results.

Table 5 - The nonlinear effect of DFIA on the Gini index

Sample:	Full dataset			
Equation	(1)	(2)	(3)	(4)
GINI t-1	0.8581***	0.8460***	0.8416***	0.8527***
	(0.0038)	(0.0043)	(0.0052)	(0.0052)
DFIA t-1	-1.5988***	-1.3948***	-1.9265***	-1.4084***
	(0.1444)	(0.1516)	(0.2415)	(0.2722)
DFIA t-1 ^2	1.5292***	1.3131***	2.0326***	1.3091***
	(0.1438)	(0.1570)	(0.2788)	(0.3352)
FIA t-1	0.0634	-0.0951	-0.1677**	-0.3746***
	(0.0517)	(0.0590)	(0.0675)	(0.0705)
Inflation t-1	0.0076***	0.0149***	0.0173***	0.0112***
	(0.0013)	(0.0014)	(0.0015)	(0.0017)
Gov. Consumption t-1		0.0183***	0.0175***	0.0147**
		(0.0042)	(0.0059)	(0.0057)
Trade Openness t-1			-0.0053***	-0.0027**
			(0.0008)	(0.0011)
GDP Growth t-1				-0.0189***
				(0.0023)
Observations	1189	1186	1186	1186
Countries	116	115	115	115
J-Statistic	89.7166	89.8581	87.6032	85.1707
p-value	0.2377	0.2114	0.2377	0.2708
AR (1)	-0.4964	-0.4951	-0.4952	-0.4969
p-value	0.0000	0.0000	0.0000	0.0000
AR (2)	0.0476	0.0484	0.0466	0.0436
p-value	0.1460	0.1401	0.1555	0.1836

Note: *Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. Standard errors between parentheses.*

4.3. Robustness Section

In order to verify the robustness, we estimated the same equations changing only the dependent variable, using the Palma ratio as a substitute for the Gini index, following the works of Cihak & Sahay (2020), Tchamyou et al. (2019), and Tridico (2018) as described in equation (4). The Palma ratio is calculated by the richest 10% of the population's share of total gross national income divided by the income share of the lowest 40% of the population. The model follows the same structure as other estimations with a single change for the inequality index, substituting Gini for the Palma ratio.

$$PALMA_{i,t} = \gamma_0 + \gamma_1 PALMA_{i,t-1} + \gamma_2 DFIA_{i,t-1} + \gamma_3 FIA_{i,t-1} + \gamma_4 Z_{i,t-1} + \mu_{i,t} \quad (4)$$

Table 8 presents the results and it shows that both FIA and DFIA have a negative and statistically significant effect on inequality here, agreeing with previous results. Other indicators like Inflation, Government Consumption, and Trade openness kept the same signals and statistical significance. GDP Growth was the single flip in direction.

Table 6 - Effect of DFIA on the Palma ratio for the full dataset

Dependent variable: Log(Palma)				
Sample:	Full dataset			
Equation	(1)	(2)	(3)	(4)
Log(Palma) t-1	0,7446***	0,7029***	0,6990***	0,7183***
	(0,0086)	(0,0101)	(0,0102)	(0,0148)
DFIA t-1	-0,0844***	-0,0823***	-0,0774***	-0,0810***
	(0,0049)	(0,0047)	(0,0049)	(0,0075)
FIA t-1	-0,1161***	-0,2181***	-0,2316***	-0,1767***
	(0,0217)	(0,0259)	(0,0263)	(0,0349)
Inflation t-1	0,0006***	0,0013***	0,0014***	0,0017***
	(0,0001)	(0,0002)	(0,0002)	(0,0003)
Gov. Consumption t-1		0,0096***	0,0095***	0,0129***
		(0,0010)	(0,0010)	(0,0020)
Trade Openness t-1			-0,0001	-0,0002*
			(0,0001)	(0,0001)
GDP Growth t-1				0,0017***
				(0,0004)
Observations	1115	1098	1098	1098
Countries	110	109	109	109
J-Statistic	68,4193	66,3106	65,3827	57,6079
p-value	0,2132	0,2395	0,2359	0,4526
AR (1)	-0,4588	-0,4473	-0,4460	-0,4440
p-value	0,0000	0,0000	0,0000	0,0000
AR (2)	0,0041	-0,0007	-0,0009	-0,0008
p-value	0,9056	0,9838	0,9795	0,9825

Note: *Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. Standard errors between parentheses.*

In Table 9, the same models were estimated for the Emerging Markets Economies (EME). The results also show that both DFIA and FIA reduce inequality measured by the Palma ratio. However, it is not possible to affirm that the effect on inequality DFIA is larger than FIA.

