Universidad Pablo de Olavide (España)
Revista de Métodos Cuantitativos para la Economía y la Empresa
número 38, 2024
ISSN: 1886-516X
DOI: 10.46661/revmetodoscuanteconempresa.6999
Sección: Artículos
Recibido: 15-05-2022
Aceptado: 10-02-2024
Publicado: 03-12-2024
Páginas: 1-21

Revista de Métodos Cuantitativos para la Economía y la Empresa

El papel de las tecnologías de la información y la comunicación (TIC) en la relación entre asimetría de la información y desarrollo financiero: Nuevas pruebas basadas en el modelo PSTR

The Role of Information and Communication technology (ICT) in the Relationship Between Information Asymmetry and Financial Development: New Evidence Based on the PSTR Model

Mahdieh Rezagholizadeh
University of Mazandaran (Iran)
https://orcid.org/0000-0003-1172-4824
m.gholizadeh@umz.ac.ir

Majid Aghaei
University of Mazandaran (Iran)
https://orcid.org/0000-0003-0833-9781
m.aghaei@umz.ac.ir

Atefeh Alipour Kebria
University of Mazandaran (Iran)
https://orcid.org/0000-0002-3649-7683
Atefeh.al.a@gmail.com

Cómo citar: Rezagholizadeh, M., Aghaei, M., & Kebria, A. A.(2024). El papel de las tecnologías de la información y la comunicación (TIC) en la relación entre asimetría de la información y desarrollo financiero: Nuevas pruebas basadas en el modelo PSTR. Revista De Métodos Cuantitativos Para La Economía Y La Empresa. 38. https://doi.org/10.46661/rev.metodoscuant.econ.empresa.6999

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

RESUMEN

Las tecnologías de la información y la comunicación (TIC) tienen potencial para complementar a las oficinas de intercambio de información (OIC) (oficinas de crédito privadas (OCP) y registros públicos de crédito (RPC)) en la reducción de la asimetría de la información (AI) para mejorar el desarrollo financiero. Utilizando las TIC como variable de transición, esta investigación emplea el modelo de regresión de transición suave de panel (PSTR) para examinar la influencia de la AI en el desarrollo financiero de 33 países menos adelantados (PMA) durante el periodo 2000-2021. Los resultados indican que el AI y el desarrollo financiero tienen un nexo no lineal y que las TIC alteran esta relación. Según las conclusiones, este impacto tiene características dinámicas de umbral y cambios graduales, y las TIC desempeñan un papel considerable en esta relación. Cuando la TIC está por debajo del valor umbral, es decir, en el régimen bajo, la PCR tiene un impacto negativo en el desarrollo financiero. En cambio, cuando las TIC superan el umbral, es decir, en el régimen alto, el coeficiente es positivo. Esto significa que el efecto negativo de la PCR sobre el desarrollo financiero se compensa e incluso se convierte en positivo a medida que aumentan las TIC. Por otra parte, la PCB tiene un efecto positivo en el desarrollo financiero tanto en el régimen de TIC bajo como en el alto. Con el traspaso del umbral de TIC, crece el impacto favorable de la PCB en la reducción del AI en la dirección del desarrollo financiero. La implicación oculta es que PCR y PCB (con IA decreciente) promueven el desarrollo financiero, cuando las TIC están en un nivel alto. En otras palabras, las TIC podrían complementar las características de la RCP y el PCB para reducir el AI y aumentar el desarrollo financiero.

PALABRAS CLAVE
Tecnología de información y comunicación; desarrollo financiero; asimetría en la información; oficinas de información compartida; regresión de transición suave de panel.

ABSTRACT

Information and communications technology (ICT) has potential to complement information sharing bureaus (ISB) (private credit bureaus (PCB) and public credit registries (PCR)) in lessening information asymmetry (IA) to enhance financial development. Using ICT as the transition variable, this research employs the panel smooth transition regression (PSTR) model to examine the influence of IA on financial development in 33 least developed countries (LDCs) over the 2000–2021. Results indicate that IA and financial development have a nonlinear nexus and ICT alters this relationship. Based on the findings, this impact has dynamic characteristics of threshold

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

and gradual changes and ICT plays a considerable part in this relationship. When ICT is below the threshold value, that is in the low regime, PCR has a negative impact on financial development. In contrast, when the ICT outstrips the threshold, that is in the high regime, the coefficient is positive. It means that the negative effect of PCR on financial development is offset and even changed into positive as ICT increases. On the other hand, PCB has a positive impact on financial development in both low and high ICT regime. With the transfer from the ICT threshold, the favorable impact of PCB on reducing IA in the direction of financial development grows. The hidden implication is that PCR and PCB (with decreasing IA) promote the financial development, when ICT is at a high level. In other words, ICT could complement the characteristics of PCR and PCB to reduce IA and increase financial development.

KEYWORDS

Information and Communication Technology (ICT); Financial Development; Information Asymmetry (IA); Information Sharing Bureaus (ISB); Panel Smooth Transition Regression (PSTR).

Clasificación JEL: E44; G00; L86; D82.

MSC2010: 91B44; 91B28; 94B99.

1. INTRODUCTION

The importance of financial system and the level of development is given by many works. financial markets and financial institutions influence to a large extend the economic development, the economic stability and the poverty reduction (Levine, 2005).

The financial sector, which acts as an intermediary in the distribution of resources to all economic sectors, significantly contributes to a nation's long-term economic growth by lowering financing costs and promoting savings and their effective utilization (Leitão, 2012). In the meanwhile, it is evident that banks and other financial institutions play a crucial role in converting deposited funds into credit and expanding businesses' access to capital. financial development is a major challenge, especially in emerging and developing economies. A key factor affected this sector, is the information asymmetry (IA) between lenders and borrowers that encourage adverse selection and moral hazard. The study of asymmetric information in financial markets began in the early 1970s. The 2001 Nobel Prize in economics for the study of asymmetric information was given to Akerlof et al. (2001). Akerlof (1970) specifically indicated that the asymmetric information might increase the possibility of "adverse selection" on the markets.

There has been a considerable number of theoretical studies supporting the position that information asymmetry (information sharing) between lenders and borrowers has an effect on the financial sector (Asongu et al., 2016; Triki and Gajigo, 2014). the aim of other group is exploring the effect of ICT on information asymmetry (information sharing) (Bayram and Demirtel, 2014), and another group have examined the role of ICT in reducing information asymmetry for financial development. aim of this group is to explore the simultaneous impact of ICT and information asymmetry on financial sector and discussed how ICT and information sharing

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

affect financial sector (Domowitz, 2002), (Purcell and Toland, 2003), (Asongu et al., 2016), (Asongu and Moulin, 2016), (Asongu and Nnanna, 2018) and (Asongu et al., 2019). A strand of financial development literature such as Asongu and Moulin (2016) and Asongu and Nnanna (2018) have emphasized the need ICT for information sharing offices (ISOs) in reducing information asymmetry for financial development. From a theoretical viewpoint, PCRs are expected to reduce information asymmetry. ICT is an instrument by which PCR mitigate information asymmetry and enhance financial sector. In contrast, another strand of the literature such as (Asongu et al., 2016) is articulating the view that information sharing offices may not be able to enhance financial sector.

