ICT technologies and financial innovations: the case of Exchange Traded Funds in Brazil, Japan, Mexico, South Korea and the United States

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Abstract:

Exchange traded funds (ETFs), funds structured in order to mimic the performance of selected financial assets, are one of the most significant innovative financial instruments recently introduced. They have gained considerable popularity among investors due to their advantages in comparison with conventional mutual funds, investment vehicles with a significantly longer history. This paper contributes by providing extensive knowledge about the empirical links between information and communications technology (ICT) penetration and the introduction of financial innovations in emerging economies. We examine the impact of increasing ICT penetration on the assets of exchange traded funds in Brazil, Mexico, Japan and South Korea and the United States. Our methodological framework includes descriptive statistics, logistic growth models applied to estimate ETF market development patterns, and panel data analysis used to test the hypothesized relationship between increasing ICT penetration and ETF market development. Our empirical findings collectively indicate that in all countries the growth of ICT has been pervasive and accompanied by a rapid development of ETF markets. Furthermore, the relationship between increasing ICT penetration and ETF market development is found to be strong, positive and statistically significant in Japan, Mexico, the United States and South Korea; while in Brazil the analogous relationship is relatively weak, although still positive.

JEL Classification: *G11, G23, O16, O33, O57*

Keywords: *emerging markets, ICT, ETFs, financial innovations.*

1. Introduction

In most emerging economies, a historically unprecedented, in terms of speed and geographical coverage, growth in information and communication technologies (ICT, see International Telecommunication Union ICT Statistics, 2013) is playing an undeniable role in accelerating economic development. One of the main advantages of the rapid expansion of ICT in emerging economies is a dynamic development of financial systems, which fosters foreign capital inflows, encourages new investors, and provides domestic participants with an opportunity to invest abroad. In this context, research relating the level of adoption of new information and communication technologies and financial development (we define financial development as growth in the size of all segments of the financial system such as banking sector and capital market, including stock market) constitutes a good base for further analysis of the benefits of the introduction of ICT in emerging economies.

This novel study is intended to contribute to the present state of the art by providing the extensive evidence on relationships between ICT penetration versus financial development with special emphasis put on the development of exchange traded funds – ETFs. To the best of our knowledge this is the first study of in which the authors target to challenge the examination of the relationships mentioned above, and one of the first where the most important contemporary issues related to development of financial innovations are considered.

First, the contribution of this analysis is to evaluate the development pattern of exchange traded funds (ETFs) in developing countries, and to empirically verify the hypothesis of a quantitative link between ICT deployment and ETF market development in a particular country (analyzed as absolute growth in value of assets of ETFs and as growth in share of ETFs in assets of a similar investment options[1]). Following this approach, we focus on emerging markets to unveil their development paths with respect to information and communication technologies and financial markets. Second, the contribution to the present state of knowledge consists in providing a deep insight into the empirical links between increasing ICT penetration and financial development (with emphasis on the development of exchange traded funds). We hypothesize that increasing ICT penetration positively impacted ETF markets development across countries in scope over 2002-2012. To verify the hypothesis empirically, we select two advanced (Kvint, 2009) emerging economies, Brazil and Mexico, and a highly developed country, namely the United States, which we treat as a benchmark in terms of ICT penetration and financial development. Apart from their similar levels of economic development (in terms of GDP per capita; see World Bank, 2013), other reasons for selecting Brazil and Mexico are their institutional and cultural similarities (both countries are in the Latin America region) and, to a lesser extent, a similarity of their financial systems (for example, strong links with the United States). While the two countries share certain features, they differ significantly in terms of ETF market development. Nevertheless, the ETF markets in these countries are among the largest in the emerging economies (in most such countries there are not listed ETFs, or their assets are very low). Selecting countries with a number of aspects in common enables us to focus on the impact of a selected factor influencing the ETF market, for instance, ICT, and allows for deep analysis of country-specific trends. To shed light on the nature of the relationship examined we include in the sample two more countries with large ETF markets, one emerging and one highly developed, for example, South Korea and Japan.

[1] For details – see Section 2.