Table 7 - Effect of DFIA on the Palma ratio for the emerging markets dataset

Dependent variable: Log(Palma)				
Sample:	Emerging Markets			
Equation	(5)	(6)	(7)	(8)
Log(Palma) t-1	0,7696***	0,7516***	0,7579***	0,7612***
	(0,0004)	(0,0043)	(0,0053)	(0,0045)
DFIA t-1	-0,0638***	-0,0620***	-0,0715***	-0,0746***
	(0,0002)	(0,0031)	(0,0025)	(0,0024)
FIA t-1	-0,0969***	-0,1371***	-0,1219***	-0,1060***
	(0,0009)	(0,0125)	(0,0143)	(0,0113)
Inflation t-1	0,0018***	0,0023***	0,0023***	0,0026***
	(0,0000)	(0,0001)	(0,0001)	(0,0001)
Gov. Consumption t-1		0,0052***	0,0040***	0,0055***
		(0,0005)	(0,0004)	(0,0005)
Trade Openness t-1			-0,0002***	-0,0003***
			(0,0000)	(0,0001)
GDP Growth t-1				0,0013***
				(0,0002)
Observations	579	578	578	578
Countries	56	56	56	56
J-Statistic	54,3972	50,5402	48,8568	49,1489
p-value	0,4211	0,4918	0,5193	0,4672
AR (1)	-0,4499	-0,4519	-0,4531	-0,4534
p-value	0,0000	0,0000	0,0000	0,0000
AR (2)	-0,0422	-0,0433	-0,0424	-0,0425
p-value	0,3552	0,3452	0,3541	0,3547

Note: *Marginal significance levels: (***) denotes 0.01, (**) denotes 0.05, and (*) denotes 0.1. Standard errors between parentheses.*

5. Conclusions

In considering the developments of digital economy, and in order to analyses the effect of different forms of financial access on inequality, a novel indicator of digital access provided by debit and credit cards (DFIA) is elaborate in this study. Therefore, through DFIA and physical financial access provide by IMF(FIA), this work estimates the effect of both financial access on income inequality for a panel of 119 countries between 2001 and 2019.

The results indicate that physical and digital financial access reduces inequality. A possible explanation could be the complementarity of better access to finance, which can help build wealth through education or entrepreneurship and smooth shocks in income. In addition, the results indicates that digital access is more relevant than physical access for Emerging Economies. That way, policymakers can see this as an opportunity to promote inequality reduction by incentivizing financial access through digital forms with proper regulation to avoid damaging side effects of inequality.

Appendix

Table A 1 - Descriptive statistics - Full dataset

	Full				
	observations	Mean	Std	Min	max
FIA	2448	0.38	0.28	0	1.00
DFIA	2696	0.25	0.25	0	1.00
GDP growth	2680	3.87	4.65	-46.08	63.38
Inflation	2494	5.97	13.74	-10.07	380.00
Trade openness	2554	92.07	58.40	0.17	442.62
Gov. consumption	2509	15.76	5.45	0.95	41.89
Education secondary	1966	84.27	27.31	6.98	163.93
Gini	2696	42.71	10.49	15.18	74.29

Table A 2 - Descriptive statistics - Emerging economies

	Emerging Markets				
	observations	Mean	Std	Min	max
FIA	1,188	0.35	0.21	0.02	0.98
DFIA	1,318	0.21	0.17	0	0.78
GDP growth	1,121	49.80	31.26	1.27	165.39
Inflation	1,316	2.82	4.69	-15.15	56.79
Trade openness	720	6.14	6.96	0.51	59.76
Gov. consumption	1,083	6.04	9.29	-33.60	93.92
Education secondary	1,057	6.93	7.23	-21.00	69.94
Gini	1,318	43.59	9.12	15.18	74.29