In keeping with the growth of these literatures, economists and policymakers have always looked for practical measures to lessen information asymmetry among financial sector activists. To address this information asymmetry, public credit registries (PCRs) and private credit bureaus (PCBs) have been established around the world and used as proxies for reducing information asymmetry. Credit registries are a typical response to information asymmetry problems between lenders and borrowers. Many studies have illustrated how comprehensive information helps lenders better predict borrower default. By closing the knowledge gap between borrowers and lenders, information sharing bureaus can increase financial access and develop financial system. In recent years, it has been recognized that one of the most crucial strategies for reducing information asymmetry in financial markets is the advancement of information and communication technology by greater information sharing between participants in various economic sectors. Also, ICT can lead to the information asymmetry decrement and financial system improvement through reducing market failures and friction such as information and transaction costs.

There are considerable differences between geographical regions in the levels of ICT development as demonstrated by the information and communication technology development Index (ICT development index, or IDI). There is also significant variation in the experience of individual countries within each region (Measuring the Information Society Report, International Telecommunication Union (ITU), 2017).

The countries under review are some of the least developed countries (LDCs) based on the United Nations classification (2022). There are currently 46 economies designated by the United Nations (2022) as the least developed countries (LDCs), entitling them to preferential market access, aid, special technical assistance, and capacity-building on technology among other concessions. These 46 LDCs are distributed across the world, with the majority (33) being located in Africa, followed by 9 countries in Asia, and one in the Caribbean and three in the Pacific region (United Nations, 2022). LDCs are identified by the United Nations according to criteria concerned with gross national income (GNI) per capita, human assets and economic vulnerability (International Telecommunication Union, 2017). While this group of countries differ in their territorial extension, population and socio-cultural characteristics, they all are low-income developing economies facing “severe structural impediments to growth”, as indicated by their high vulnerability to external economic shocks, low levels of human capital, and susceptibility to natural and man-made disasters and communicable diseases.

Also, most of The United Nations identified 46 countries as LDCs, are the low quartile countries represented based on the Information and Communication Technology Development Index (ICT Development Index, or IDI) ranking by the International Telecommunication Union (ITU). These countries although they have made progress in improving ICT infrastructures and services, and in some cases significant leaps forward, LDCs continue to lag behind other regions in terms of the key indicators that will influence their position in the emerging digital economy (International Telecommunication Union, 2017).

The growth potential of ICT in these countries is higher compared to other continents. In essence, while high-end markets in other countries are currently experiencing stabilization in the growth of ICT, business opportunities related to mobile phones and the internet are still substantial in LDCs. As of 2010, whereas penetrations of the internet and the mobile phone had reached points

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

of saturation in developed economies, there was still much room for their developments in LDCs (Asongu and Moulin, 2016).

In accordance with the narrative above on the growth potential of internet and mobile phones in LDCs, it is reasonable to assess if this ICT has potential to complement information sharing bureaus (ISB) (private credit bureaus (PCB) and public credit registries (PCR)) in their role of information sharing for financial development. So, in this study, we integrate ICT variable into the modelling exercise in order to examine how ICT complement the role of information sharing bureaus (ISB) in lessening information asymmetry to enhance financial development. In other words, the goal of this study is to examine the role of ICT in boosting information sharing (reduce information asymmetry) for financial development in 33 selected LCDs for the period 2000–2021.

The previous relevant studies most employ linear models to examine the nexus among ICT, IA, and financial sector, all of which are predicated on the premise that the coefficients of the concerned variables are constant and do not change with other variables. However, the influence information asymmetry exerts on financial development is likely to vary with the magnitude of ICT changes. Therefore, it is necessary to employ the nonlinear model to examine how information asymmetry affects financial development. This research aims to take a different standpoint from previous studies to examine the impact of information asymmetry on financial development by using nonlinear smooth panel transition regression (PSTR), which takes into account the importance of ICT. To the best of our knowledge, no research has employed the nonlinear PSTR model to investigate the dynamic impact of information asymmetry on financial development when ICT varies. The traditional research techniques used in previous related studies have the following limitations. First, most studies using panel data encounter the problem of cross-sectional heterogeneity and temporal instability, which lead to biased estimates. Second, the traditional nonlinear threshold approaches cannot capture the threshold level endogenously or a transition's smoothness from the low regime to the high regime. To overcome the above econometric issues, we use the newly introduced PSTR model, which differs from the previous one studies in both theoretical and empirical design. The PSTR model is a regime-switching model with smooth transitions between different regimes, which allows for several regimes connected to the value of a transition function (Nan et al., 2022a) and (Nan et al., 2022b).

This research highlights the underlying mechanism by which the positive effect of IA reduction on financial development may be strengthened with the improving of the ICT level. Hence, from a theoretical standpoint, our study aims to fill the gap by postulating ICT as a transition variable. The empirical results of this research indicate that the relationship between information asymmetry and financial development is nonlinear and is suitable to be characterized by the transition variable ICT. Based on these results, ICT will decrease information asymmetry through the establishment and expansion of information sharing bureaus (PCR and PCB), which will enhance the financial development.

To achieve the above-mentioned goals, this study is organized as follows: the second section provides literature review. data and PSTR model specification are covered in Section 3. Section 4 presents the empirical results and finally, conclusion and policy implications are provided in Section 5.

2. LITERATURE REVIEW

2.1. Financial market structure under conditions of asymmetric information

Information is the fundamental component of market efficiency in the modern world and in financial transactions. The pricing will accurately reflect the information that is accessible, and as a result, the more efficient the market, the more secure it will be and the more confident its users will be. This problem attracts errant capital, directs it toward productive endeavors, boosts output and national income, and ultimately improves economic conditions. The fundamental barrier to the smooth operation of the financial system is the asymmetry of information, which

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

will have a substantial impact on boosting market efficiency as the number of participants in the financial markets rises. When one side to a contract or transaction has more information and effectively communicates with the other party using that information, this is known as information asymmetry (Aboody and Lev, 2000). This information primarily results in financial gains for the party with the additional knowledge, but it also causes moral hazard (misbehavior) and the issue of adverse selection (selection bias). Due of a lack of knowledge regarding the characteristics of borrowers, lenders frequently experience issues with adverse selection, especially when it comes to risks associated with the investment for which borrowers want to mobilize financial resources. In addition, the concern is even more worrisome when lenders are unable to control the actions of borrowers after credit has been granted. Accordingly, a borrower could decide to conceal the proceeds of the underlying investment in order to reduce responsibility in event of default or prevent repayment of the underlying debt (Asongu et al., 2016).