The the paper comprises six logically structured sections. The first section is the introduction. Section two provides conceptual framework and extended background of the study. Henceforth, it demonstrates ETFs as a case of financial innovation, explains the relationship between ICT and financial markets, and it formulates the explicit hypothesis that increasing ICTs penetration positively impacted ETF markets development across analyzed countries over 2002-2012. Section two of the paper is followed by a third section specifying the data sources and methodological procedures. Sections four and five are entirely empirical. Section four presents preliminary evidence on ETF market development and changes in ICTs penetration in analyzed countries over 2002-2012. These two elements – ETFs and ICT – are analyzed separately. Additionally, in section four, we use logistic growth model to approximate ETF market development patterns and demonstrate their prospected future development. Section five exhibits panel regression results, which explicitly address the hypothesis that increasing ICTs penetration positively impacted ETF market development across analyzed countries over 2002-2012. In this section, we also deliberately disaggregate the evidence and present country-specific (for Brazil, Japan, Mexico, South Korea, and the United States) estimations. Finally, the last section six contains the main findings and discussion.

2. Exchange traded funds and new technologies. Conceptual framework.

2.1. Exchange traded funds – a case of financial innovation.

Over the past few decades, the group of financial innovations has grown rapidly. It includes new or modified financial products and services, financial market technologies and institutions transforming the global financial system (Allen, 2012). One example of such financial innovations is exchange traded funds. ETFs first became available in Canada in 1989 (on the Toronto Stock Exchange), four years later they were launched in the United States, in Asia in 1999, and finally in Europe in 2001 (Deville, 2008). Despite their short history, ETFs are currently one of the most popular instruments among financial professionals (it should be noted that due to the features of ETFs they are also regarded as a category of financial companies instead of instruments; ICI, 2013). In their basic form, ETFs are financial instruments with prices closely replicating (tracking) the performance of selected financial assets (usually tracking the returns of financial market indexes) (Hehn, 2005). The structure of the first ETFs was simple as they were based solely on stocks or other securities. Such ETFs remain the most popular and are called 'physical'. However, in the 2000s the rising status of less liquid markets and the increased sophistication of the instruments offered on global financial markets led to the development of new types of ETFs with complex structures ('synthetic' ETFs) based on derivatives (Awrey, 2013). Due to regulatory concerns and the lack of sufficiently developed derivatives markets, synthetic ETFs are seldom used in emerging economies (apart from the most developed ones, such as South Korea).

Physical ETFs are the oldest and least complex type. The key roles in the creation and trading of physical ETFs are played by financial institutions that act as ETFs sponsors and authorized participants (market-makers); other categories of market participants are secondary market investors and stock exchanges (Deville, 2008). The authorized participants are responsible for purchasing shares of the companies included in the market index and delivering them to the sponsor (the fund's trustee). In exchange for these baskets of securities, the authorized participants receive creation units (ETF shares) (Ramaswamy, 2011). The creation units received by the authorized participants may then be sold to institutional investors or retail market

participants, who can conduct transactions in ETF shares through stock exchanges without the intermediation of authorized participants (Aggarwal, 2012).

In our study we refer to two categories of investment companies (defined in ICI, 2013):

- mutual funds;
- exchange traded funds (ETFs).

We label together the investment companies in these two categories as 'investment funds' (IF). This choice is made in order to analyze the changing market shares of the two investment options. In the preliminary analysis, due to data availability issues, we also use a wider category of investment products: exchange traded products, ETPs, securities that may be traded on one or more exchanges. These include, in addition to ETFs, other similar, more recently introduced, instruments such as exchange traded notes (ETNs) and exchange traded commodities (ETCs) (BlackRock, 2012b). However, in the second part of our analysis we focus exclusively on the ETF market. The concept of mutual fund used in this research is based on the definition of the Investment Company Institute (ICI), according to which it is a type of investment company that buys a portfolio of securities and manages them according to a specified financial goal, ready to buy back its shares at a price calculated by the investment company (ICI, 2013). ETFs are usually regarded as a substitute for mutual funds, particularly index funds, mutual funds with investment aims identical to ETFs (tracking the returns of selected indexes) (Agapova, 2011).