Table A 3 - Variables Description

Variable name	Description	Source
FIA	The composite indicator part of the Financial Development Index includes the number of bank branches and ATMs per 100.000 inhabitants	IMF
DFIA	Aggregate index created by the author to measure digital forms of financial access using the number of credit cards and debit cards per 100,000 inhabitants	Author himself
GINI	Gini index that measures income inequality	World Income Inequality Database - UN
GDP	GDP growth rate	World Bank
Government Consumption	Government consumption includes all expenditure on goods and services (including employee's salaries), except military expenditures that are part of capital formation.	World Bank
Education Secondary	Gross enrollment in the population of the age group corresponds to secondary education.	World Bank
Inflation	Inflation is measured by the consumer price index reflecting the annual percentage change in the average cost of purchasing a basket of services and changing at fixed intervals. In general, the Laspeyres form is used.	World Bank
Trade Openness	Sum of imports and exports as a percentage of GDP.	World Bank

Table A 4 - Wald test of FIA=DFIA for full and emerging markets sample

	Full sample		Emerging markets sample	
Test Statistic	F-statistic	Chi-square	F-statistic	Chi-square

Value	3,156786	3,156786	173,3878	173,3878
df	(1, 1179)	1	(1, 566)	1
Probability	0,0759	0,0756	0	0

Table A 5 - Instruments used in equations

Full Dataset Equations for the Gini index 1 to 4 (table 5) and Nonlinear Equations 1 to 4 (table 7)	Gini(-2 to -7), DFIA(-2 to -5), FIA(-2 to -3), Education Secondary(-2) Inflation(-2), Gov. Consumption(-2)
EME for the Gini index Dataset Equations 1 to 4 (table 6)	Gini(-2 to -4), DFIA(-2), FIA(-2 to -3), Education Secondary(-2 to -3) Inflation(-2 to -4)
Full Dataset Equations for the Palma ratio 1 to 4 (table 8)	Palma(-2 to -5), Inflation(-2 to -5), GDP Growth(-2 to -3), Trade Openess(-2 to -5), Education Secondary(-2 to -3)
EME for the Gini index Dataset Equations 5 to 8 (table 9)	Palma(-2 to -5), Inflation(-2 to -5), GDP Growth(-2 to -3), Trade Openess(-2), Education Secondary(-2)

Table A 6 – List of Countries

Afghanistan		Denmark		Lao PDR		Russian Federation	*
Albania	*	Dominican Republic	*	Latvia		Rwanda	
Algeria	*	Ecuador	*	Lebanon	*	Samoa	
Angola	*	Egypt, Arab Rep.	*	Lesotho		San Marino	
Argentina	*	El Salvador	*	Liberia		Sao Tome and Principe	
Armenia	*	Equatorial Guinea	*	Lithuania		Saudi Arabia	*
Aruba	*	Estonia		Luxembourg		Serbia	*
Australia		Ethiopia		Macao SAR, China		Seychelles	*
Austria		Fiji	*	Madagascar		Singapore	
Azerbaijan	*	Finland		Malaysia	*	Slovak Republic	
Bahamas, The	*	France		Maldives		Slovenia	
Bangladesh		Gambia, The		Malta		South Africa	*
Barbados	*	Georgia	*	Mauritania		South Sudan	
Belarus	*	Germany		Mauritius	*	Spain	
Belgium		Ghana		Mexico	*	Sri Lanka	*
Belize	*	Greece		Moldova		Sudan	
Bolivia	*	Guinea		Mongolia	*	Sweden	
Bosnia and Herzegovina	*	Honduras		Montenegro	*	Switzerland	
Botswana	*	Hong Kong SAR, China		Morocco	*	Tanzania	
Brazil	*	Hungary	*	Mozambique		Thailand	*
Brunei Darussalam	*	Iceland		Myanmar		Trinidad and Tobago	*
Bulgaria	*	India	*	Namibia	*	Tunisia	*
Cabo Verde		Indonesia	*	Nepal		Turkey	*
Cambodia		Iran, Islamic Rep.	*	Netherlands		Uganda	
Cameroon		Iraq	*	Nicaragua		Ukraine	*
Canada		Ireland		Nigeria	*	United Arab Emirates	*
Chad		Israel		North Macedonia	*	United Kingdom	
Chile	*	Italy		Norway		United States	
China	*	Jamaica	*	Pakistan	*	Uruguay	*
Colombia	*	Japan		Panama	*	Uzbekistan	
Comoros		Jordan	*	Paraguay	*	Vietnam	*
Congo, Dem. Rep.		Kazakhstan	*	Peru	*	West Bank and Gaza	*
Costa Rica	*	Kenya		Philippines	*	Yemen, Rep.	
Croatia	*	Korea, Rep.		Poland	*	Zambia	
Cyprus		Kuwait	*	Portugal		Zimbabwe	
Czech Republic		Kyrgyz Republic		Romania	*		