On the other hand, information asymmetry has negative effects that include raising transaction costs, lowering market liquidity, reducing market efficiency, and generally lowering the return from capital market operations (Jiang and Kim, 2004).

Major economists like George Akerlof and Joseph Stiglitz set the groundwork for financial market structure in the 1970s when there was asymmetric information. In light of the assumption of a competitive market, or information symmetry, they arrived to the conclusion that the evolution of the financial structure will occur in a transparent economic environment. This presumption is based on the notion that all players in the market are fully informed of all prices and data.

The reduction of information asymmetry has positive implications for relaxing credit constraints, increasing competition in the credit market and the efficient allocation of capital (Triky and Gajio, 2014).

But the market will collapse if it is unable to carry out its primary role and instead performs in an inefficient manner as a result of the asymmetry of knowledge between the trading participants. Akerlof (1970) demonstrated using a scientific premise that an information problem could cause the market to contract and result in an undesirable selection of low-quality products. These downsides can be limited by the sharing of information on borrowers' solvency characteristics. in other words, by disclosing details about the debt characteristics of borrowers, these drawbacks can be mitigated.

2.2. The impact of information sharing bureaus (ISB) on information asymmetry in financial markets

Information sharing offices prior to 2008 restricted to a few countries in the Organisation for Economic Cooperation and Development and LatinAmerica Mylenko (2008) and after that have been established in nations to lessen the information asymmetry between lenders and borrowers in the financial industry. Researchers like Batuo and Kupukile (2010) and Triki and Gajigo (2014) have argued that the establishment of information sharing offices is predicated on the premise that a significant portion of businesses' and economic activists' difficulty accessing financing is caused by information asymmetry. In essence, the introduction of ISO has been motivated by the idea that lack of financial access is constrained by factors that can be explained by information asymmetry, namely: eligibility to bank lending, physical access and affordability Batuo and Kupukile (2010) and Allen et al. (2011). Apart from serving as brokers between lenders and borrowers in financial institutions, by sharing information these brokers enable, among others: the efficient allocation of capital, relaxation of credit constraints and increase of credit market competition (Jappelli and Pagano, 2002). Galindo and Miller (2001) have provided evidence that show that countries with better developed credit registries enjoy lower financial restrictions than those where credit bureaus are underdeveloped. They find that well performing credit registries can account for significant reductions in the sensitivity of a firm's

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

investment decisions to availability of cash flows, a measure that has typically been used in the literature as a proxy for financial constraints.

The two main kinds of institutions for collecting and sharing information on credit transactions are public credit registry (PCR) and private credit bureau (PCB). A public registry is usually created by the public sector, generally the central bank, while a private bureau is managed by the private sector. In theory, the two institutions should be perfect substitutes – it shouldn't matter whether information is supplied by a public or private entity. Public and private credit registries exist to improve the information available on borrowing firms (and individuals), in an effort to ease financing constraints. The information they make available –from a borrower's total number of current loans, repayment history, previous bankruptcies, etc. – can allow lenders to extend greater credit at more favorable interest rates. it should be noted that ISB also have the mission of playing the role of disciplining borrowers and preventing them from defaulting on their debts and/or seeking refuge in the non-formal and informal financial sectors. Therefore, the ISB also play a significant role in mitigating moral hazard on the part of borrowers (Asongu and Nnanna, 2018).

According to Diamond (1984) and Diamond and Dybvig (1983), the major goal of information sharing bureaus is to lower transaction costs and information costs brought on by the information asymmetry that exists between borrowers and lenders. The ability to eliminate information asymmetry in the direction of access and financial development is thus made possible by information sharing offices (Ibrahim and Alagidede, 2017).

For 42 African nations, Triki and Gajigo (2014) looked at the impact of private and public credit registry bureaus on the availability of credit as well as the impact of the public credit registry scheme on the severity of financing constraints. The findings of this study demonstrated that countries with private credit registration bureaus had greater access to funding than countries with public credit registration bureaus or nations without either of these bureaus.

Love and Mylenko (2003) have combined public and private credit registries with firm related data from the World Bank Business Environment Survey (WBES) to investigate whether the presence of a credit registry in a country is associated with lower financing constraints, and with higher share of bank financing. They find that the existence of private credit registries is associated with lower financing constraints and higher share of bank financing, while the existence of public credit registries does not seem to have a significant effect on these perceived financing constraints.

Asongu et. al (2016) have examined the effect of Information asymmetry on the financial development in Africa for the period 2004–2011. The following findings are established. First, PCRs and PCBs have negative effects on financial depth, with the magnitude of the former higher. Second, contrary to PCRs which have insignificant effects, PCBs have a negative impact on banking system efficiency. Third, PCRs and PCBs have negative impacts on financial activity, with the magnitude of the latter higher.

2.3. The role of information and communication technology (ICT) in the relationship between information asymmetry and financial development

After 2008, the burgeoning of information and communication technologies has substantially favoured the establishment of ISOs in Sub-Saharan Africa, Eastern Europe and the Middle East and North Africa. Therefore, by 2008, few countries had ISOs and unfortunately, given the lack of proper technology and incentives, timely and accurate information was not often provided by these credit registries. However, with the growth of information and communication technology, several initiatives on introducing ISOs were taken across the continent (Asongu et al., 2016). ICT is a policy instrument for improving the work of information sharing offices because it is logically connected with the goal of disseminating information and reducing information asymmetry between lenders and borrowers. Therefore, in order to collect and share information with banks,

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

credit bureaus are very likely to use ICT mechanisms (Asongu et al., 2019). According to Purcell and Toland (2003), information and communication technology helps banks and institutions in creating and maintaining information and credit databases. Asongu and Nnanna (2018) argued that ICT enables financial institutions to have up-to-date information, encourages the participation of customers in the lending process, reduces informational rents previously enjoyed by big banks and reduces the abuse of market power by large financial institutions.

Therefore, it can be said that the expansion of information and communication technology is one of the main ways to increase information sharing in order to reduce information asymmetry and develop the financial sector (Asongu et al., 2016).

Domowitz (2002) believe that improving the level of information and communication technology will reduce the cost of communication, computing and data processing, etc., and buyers and sellers of financial assets will have access to more information and, as a result, transparency. And competition in financial markets increases. On the other hand, the expansion of ICT leads to the integration and competitiveness of the markets, so that information on the price, volume of transactions, etc. in different markets is available to everyone at the same time, and as a result, investors have a wider view. increases and helps them control the market and the time of quick implementation of exchange strategies.

To summarize, the use of ICT by information sharing offices has the potential to reduce information asymmetry between borrowers and lenders to enhance financial development.