Even though ETFs share several common features with mutual funds, there are notable differences, as outlined in Table 1. The main advantages of ETFs are lower costs (IMF, 2011) and reduced tracking errors (Athma and Raj Kumar, 2011). Their low level of tracking errors is a result of arbitrage transactions that ensure that the market value of the underlying securities and ETF shares remain at similar levels (Aggarwal, 2012). In the case of intensive market activity, some departures are possible but they should be limited by the actions of the market participants. Due to the fact that ETFs are listed and traded on stock exchanges, they offer other relative benefits, which include greater liquidity and more efficient pricing mechanisms (see Table 1); they can also be more conveniently used to offset the exposure of other investments (to hedge) (Ramaswamy, 2011). Moreover, because of differences in the redemption method, ETFs are considered to be more tax efficient than mutual funds (Agapova, 2011).

[Table 1 about here]

Various groups of investors, both institutional and retail, use ETFs. A second category can use them to gain access to otherwise unavailable asset classes (due to, for example, high minimum investment requirements) (Diaz-Rainey and Ibikunle, 2012). The advantages of ETFs outlined attract the attention of a significant number of investors and are the main reasons for the growing underlying demand for them.

The supply-side factors determining the development of the ETF market are linked to a variety of relatively recent developments in the financial sector (initially in advanced economies) influencing the rate of financial innovation (Frame and White, 2004). These include the introduction of new or modified financial instruments, changes in macroeconomic conditions, taxes or regulatory environments, and the adoption of new technologies (with ICT among the most crucial; the financial sector

is sometimes described as the major user of new technologies; Gani and Ngassam, 2003). This last group is particularly important in the context of this research.

The global ETF market can be divided into two broad categories based on the development level of the countries in which the assets underlying the creation of the ETFs are listed. These two groups are developed country ETFs and emerging market ETFs. Currently, the largest subcategory of emerging market ETFs are funds listed and traded exclusively or primarily on stock exchanges in highly developed countries, tracking the returns on foreign assets. However, the second subcategory, ETFs listed on exchanges in emerging countries, is a rapidly growing class of ETFs, yet one still relatively neglected in research.

In contrast with ETFs with emerging market exposure listed on North American or European exchanges, ETFs listed on local stock exchanges are available as index tracking tools for a wide group of local entities, even for investors with limited funds. Moreover, relatively high liquidity (see Table 1) should also be perceived as one of the key ETF market development factors, as the insufficient liquidity of various financial assets in emerging economies is among the key investment barriers for both foreign and domestic entities (Bekaert et al., 2007). ETF market development in emerging countries has also been spurred by the activity of global financial groups (with BlackRock being the world leader, offering iShare ETFs; BlackRock, 2012a), which manage most such products and offer them to various clients (including ones from developed countries wishing to invest in markets with higher growth potential). The introduction and increased popularity of ETFs listed on emerging stock markets managed by global investment companies is a consequence of the increased sophistication of financial markets, caused by the liberalization of capital flows and changes in the legal environment. Yet another factor increasing demand for ETFs is the introduction of ETFs with exposure to advanced markets, thus allowing local investors to gain easier indirect access to foreign investments.

Most emerging market ETFs offer investors returns on assets listed in countries which attract the greatest attention of global investors - BRIC or other countries with strong economic ties with developed economies and limited foreign investment restrictions (as a result, financial innovations introduced in developed economies are adopted relatively quickly and on a large scale in these economies). An example of a country from the latter category is Mexico, whose economy, including its financial markets, is influenced by the US economy to a large extent, and its ETF market, as described later, is relatively developed.