* Emerging Market Economy

References

Agarwal, S., Kigabo, T., Minoiu, C., Presbitero, A., & Silva, A. (2018). Financial Access Under the Microscope. In *IMF Working Papers: Vol. 18/208*. https://doi.org/10.5089/9781484376362.001

Arellano, M. (2003). *Panel Data Econometrics*. Oxford University Press. https://doi.org/10.1093/0199245282.001.0001

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. https://doi.org/10.2307/2297968

Arellano, M., & Bover, O. (1995). Another look at the instrumental variable estimation of error-components models. *Journal of Econometrics*, *68*(1), 29–51. https://doi.org/10.1016/0304-4076(94)01642-D

Aslan, G., Deléchat, C., Newiak, M., & Yang, F. (2017). Inequality in Financial Inclusion and Income Inequality. *IMF Working Papers*, *17*(236), 1. https://doi.org/10.5089/9781484324905.001

Auer, R., Cornelli, G., & Frost, J. (2020). COVID-19, cash, and the future of payments. *BIS Bulletin*, *3*, 3. https://www.bis.org/publ/bisbull03.htm

Banerjee, A. V., & Newman, A. F. (1993). Occupational choice and the process of development. *Journal of Political Economy*, *101*(2), 274–298. https://doi.org/10.1086/261876

Barro, R. J. (2000). Inequality and growth in a panel of countries. *Journal of Economic Growth*, *5*(1), 5–32. https://doi.org/10.1023/A:1009850119329

Bayar, Y., & Sezgin, H. F. (2017). Trade Openness, Inequality And Poverty. *Ekonomika*, *96*(1), 47–57.

Beck, T. (2016). Financial Inclusion – measuring progress and progress in measuring. In *Fourth IMF Statistical Forum*.

Beck, T., Demirgüç-Kunt, A., & Levine, R. (2007). Finance, inequality and the poor. *Journal of Economic Growth*, *12*(1), 27–49. https://doi.org/10.1007/s10887-007-9010-6

Blundell, R., & Bond, S. (1998). Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*, *87*(1), 115–143. https://doi.org/10.1016/S0304-4076(98)00009-8

Bond, S. R., Hoeffler, A., Temple, J., Bond, S., Hoeffler, A., & Temple, J. (2001). GMM Estimation of Empirical Growth Models. In *Economics Papers* (No. W21; Issue W21). Economics Group, Nuffield College, University of Oxford. https://econpapers.repec.org/RePEc:nuf:econwp:0121

Cardoso, S. M., & Teixeira, A. A. C. (2020). The Focus on Poverty in the Most Influential Journals in Economics: A Bibliometric Analysis of the “Blue Ribbon” Journals. *Poverty and Public Policy*, *12*(1), 10–42. https://doi.org/10.1002/pop4.269

Célerier, C., & Matray, A. (2019). Bank-Branch Supply, Financial Inclusion, and Wealth Accumulation. *Review of Financial Studies*, *32*(12), 4767–4809. https://doi.org/10.1093/rfs/hhz046

CHRISTOPOULOS, D., & MCADAM, P. (2017). On the Persistence of Cross-Country Inequality Measures. *Journal of Money, Credit and Banking*, *49*(1), 255–266.

https://doi.org/10.1111/jmcb.12374

Cihak, M., & Sahay, R. (2020). Finance and Inequality. *Staff Discussion Notes*, *20*(1). https://doi.org/10.5089/9781513526546.006

Claessens, S., & Perotti, E. (2007). Finance and inequality: Channels and evidence. *Journal of Comparative Economics*, *35*(4), 748–773. https://doi.org/10.1016/j.jce.2007.07.002

Daumal, M. (2013). The Impact of Trade Openness on Regional Inequality: The Cases of India and Brazil. *International Trade Journal*, *27*(3), 243–280. https://doi.org/10.1080/08853908.2013.796839

David, B., Abel, F., & Patrick, W. (2016). Debit card and demand for cash. *Journal of Banking and Finance*, *73*. https://doi.org/10.1016/j.jbankfin.2016.08.009

de Moraes, C., Galvis-Ciro, J. C., & Gargalhone, M. (2021). Financial access and interest rate spread: An international assessment. *Journal of Economics and Business*, *114*(November), 105958. https://doi.org/10.1016/j.jeconbus.2020.105958