Asongu and Moulin (2016) assess the role of ICT in reducing information asymmetry for financial access by using Generalised Method of Moments in 53 African countries for the period 2004–2011. The results showed that the marginal effects from interactions between ICT and PCR (PCB) are consistently positive (negative). Asongu and Nnanna (2018) examine the role of ICT in Reducing Information Asymmetry for Financial Sector Competition (financial sector dynamics of formalization, informalization and non-formalization) by using Generalized Method of Moments (GMM). The findings of this research differ across financial sectors in terms of marginal, net and threshold effects. Based on the findings, the marginal effect from the interaction between PCR and mobile phones is positive, while the marginal effects from the interactions between ICT and PCB are negative. Asongu et. al (2019) have investigated loan price and quantity effects of information sharing offices with ICT, in a panel of 162 banks consisting of 42 African countries by using Generalized Method of Moments and Instrumental Quantile Regressions. Their findings indicate that ICT when integrated with the role of public credit registries significantly lowered the price of loans and raised the quantity of loans. on the other hand, ICT could complement the characteristics of private credit bureaus to reduce loan prices and increase loan quantity, but only when certain thresholds of ICT are attained.

3. DATA AND PSTR MODEL SPECIFICATION

From the empirical point of view, our research aims to explore the nonlinear influence of information asymmetry on financial development. This study uses the Panel Smooth Transition Regression (PSTR), which takes into consideration the cross-sectional dependence of estimation coefficients and solves the issue of time instability (Gonzalez et al., 2017), to explore the dynamic influence of IA on financial development with the changing of ICT.

3.1. Panel Smooth Transition Regression (PSTR)

Fok et al. (2004), Gonzalez et al. (2017), and Fouquau et al. (2008) introduced and improved the panel smooth transition regression model (PSTR). This method models the change in parameters over time as well as the change in parameters across countries in a continuous way. The regime changes regression model by Bacon and Watts (1971) was introduced, and it can be thought of as an enlarged version of the smooth transition regression model, which is a non-linear time

series regression model. The model that these researchers created allows for a smooth transition between the two regression lines that they took into account. The smooth transition model was discussed and proposed by Bar in their studies. Using a continuous transfer function, the PSTR model simulates potential non-linear relationships between variables (Fouquau et al., 2008). Additionally, this model permits estimated coefficients to change for various nations and even over time, offering a straightforward solution to the issue of heterogeneity in the estimated parameters in the panel data model (Jude, 2010). A PSTR model with two limit regimes and a transfer function is stated as follows, according to Gonzalez et al. (2017) and Colletaz and Hurlin (2006).

(1)

$$Y_{it} = \mu_i + \beta_0 X_{it} + \beta_1' X_{it} * F\left(q_{it}; \gamma, c_j\right) + u_{it} \qquad Y_{it} = \mu_i + \beta_0 X_{it} + \beta_1' X_{it} * F\left(q_{it}; \gamma, c_j\right) + u_{it}$$

$$i = 1, \ldots, N, \; t = 1, \ldots, T$$

Where: Y_{it} is the dependent variable, X_{it} is a vector of exogenous variables, μ_i is the cross-sectional fixed effects and $\mu_{it} \approx iid(0, \sigma^2)$ is the error component. The transition function $F(q_{it}; \gamma, c)$ is smoothly converted between 0 and 1 with the transition variable qit changes. where γ is the slope parameter indicating how quickly a transition function changes between regimes and c_j is the location parameter (Nan et al., 2022b). It is assumed that the transition function usually takes a logistic function and is expressed as follows (Gonzalez et al. 2017):

(2)

$$F(q_{it}; \gamma, c) = \left[1 + exp\left(-\gamma \prod_{j=1}^{m} (q_{it} - c_j)\right)\right]^{-1}$$

$$, \; \gamma > 0. \; c_1 \leq c_2 \leq , \ldots, \leq c_m$$

Gonzalez et al. (2017) assert that it is sufficient to include one or two threshold values of $m = 1$ or $m = 2$ in order to deal with parameter variability in practice. The PSTR model is based on two limit regimes corresponding to the values for m$m = 1$ With a uniform transfer function of coefficients β_0 to $\beta_0 + \beta_1$, and less and more than the transfer variable (q_{it}) compared to the threshold limit $(c_1$), it indicates less and more. If the slope parameter γ tends to infinity, the PSTR model becomes a two-regime panel threshold model (PTR) (Hansen, 1999). This means that for $q_{it} > c_1$ values, the transfer function includes the numerical value of one and otherwise the numerical value of zero. For $m = 2$, the transfer function is minimized at the point $(c_1 + c_2)/2$ and includes the numerical value of one for smaller and larger values of the transfer variable (q_{it}). In this case, when the slope parameter γ tends to zero and with any number of m, the PSTR model is reduced to a linear or homogeneous regression model with fixed effects.

According to the mentioned materials, in the PSTR model, the estimated coefficients change continuously between the two limit states $F = 0$ and $F = 1$ according to the observations of the transfer variable and the slope parameter, which are defined as follows:

(3)

$$y_{it} = \begin{cases} \mu_i + \beta_0 x_{it} + \mu_{it} & F = 0 \\ \mu_i + (\beta_0 + \beta_1) x_{it} + \mu_{it} & F = 1 \end{cases}$$

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

The analysis of the PSTR model is implemented in three steps: testing the linearity and figuring out how many transition functions there are (γ) and how many regimes they correspond to (m), model estimation.

3.1.1 Linearity test

Although the test of linearity in the PSTR model can be done by testing the null hypothesis $H_0: \beta_0 = \beta_1$ or $H_0: \gamma = 0$, but since the PSTR model under the null hypothesis has Unidentified Nuisance Parameters, the test statistics of both the above hypotheses are non-standard. to solve this problem Luukkonen et al. (1988) and Terasvirta (1998) have suggested the use of the Taylor approximation of the transfer function. For this purpose, Gonzalez et al. (2017) and Colletaz and Hurlin (2006) have also proposed replacing the transfer function with its Taylor series approximation around $\gamma = 0$ and thus testing an equivalent hypothesis in auxiliary regression. The Taylor series for a PSTR model with n number of threshold limits is specified as follows (Seleteng et al., 2013):

(4)

$$y_{it} = \mu_i + \beta_0'^{*} x_{it} + \beta_1'^{*} x_{it} \,.\, F\left(q_{it}; \gamma, C\right) + \ldots + \beta_m'^{*} x_{it} q_{it}^{m} + u_{it}^{*}$$

Thus, the linearity test is $H_0: \beta_0'^{*} = \beta_m'^{*} = 0$, we employ LMw, LMF, and LRT statistics to test the hypothesis:

(5)

$$\mathrm{LM_W} = \frac{\mathrm{TN(SSR_0 - SSR_1)}}{\mathrm{SSR_0}}$$

(6)

$$\mathrm{LM_F} = \frac{\left[\frac{\mathrm{SSR_0 - SSR_1}}{\mathrm{mK}}\right]}{\left[\mathrm{SSR_1/(TN - N - mK)}\right]}$$

(7)

$$\mathrm{LRT} = -2\mathrm{Log}\left(\mathrm{SSR_1/SSR_0}\right)$$

In above equations SSR_0 is the sum of the remaining squares of the linear panel model and SSR_1 is the sum of the squared residuals under the null hypothesis. Also, T is the time period, N is the number of cross-sections, K is the number of explanatory variables included in the model and m is the number of threshold limits.