The total value (assets under management, AUM) of the global ETP market amounts (all data unless noted otherwise refer to the end of September 2012) to $1.85 trillion and the largest group of ETPs is ETFs (89% of the total AUM); the number of ETPs listed worldwide is 4748 (3297 ETFs and 1451 other products) (Blackrock, 2012a). Compared with the 2002 figure of $145.7 billion global ETP assets, this means a twelvefold increase and compound annual growth rate of ca. 30%. The ETP market is highly concentrated: the ten largest products account for 25% of it, and ten providers (ETP sponsors) account for 84% of the total AUM. This high level of concentration of the ETF market with regard to the number of providers is, among other things, a consequence of the high level of ICT infrastructure requirements: modern technologically advanced systems are necessary to create and manage ETFs. Two leading ETF providers, BlackRock and State Street Corporation, managing almost 57% of the global ETF AUM, spent over $1 billion on technology and communications in 2012; both companies invest considerable funds in ICT, which is regarded as one of the key elements of their strategies (BlackRock, 2014; State Street Corporation, 2013). The most important categories in terms of AUM in 2012 were ETFs offering exposure to: equity (69.9% of

the total); fixed income (17.4%); and commodities (11.2%). ETPs with exposure to emerging market equity accounted for 12.6% of the total AUM ($230.6 billion; there were 681 such products) and were the third largest group (after North American equity, Canadian and US, and fixed income). It should be noted, however, that most of the ETPs with such exposure are listed on stock exchanges in developed countries. Among the ETPs with single emerging equity market exposure, most assets were gathered by funds tracking returns on securities traded in the following countries: China ($40.9 billion), Brazil ($13.2 billion, mostly listed in the United States), South Korea ($11.2 billion), Mexico ($8.8 billion) and India ($5.1 billion).

2.2. ICT for financial markets – tracing hypothetical links.

It is claimed that ICT constitute an important factor contributing to strengthening of financial systems and financial development (see, for example, Wurgler, 2000; Yartey, 2008). As argued by some authors, (Stigler, 1961; Morck et al., 2000) financial markets may be regarded as 'information markets'; henceforth, ICT reshape their functioning, as they enable information and data dissemination, eradicating market failures like, inter alia, time delays or information asymmetries. ICT enhance flows of information, which in turn is a prerequisite for decentralized financial markets to work efficiently, as geographically separated actors are offered to benefit from new opportunities, for instance, purchase of assets not available in their original location. Regarding the previous, access to high-speed Internet (broadband network) yields special attention, as communications systems based on wide bandwidth posses significant information-carrying capacity, allowing for increases of financial market activities (like, for instance, trading).

Despite the above-mentioned advantages of ICT for the development of financial systems, there are also noticeable problems. Singh (1997) claims that growing cohesion and integration of financial markets brings identifiable threats and risks for those that join the system; while Ilyina and Samaniego (2011) emphasize that financial markets become more volatile and sensitive, which affects the profitability of transactions and, on a larger scale, the system stability. Perez (2002) and Pozzi et al. (2013) highlight that growing discrepancies in ICT penetration in various locations bring the risk of growing financial exclusion and the widening of gaps between those who have direct access to information flows and those who are excluded from such opportunities. As claimed by Binswanger (1999) and Singh (1997), due to fast information flows, the prices of financial assets change rapidly which may induce growing interest in short-term, instead of long-term, investments, with negative consequences for countries' development opportunities.

Summarizing these considerations on the hypothetical links between increasing ICT penetration and financial development, it may be argued that the impact of ICTs may be seen as dual. On the one hand, ICTs bring opportunities for dynamic financial development, which is enabled by the eradication of information asymmetries and free flows of data, but, on the other hand, amplified price and volume fluctuations, greater exposure to the risk of financial volatility and a widening of differences in access to financial services constitute threats which should not be overlooked.

So far, the empirical evidence on the influence of increasing ICT penetration on financial development is partial and fragmented; hence the gap in knowledge is significant. Shamim (2007), in a pioneering study covering empirical linkages between increasing ICT penetration and financial markets in 61 economies over the period 1990-2002, claims that new technologies positively affect financial development. He puts special emphasis on the idea that in developing countries with

weak financial systems ICTs may play a crucial role in financial development, as they are a cheap and easily acquirable means of communication and data acquisition. Similar evidence for developing countries is provided in a study by Claessens et al. (2002), who also claim that development of ICT infrastructure may positively contribute to financial development in developing and emerging economies. Andrianaivo and Kpodar (2011), in a study covering African economies, also underline that broad adoption of ICTs positively impacts financial inclusion, and as a result generates positive spillovers for financial development and economic growth. Sassi and Goaied (2013), in a study covering the MENA region, state that a higher level of ICT penetration rate positively affects financial development, and, in addition, if the two-way relationship is important, it is a stimulus to economic growth. Falahaty and Jusoh (2013) provide similar evidence on a positive influence of ICT on financial development in MENA countries.