Demirguc-kunt, A., and Klapper, L. (2012). Measuring financial inclusion. The Global findex database. In *Policy research working paper* (No. 6025). https://doi.org/10.1596/978-0-8213-9509-7

Espinosa-Vega, M., Shirono, K., Carcel Villanova, H., Chhabra, E., Das, B., & Fan, Y. (2020). Measuring Financial Access. In *Departmental Papers / Policy Papers* (20/08, Vol. 2020, Issue 8). https://doi.org/10.5089/9781513538853.087

Franco, C., & Gerussi, E. (2013). Trade, foreign direct investments (FDI) and income inequality: Empirical evidence from transition countries. *Journal of International Trade and Economic Development*, *22*(8), 1131–1160. https://doi.org/10.1080/09638199.2011.647048

Global Partnership for Financial Inclusion. (2016). G20 High-Level Principles for Digital Financial Inclusion. In *Global Partnership for Financial Inclusion*.

Greenwood, J., & Jovanovic, B. (1990). Financial Development, Growth, and the Distribution of Income. *Journal of Political Economy*, *98*(5, Part 1), 1076–1107. https://doi.org/10.1086/261720

Gresvik, O., & Haare, H. (2009). Costs in the Payment System. *Economic Bulletin*, *27*, 16–27.

Hamori, S., & Hashiguchi, Y. (2012). The effect of financial deepening on inequality: Some international evidence. *Journal of Asian Economics*, *23*(4), 353–359. https://doi.org/10.1016/j.asieco.2011.12.001

Hayashi, F., & Keeton, W. R. (2012). Measuring the Costs of Retail Payment Methods. *Economic Review*, 1–41. https://www.kansascityfed.org/documents/1383/2012-Measuring the Costs of Retail Payments Methods.pdf

Humphrey, D. B., Kim, M., & Vale, B. (2001). Realizing the Gains from Electronic Payments: Costs, Pricing, and Payment Choice. *Journal of Money, Credit and Banking*, *33*(2), 216. https://doi.org/10.2307/2673882

Inoue, T., & Hamori, S. (2016). Financial Access and Economic Growth: Evidence from Sub-Saharan Africa. *Emerging Markets Finance and Trade*, *52*(3), 743–753. https://doi.org/10.1080/1540496X.2016.1116282

Kendall, J., Mylenko, N., & Ponce, A. (2010). Measuring financial access around the world. In *Policy Research Working Paper* (No. WPS5253; 1). http://documents.worldbank.org/curated/en/558201468163755866/Measuring-financial-

access-around-the-world

Kuznets, S. (1955). Economic growth and the environment. *The American Economic Review*, *45*(1), 1–28. http://www.jstor.org/stable/1811581

Lee, C.-C., Wang, C.-W., & Ho, S.-J. (2020). Financial inclusion, financial innovation, and firms' sales growth. *International Review of Economics & Finance*, *66*, 189–205. https://doi.org/10.1016/j.iref.2019.11.021

Lee, H. S. (2021). State expenditures and inequality in the U.S. *Social Science Journal*, *00*(00), 1–14. https://doi.org/10.1080/03623319.2021.1900670

Li, H., & Zou, H. F. (2002). Inflation, growth, and income distribution: A cross-country study. *Annals of Economics and Finance*, *3*(1), 85–101.

Lo Prete, A. (2013). Economic literacy, inequality, and financial development. *Economics Letters*, *118*(1), 74–76. https://doi.org/10.1016/j.econlet.2012.09.029

Makina, D., & Walle, Y. M. (2019). Financial Inclusion and Economic Growth: Evidence From a Panel of Selected African Countries. In *Extending Financial Inclusion in Africa* (pp. 193–210). Elsevier Inc. https://doi.org/10.1016/B978-0-12-814164-9.00009-8

Mao, L., & Chen, S. (2015). The growth of mobile payment and effect on consumption via cash and bankcard. *2015 8th International Conference on Biomedical Engineering and Informatics (BMEI)*, *Bmei*, 872–877. https://doi.org/10.1109/BMEI.2015.7401625

Nickell, S. (1981). Biases in Dynamic Models with Fixed Effects. *Econometrica*, *49*(6), 1417. https://doi.org/10.2307/1911408

Nirmala, T., & Widodo, T. (2011). Effect of increasing use the card payment equipment on the indonesian economy. *Jurnal Bisnis Dan Ekonomi (JBE)*, *18*(1), 36–45.