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

3.1.2 Model Evaluation

PSTR model evaluation is the main part in the model structure. For this purpose, in this part, the non-linear residual relationship test, which was used by Eitrheim and Terasvirta (1996) for univariate STAR models and is suitable for the present panel framework, is performed. According to Baltagi and Li (1995), the number of regimes in the PSTR model is determined by using the non-linear relationship test in the residuals. In fact, the purpose of testing the non-linearity of the residuals is twofold. Although this test is a test with an inappropriate specification, it is a useful tool to determine the number of transitions in the model. The following sequential procedure may be used for this purpose:

1. Estimation of a linear (homogeneous) model and the test of linearity at a predetermined significance level
2. Estimation of a two-regime PSTR model in case of rejecting the null hypothesis of linearity
3. Testing the hypothesis of non-linear relationship in the residuals of this model, if this hypothesis is rejected, estimate a PSTR model with two transfer functions.

Continue until the first hypothesis was not zero, the non-linear relationship in the residuals is not rejected (Jude, 2010).

3.1.3 Parameter estimation

In estimating the PSTR model, the effects of cross-sectional units are removed by removing individual averages, then the PSTR model is estimated using the nonlinear least squares (NLS) method, which is equivalent to the maximum likelihood (ML) estimator, while removing the effects The constant in the linear tabular data model is the standard transformation, this operation requires more precision in the PSTR model. (Geng, 2011).

3.2. Model and data

A model for examining the effect of information and communication technology on the relationship between information asymmetry and financial development in LCDs countries, using a panel smooth transition regression model (PSTR) from 2000 to 2021 is specified as follows:

(8)

$$FD_{it} = \mu_i + \beta_1 PCR_{it} + \beta_2 PCB_{it} + \beta_3 OPEN_{it} + \beta_4 GDP_{it} + \left(\beta_1' PCR_{it} + \beta_2' PCB_{it} + \beta_3' OPEN_{it} + + \beta_4' GDP_{it}\right) * F\left(ICT_{it}; \gamma, C\right) + u_{it}$$

Where, i represents the country under study and t represents the time; FDit is the financial development includes all financial dimensions identified, namely: depth (size and liquidity), access (ability of individuals and companies to access financial services), and efficiency (ability of institutions to provide financial services at low cost and with sustainable revenues and the level of activity of capital markets) (IMF Database); PCR_{it}: Public credit registry in country i at the time t and PCB_{it}: private credit bureau in country i at the time t. In accordance with Triki and Gajigo (2014) and Asongu et al. (2016), Public credit registries (PCRs) and private credit bureaus (PCBs) use as proxies for reducing information asymmetry; ICTit, Denotes the Transition variable information and communication technology. Consistent with the motivation of the inquiry and consider to growth potential of internet and mobile penetrations in selected countries, in this research ICT is measured with Combined index of Internet penetration and mobile phone

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

penetration Asongu and Moulin (2016), Tchamyou and Asongu (2017) and Penard et al. (2012); OPENit is the trade Openness)total export and import of goods and services as a share of GDP), Do and Levchenko (2004), Huang and Temple (2005) and Thuy and Trong (2021) are supportive of the positive influence of trade openness on levels of financial development. Kim et al (2010) find that trade openness is positively correlated with financial development in the long-run but there is a negative relationship in the short-run. On the other hand, Gries et al. (2009) indicate that the connection between trade openness and financial development are not very strong in sample of 16 Sub-Saharan African countries; GDPit, Saint Paul (1992), Greenwood and Jovanovic (1990), Levine (1997) and Asongu (2015) show that there is a positive relationship between GDP growth and financial development.

It should be noted that $F(ICT_{it};\gamma,C)$ is the transfer function of the smooth panel transfer model with ICT as the threshold variable.

The study investigates a panel of 33 selected least developed countries (LDCs) for the period 2000–2021, with data from the World Bank (WB), the International Monetary Fund (IMF), the International Telecommunication Union (ITU) and United Nations (UN).

3.2.2 Descriptive Statistic Analysis

Descriptive statistics are presented to reveal the main characteristics of data used in this study. For each variable, we display mean, median, standard deviation, minimum and maximum values. Table 1 below summarizes variable descriptive statistics of the model.

Table 1. Descriptive statistics

Variable	Mean	Median	Maximum	Minimum	Standard deviation
FD	0.101570	0.097494	0.284391	.0260242	0.039895
ICT	346.4353	1844177	2.04E+08	230	27352450
PCR	1.303929	0.200000	21.06444	1.963736	2.728530
PCB	7.099174	0.100000	83	1	15.7214
OPEN	64.04936	56.63538	232.0942	3.892657	33.03387
GDP	0.82E+10	.90E+09	4.16E+11	63101272	78E+10

Reference: Research findings

The average value of ICT is equal to 346.4353 with a maximum value of 2.04E+08 and a minimum value of 230.

4. EMPIRICAL RESULTS

4.1. Stationary tests

Before estimating the panel data model, it is necessary to perform the variables unit root test. However, before performing the panel data unit root test, the cross-sectional dependence test must be performed to select the appropriate unit root test. There are several tests such as augmented Dicky-Fuller (ADF), Levine, Lin, and Chu (LIC), augmented Dickey-Fuller Fisher (ADFF), Philips-Perron-Fisher (FPF), Pesaran's unit root tests for evaluating the stationarity of variables in panel data. selecting the appropriate unit root test requires investigating the existence of cross-

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

sectional dependence (Baltagi et al. 2005). The Pesaran's cross-sectional dependence test (Pesaran, 2015) which is a completed version of (Pesaran, 2003), has been used to investigate the cross-sectional dependence. If the cross-sectional dependence of the panel data is confirmed, the use of conventional panel data unit root methods such as LIC and IPS tests will increase the probability of false unit root results. To fix this issue, several panel data unit root tests have been proposed taking the cross-sectional dependence into account, including cross-sectional augmented IPS (CIPS) (Rezagholizadeh and Abdi, 2022). The results of the CIPS test to choosing appropriate panel unit root are listed in Table 2.

Table 2. results of CIPS test.

Variable	CD statistic	Number of observations	P-VALUE
FD	3.70848	726	0.0000**
ICT	5.88768	726	0.0000**
PCR	7.03876	726	0.0000**
PCB	4.97958	726	0.0000**
OPEN	6.435143	726	0.0000**
GDP	7.20077	726	0.0000**

Reference: Research findings. The prob values * and ** show statistical significance at 5 and 10% levels, respectively.

As shown in the Table 2, the null hypothesis indicating no cross-sectional dependence is rejected for all the variables. Since the cross-sectional dependence was confirmed for the variables, the stationarity evaluation of these variables is performed through the unit root test presented by (Pesaran, 2003) in which the cross-sectional dependence is taken into consideration.

Table 3 presents the unit root test for all variables. It can be observed that all variables are stationary in level.

Table3. results of IPS test.

Variable	Degree of Stationarity	P-VALUE	Test statistic
FD	-6.130	0.0000**	I(0)
ICT	-23.86	0.0000**	I(0)
PCR	-3.674	0.0001**	I(0)
PCB	-2.924	0.0017**	I(0)
OPEN	-5.662	0.0000*	I(0)
GDP	-10.460	0.0000**	I(0)

Reference: Research finding. The prob values * and ** show statistical significance at 5 and 10% levels, respectively.

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

4.2. Results of the Linearity Tests

As mentioned above, the existence of nonlinearity is the premise of conducting PSTR analysis. Table 4 lists the outcomes of the linearity test. The LM, LMF and LRT tests' results indicate that the linear null hypothesis is rejected at the 1% level of significance, indicating that the relationship between information asymmetry and financial development is following a non-linear model and the influence is not constant because of the transition effect of ICT. As a result, the alternative hypothesis that there is at least one transition function is not rejected. Hence, it may be inferred that using linear models to analyze the relationship between information asymmetry and financial development is inappropriate. Appropriately, the relationship between the two variables should be further analyzed using the PSTR model.

Table 4. Linearity test

Transition variables: ICT	Hypothesis	LM Statistics	LM_F Statistics	LRT Statistic
m=1		50.541 *** (0.000)	12.898*** (0.000)	52.453*** (0.000)
m=2		-131.507*** (0.000)	-13.036*** (0.000)	-120.539*** (0.000)

Notes: *** denote Significant at 1%

4.3. Results of the Remaining Nonlinearity Tests

Considering that the linearity hypothesis is rejected, the remaining nonlinearity test must be conducted to confirm the quantity of transition functions (Nan et al., 2022b).

In accordance with Gonzalez et al. (2017) and Colletaz and Hurlin (2006), the null hypothesis of the existence of a PSTR pattern with one transfer function was compared against the hypothesis of the existence of a PSTR pattern with at least two transfer functions for this purpose.

The outcomes of the remaining nonlinearity tests are displayed in Table 5.

Table 5. the remaining nonlinearity tests

Transition variables: ICT	Hypothesis	LM Statistics	LM_F Statistics	LRT Statistic
m=1	$H_0: r = 0 \; vs \; H_1: r \geq 1$	31.108 (1.000)	7.616 (1.000)	31.818 (1.000)
m=2	$H_0: r = 0 \; vs \; H_1: r \geq 1$	-213.333 (1.000)	-19.024 (1.000)	-186.279 (1.000)

The results indicate that the null hypothesis regarding the sufficiency of including a transfer

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

function (H0: r = 1) has not been rejected in either the case of one threshold limit (m=1) or two threshold limits (m=2). As a transfer function can specify the nonlinear behavior of the model, the PSTR model with a transfer function (r=1) is used.

4.4. Determination of the number of location parameters

Table 6. Determination of the numbers of location parameters.

Number of location parametrs	AIC	BIC
m=1	-8.431	-8.368
m=2	-8.427	-8.357

4.5. PSTR model estimation

To examine how information asymmetry influences financial development and determine whether the influence varies according to the ICT, we use the PSTR model estimated by non-linear least squares techniques to carry out this study.

A two-regim model is estimated after identifying the number of transfer functions and the optimal threshold limit. Table 7 displays the estimation outcomes for this model.

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

Table 7. PSTR model estimation results.

Variables	Cofficients	T-Statistic
The linear Part		
PCR	-0.0007*** (0.0003)	-2.6327
OPEN	-0.0119*** (0.0052)	-2.2699
GDP	0.0297*** (0.0033)	9.0713
PCB	0.0011*** (0.0002)	6.1781
The nonlinear Part		
PCR	0.0038*** (0.0009)	4.2949
OPEN	-0.0206*** (0.0073)	-2.8238
GDP	0/0042*** (0.0014)	3/0032
PCB	0/0003*** (0.0001)	3/0002
Slope parameter γ	0.1997	
Location paramete c	6.288e+06	
AIC	-8.431	
BIC	-8.368	
RSS	0.152	

Notes: The values in parentheses are standard errors. (***), (**), (*) denote significance at 1%, 5% and 10%, respectively

The location parameter (c) is identified to 6.288e+06, which indicates that when *ICT* < 6.288e+06, the model is in the low regime and the model is specified as follows:

$$FD_{it} = \mu - 0.0007PCR_{it} + 0.0011PCB_{it} - 0.0119OPEN_{it} + 0.0297GDP_{it} \quad (9)$$

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

while when ICT > 6.288e+06, the model is in the high regime And the model is as follows:

(10)

$$FD_{it} = \mu + 0.0031PCR_{it} + 0.0014PCB_{it} - 0.0325OPEN_{it} + 0.0339GDP_{it}$$

the estimated coefficients of the PSTR model cannot be interpreted as the traditional linear model because of the nonlinear transition function in the model, and the estimated sign is important than the estimated values (Gonzalez, et.al, 2017).

It is intriguing to note that the PCR and PCB coefficients are significant both in the linear and nonlinear components of the PSTR model, showing that the relationship between information asymmetry and financial development is nonlinear and is suitable to be characterized by the transition variable ICT. when ICT is below the threshold value, that is in the low regime, PCR has a negative impact on financial development. In contrast, when the ICT outstrips the threshold, that is in the high regime, the coefficient (defined as the sum of β_1 and β_1') is spositive: 0.0031. It means that the negative effect of PCR on financial development is offset and even changed into positive as ICT increases.

On the other hand, PCB has a positive impact on financial development in both low and high ICT regime. With the transfer from the ICT threshold (in the second regime), the favorable impact of PCB on reducing information asymmetry in the direction of financial development grows.

The hidden implication is that PCR and PCB (with decreasing in information asymmetry) promote the financial development, when ICT is in a high level (ICT > 6.288e+06). In other words, ICT could complement the characteristics of PCR and PCB to reduce information asymmetry and increase financial development.