OECD, E. U. and J. R. C.-E. C. (2008). *Handbook on Constructing Composite Indicators: Methodology and User Guide* (Vol. 63). OECD. https://doi.org/10.1787/9789264043466-en

Omar, M. A., & Inaba, K. (2020). Does financial inclusion reduce poverty and income inequality in developing countries? A panel data analysis. *Journal of Economic Structures*, *9*(1). https://doi.org/10.1186/s40008-020-00214-4

Ratnawati, K. (2020). The Impact of Financial Inclusion on Economic Growth, Poverty, Income Inequality, and Financial Stability in Asia. *The Journal of Asian Finance, Economics and Business*, *7*(10), 73–85. https://doi.org/10.13106/jafeb.2020.vol7.no10.073

Rehman, H. U., Khan, S., & Ahmed, I. (2008). Income Distribution, Growth, and Financial Development: A Cross Countries Analysis. *Pakistan Economic and Social Review*, *46*(8), 1–16.

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. https://doi.org/10.1016/j.jpubeco.2009.04.003

Roodman, D. (2009). A Note on the Theme of Too Many Instruments. *Oxford Bulletin of Economics and Statistics*. https://doi.org/10.1111/j.1468-0084.2008.00542.x

Roodman, D. (2012). *Due Diligence: An Impertinent Inquiry into Microfinance* (Issue 1). Center for Global Development. https://doi.org/10.1080/10402659.2017.1272345

Sahay, R., Čihák, M., N'Diaye, P., Barajas, A., Bi, R., Ayala, D., Gao, Y., Kyobe, A., Nguyen, L., Saborowski, C., Svirydzenka, K., & Reza Yousefi, S. (2015). Rethinking Financial

Deepening: Stability and Growth in Emerging Markets. In *IMF Staff Discussion Notes* (15/08; SDN).

Scholnick, B., Massoud, N., Saunders, A., Carbo-Valverde, S., & Rodríguez-Fernández, F. (2008). The economics of credit cards, debit cards and ATMs: A survey and some new evidence. *Journal of Banking and Finance*, *32*(8), 1468–1483. https://doi.org/10.1016/j.jbankfin.2007.05.001

Seven, Ü. (2022). Finance, talent and income inequality: Cross-country evidence. *Borsa Istanbul Review*, *22*(1), 57–68. https://doi.org/10.1016/j.bir.2021.01.003

Svirydzenka, K. (2016). Introducing a New Broad-based Index of Financial Development. In *IMF Working Papers* (No. 16; 5, Vol. 16, Issue 5). https://doi.org/10.5089/9781513583709.001

Tanninen, H. (1999). Income inequality, government expenditures and growth. *Applied Economics*, *31*(9), 1109–1117. https://doi.org/10.1080/000368499323599

Tchamyou, V. S., Erreygers, G., & Cassimon, D. (2019). Inequality, ICT and financial access in Africa. *Technological Forecasting and Social Change*, *139*(November), 169–184. https://doi.org/10.1016/j.techfore.2018.11.004

The World Bank Group. (2018). *UFA2020 Overview: Universal Financial Access by 2020*. https://www.worldbank.org/en/topic/financialinclusion/brief/achieving-universal-financial-access-by-2020

Tiberto, B. P., de Moraes, C. O., & Corrêa, P. P. (2020). Does transparency of central banks communication affect credit market? Empirical evidence for advanced and emerging markets. *North American Journal of Economics and Finance*, *53*(December 2019), 101207. https://doi.org/10.1016/j.najef.2020.101207

Tridico, P. (2018). The determinants of income inequality in OECD countries. *Cambridge Journal of Economics*, *42*(4), 1009–1042. https://doi.org/10.1093/cje/bex069

United Nations. (2018). *Igniting Sdg Progress Through Digital*. 45. https://www.betterthancash.org/tools-research/reports/igniting-sdg-progress-through-digital-financial-inclusion

Vives, X. (2016). *Competition and Stability in Banking: The role of regulation and competition policy.* Princeton University Press.

Yue, H. (2011). Income Inequality, Economic Growth and Inflation: a Study on Korea. *International Journal of Economics and Research*, *02*(05), 14–21.