All of the above illustrates that the influence of information asymmetry on financial development is nonlinear and varies with the magnitude of ICT. The above findings confirm the hypothesis of this research that there is a regime-switching impact in the information asymmetry and financial development nexus that depends on the threshold level of ICT. The possible explanation is that once ICT surpasses the threshold, the magnitude of ICT has the potential to reduce information asymmetry by improvement in Information sharing institutions (PCR and PCB) and enhance financial development. Therefore, Information sharing institutions (PCR and PCB) exert a promoting effect on financial development in the high ICT regime.

Based on the results, the GDP has a positive effect on financial development in both regimes, with this effect growing in the second regime. In contrast, the results indicate that trade openness has a negative effect on the financial development in both high and low regime.

The slope parameter (γ) is very small and equals to 0.1997 which shows that the influence information asymmetry exerting on financial development switches from the low regime to the high regime with the improving of ICT is not sudden but rather smooth.

5. CONCLUSION AND POLICY IMPLICATIONS

In this study, using ICT as the transition variable, our research uses the PSTR model to examine the influences of information asymmetry on financial development in 33 least developed countries (LDCs) between 2000 and 2021. The following are the main empirical conclusions:

- Financial development is in keeping with a nonlinear PSTR model with ICT as a transition variable exerting an influence on the information asymmetry–financial development nexus. To limit the error brought on by omitted variables, a set of control variables is included in our research, including GDP and trade openness.

- The empirical results indicate that ICT influences information asymmetry and financial development nexus, and this impact has dynamic characteristics of threshold and gradual

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

changes.

- The result validates our hypothesis in which we assume the threshold value of ICT (6.288e+06) drives a regime switching effect of information asymmetry on financial development.

- ICT will decrease information asymmetry through the establishment and expansion of information sharing offices (PCR and PCB), which will enhance the financial development. It can be said that the expansion of information and communication technology is one of the main ways to increase information sharing in order to reduce information asymmetry and develop the financial sector. To summarize, the use of ICT by information sharing offices has the potential to reduce information asymmetry to enhance financial development.

Furthermore, it is important to compare the results above with similar studies. For instance, Asongu and Moulin (2016) and Asongu and Nnanna (2018) argue that the use of ICT by information sharing offices (PCR or PCB) has the potential to reduce information asymmetry to enhance financial development. Their results showed that the marginal effects from interactions between ICT and PCR are positive, while the marginal effects from the interactions between ICT and PCB are negative. Galindo and Miller (2001) established that countries with credit registries are less restrictions to financial access. Also Triki and Gajigo (2014) show that access to finance is on average higher in countries with private credit bureaus (PCBs), relative to countries with neither PCB and PCR. In contrast, Asongu et. al (2016) have found that PCRs and PCBs have negative effects on financial depth and financial activity and have a positive effect on financial size.

The obtained results indicate that trade openness in the analyzed countries has a negative effect on financial development in both high and low regime. Gries et al. (2009) consider the connection between trade openness and financial development with a sample of 16 Sub-Saharan African countries and indicate that this relationship is not very strong. Our finding is with results differ significantly from Thuy and Trong (2021), despite that trade openness may strengthen financial depth in some countries.

Consistent with the findings of Saint Paul (1992), Greenwood and Jovanovic (1990), Levine (1997) the findings indicate that the impact of GDP on financial development is positive. After exceeding the threshold level of ICT and entering the second regime, the intensity of the positive effect of GDP on financial development increases.

In consideration of the relevant conclusions obtained above, the following policy recommendations are proposed:

PCR and PCB mitigate information asymmetry with the help of ICT need to be improved in order to discipline borrowers more effectively. A fundamental implication of this study is that, the complementarity of ISO and ICT needs to be encouraged and consolidated in order to enhance financial sector. It is suggested that information sharing offices are most likely to use various ICT mechanisms to communicate with borrowers and their lenders in an effort to reduce moral hazard.

REFERENCES

Aboody, D., & Lev, B. (2000). Information asymmetry, R&D, and insider gains. *The journal of Finance*, *55*(6), 2747-2766.

Akerlof, G. A. (1970). Quality uncertainty and the. *The quarterly journal of economics*, *84*(3), 488-500.

Akerlof, G., Spence, M., & Stiglitz, J. (2001). Information asymmetry at the heart of the new microeconomics.. *Problemes economiques*, 19-24.

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

Allen, F., Otchere, I., & Senbet, L. W. (2011), African financial systems: a review, *Review of Development Finance*, 1(2), pp. 79-113.

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

Asongu, S. A., & Moulin, B. (2016). The role of ICT in reducing information asymmetry for financial access. Research in International Business and Finance, 38, 202-213.

Asongu, S. A., Nwachukwu, J. C., & Tchamyou, V. S. (2016). Information asymmetry and financial development dynamics in Africa. *Review of Development Finance*, *6*(2), 126-138.

Asongu, S., & Nnanna, J. (2018). ICT in reducing information asymmetry for financial sector competition. *DBN Journal of Economics and Sustainable Growth (Forthcoming), AGDI Working Paper No. WP/18/035*.

Asongu, S., Le Roux, S., Nwachukwu, J., & Pyke, C. (2019). Reducing Information Asymmetry with ICT: A critical review of loan price and quantity effects in Africa. *International Journal of Managerial Finance*. Vol. 15 No. 2, 130-163. https://doi.org/10.1108/IJMF-01-2018-0027

Bacon, D. W., & Watts, D. G. (1971). Estimating the Transition between Two Intersecting Straight Lines. *Biometrika*, *58*(3), 525–534. https://doi.org/10.2307/2334387

Baltagi, B. H., Bratberg, E., & Holmås, T. H. (2005). A panel data study of physicians' labor supply: the case of Norway. *Health Economics*, *14*(10), 1035-1045.

Baltagi, B. H., and Q. Li (1995). Testing AR (1) against MA (1) disturbances in an error component model. *Journal of Econometrics*, Volume 68, Issue 1, 133–151.

Batuo, E., & Kupukile, M. (2010). How can economic and political liberalisation improve financial development in African countries? *Journal of Financial Economic Policy*, 2(May), 35-59. 10.1108/17576381080001419

Bayram, Ö. G., & Demirtel, H. (2014). Effect of ICT on information sharing in enterprises: The case of Ministry of Development. *Volume One*, 94.

Colletaz, G. and Hurlin, C. (2006). Threshold Effects of the Public Capital Productivity: An International Panel Smooth Transition Approach. Working Paper, 1/2006, LEO, Université d'Orléans.

Diamond, D. W. (1984). Financial intermediation and delegated monitoring. *The review of economic studies*, 51(3), 393-414.

Diamond, D. W., & Dybvig, P. H. (1983). Bank runs, deposit insurance, and liquidity. *Journal of political economy*, *91*(3), 401-419.

Do, Q. T., & Levchenko, A. A. (2004). Trade and financial development. *Available at SSRN 610391*.

Domowitz, I. (2002). Liquidity, transaction costs, and reintermediation in electronic markets. *Journal of Financial Services Research*, 22(1–2), 141–157.

Eitrheim, Ø., & Teräsvirta, T. (1996). Testing the adequacy of smooth transition autoregressive models. *Journal of Econometrics*, *74*(1), 59-75.

Fok, D., van Dijk, D. & Franses, P. (2005). A Multi-Level Panel STAR Model for US Manufacturing Sectors, *Journal of Applied Econometrics*20(6), 811-827

Fouquau, J., Hurlin, C., & Rabaud, I. (2008). The Feldstein–Horioka puzzle: A panel smooth transition regression approach. *Economic Modelling*, *25*(2), 284-299.

Galindo, A., & Miller, M. (2001). Can credit registries reduce credit constraints? Empirical evidence on the role of credit registries in firm investment decisions. In *Annual Meetings of the Inter-American Development Bank, Santiago Chile*.

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

Geng, N. (2011). The dynamics of market structure and firm-level adjustment to India's pro-market economic liberalizing reforms, 1988–2006: A Time Varying Panel Smooth Transition Regression (TV-PSTR) approach. *International Review of Economics & Finance*, *20*(4), 506-519.

Gonzalez, A. Terasvirta, T. & van Dijk, D. , & Yang, Y. (2017). Panel smooth transition regression model. SSE/EFI Working Paper Series in Economics and Finance 604, Stockholm School of Economics.

Greenwood, J., & Jovanovic, B. (1990). Financial development, growth, and the distribution of income. *Journal of Political Economy*, *98*(5 Part 1), 1076-1107.

Gries, T., Kraft, M., & Meierrieks, D. (2009). Linkages between financial deepening, trade openness, and economic development: Causality evidence from Sub-Saharan Africa. *World Development*, 37(12), 1849–1860.

Hansen, B. E. (1999). Threshold effects in non-dynamic panels: Estimation, testing, and inference. *Journal of econometrics*, *93*(2), 345-368.

Huang, Y., & Temple, J. R. (2005). Does external trade promote financial development? Bristol Economics Discussion Papers 05/575, School of Economics, University of Bristol, UK.

Ibrahim, M., & Alagidede, P. (2017). Financial Development, Growth Volatility and Information Asymmetry in Sub-Saharan Africa: Does Law Matter? *South African Journal of Economics*, *85*(4), 570-588.

International Telecommunication Union (ITU). Measuring the Information Society Report. (2017). Volume 1,

Jappelli, T., & Pagano, M. (2002). Information sharing, lending and defaults: Cross-country evidence. *Journal of Banking & Finance*, *26*(10), 2017-2045.

Jiang, L., & Kim, J. B. (2004). Foreign equity ownership and information asymmetry: Evidence from Japan. *Journal of International Financial Management & Accounting*, *15*(3), 185-211.

Jude, E. C. (2010). Financial development and growth: A panel smooth regression approach. *Journal of Economic Development*, *35*(1), 15.

Kim, D. H., Lin, S. C., & Suen, Y. B. (2010). Dynamic effects of trade openness on financial development. *Economic Modelling*, *27*(1), 254-261.

Leitão, N. C. (2012). Bank credit and economic growth: A dynamic panel data analysis. *Economic Research Guardian*, 256-267.

Levine, R. (1997). Financial development and economic growth: views and agenda. *Journal of Economic Literature*, 35(2), 688-726.

Levine, R. (2005). Finance and growth: theory and evidence. Handbook of economic growth, 1, 865-934.

Love, I., & Mylenko, N. (2003). *Credit reporting and financing constraints* (No. 3142). World Bank Publications.

Luukkonen, R., Saikkonen, P., & Teräsvirta, T. (1988). Testing linearity in univariate time series models. *Scandinavian Journal of Statistics*, Vol. 15, No. 3, pp. 161-175

Mylenko, N. (2008). Developing credit reporting in Africa: opportunities and challenges. In African Finance for the 21st Century, High Level Seminar Organized by the IMF Institute in collaboration with the Joint Africa Institute, Tunis, Tunisia.

Nan, S., Huang, J., Wu, J., & Li, C. (2022a). Does globalization change the renewable energy consumption and CO2 emissions nexus for OECD countries? New evidence based on the nonlinear PSTR model. *Energy Strategy Reviews*, *44*, 100995.

N. 38, 2024 - ISSN: 1886-516X - DOI: 10.46661/revmetodoscuanteconempresa.6999-[Págs. 1-21]

Nan, S., Wang, Z., Wang, J., & Wu, J. (2022b). Investigating the Role of Green Innovation in Economic Growth and Carbon Emissions Nexus for China: New Evidence Based on the PSTR Model. *Sustainability*, *14*(24), 16369.

Pénard, T., Poussing, N., Zomo Yebe, G., & Ella, N. (2012). Comparing the determinants of internet and cell phone use in Africa: evidence from Gabon. *Communications & Strategies*, (86), 65-83.

Pesaran, M. H. (2003). Estimation and inference in large heterogenous panels with cross section dependence. *Available at SSRN 385123*.

Pesaran, M. H. (2015). Testing weak cross-sectional dependence in large panels. *Econometric reviews*, *34*(6-10), 1089-1117.

Purcell, F., & Toland, J. (2003). E-Finance for Development: Global Trends, National Experience and SMEs. The Electronic Journal of Information Systems in Developing Countries, 11(1), 1-4.

Rezagholizadeh, M., & Abdi, Y. (2022). Financial development and development of renewable energy technologies: A comparison of developing and developed countries. *ECONOMICS AND POLICY OF ENERGY AND THE ENVIRONMENT*, FrancoAngeli Editore, vol. (1), pages 95-118.

Saint-Paul, G. (1992). Fiscal policy in an endogenous growth model. The Quarterly Journal of Economics, 107(4), 1243-1259.

Tchamyou, V. S., & Asongu, S. A. (2017). Information sharing and financial sector development in Africa. *Journal of African Business*, *18*(1), 24-49.

Seleteng, M., Bittencourt, M., and Van Eyden, R. (2013). Non- Linearities in inflation- growth nexus in the SADC region: A panel smooth transition regression approach. *Economic Modelling*, 30, 149-156.

Teräsvirta, T. (1996). Modelling economic relationships with smooth transition regressions (No. 131). Stockholm School of Economics.

Thuy, D. P., Nguyen Trong, H. (2021). Impacts of openness on financial development in developing countries: Using a Bayesian model averaging approach. *Cogent Economics & Finance*, *9*(1), 1937848.

Triki, T., & Gajigo, O. (2014). Credit bureaus and registries and access to finance: new evidence from 42 African countries. Journal of African Development, 16(2), 73-101.

United Nations. Least Developed Countries (LDCs). (2022).