2.3. The theoretical relationships between ICT and ETF market development.

The role played by ICT in ETF market development can be observed both on the demand and supply side and is linked with the general factors outlined in sections 2.1 and 2.2. It should be noted that due to the fact that ETFs are instruments listed and traded on stock exchanges their development depends to a large extent on changes occurring in capital markets, including those caused by increasing ICT penetration. This section will focus on relationships between increasing ICT penetration and ETF market development, with special emphasis on the contribution of ICT to the development of capital markets and its consequences for the ETF market.

The first group of factors are features of ETFs, which make them more beneficial for investors than other options, particularly mutual funds (due to, for instance, lower costs), and which lead to growth in demand for these instruments. These advantages are magnified by a higher level of stock market development for the reasons outlined in the next paragraphs.

The most important change occurring in stock markets which is preconditioned by increasing ICT penetration is the introduction and development of electronic trading systems, causing a deep transformation of the microstructure of markets (Nishimura, 2010). One of the most sophisticated forms of electronic trading is algorithmic trading - using computer algorithms to place orders and execute transactions. These algorithms enable investors to tactically modify their transactions, for example, in order to limit the losses from unfavourable price movements for orders which are large in relation to the market. A high level of automation of the trading process leads to a significant reduction in trading costs, and, as a result, facilitates more efficient risk-sharing, and improves the liquidity and efficiency of pricing mechanisms (Hendershott et al., 2011). Furthermore, the adoption of electronic trading increases the rate of dissemination of information between different markets and market participants (Nishimura, 2010). These effects are enabled and magnified by such aspects of ICT as wider access to the Internet and greater network bandwidth; this means that organizational innovation is implemented by using more advanced physical technologies.

As the cost of investing in ETFs is mostly comprised of exchange trading expenditures, the introduction and development of electronic trading systems, which results in lower trading costs, increases the attractiveness of these funds compared with mutual funds. It should be noted, however, that reduced tracking costs can be observed for both categories of investments.

Nevertheless, the impact on mutual funds is more indirect and relatively weaker than that on ETFs – other costs, such as distribution fees, are more important.

Another benefit of ETFs is that there is lower tracking error than for comparable mutual funds (index funds). Departures of ETF prices from the prices of tracked instruments should be minimized by arbitrage transactions. In order to limit tracking errors, arbitrage transactions need to be conducted with maximally limited time delays and transaction costs (including costs linked to an inability to find the second part of a transaction) as well as with access to up-to-date market information, particularly concerning the prices of both underlying securities and ETF shares. Adoption of electronic trading systems together with wider access to fast Internet connections enables market participants to act quickly and conduct transactions based on the latest market data. A lack of timely quotes for both ETFs and the securities tracked can lead to a failure of the arbitrage process and large discrepancies between their valuations, eliminating one of their key advantages (Madhavan, 2012). Moreover, such divergences can negatively affect another benefit of ETFs, providing investors with a price continually determined by supply and demand on the stock exchange, as well as the ability to buy or sell ETF shares on the stock exchange at any moment during trading hours.

Another possible link between ICT diffusion and the development of stock markets, and, consequently, the development of the ETF market is an increased participation of retail investors in the stock market and a greater demand for available securities (including ETFs). These changes can occur due to the adoption of information technologies which are more time- and cost-effective than ones used previously (Gani and Ngassam, 2003). A wider use of the Internet as well as other related communication technologies (for example, wireless networks) provides people with a greater amount of and more convenient access to up-to-date information about stock markets and increases the level of their knowledge regarding this subject compared with using, for instance, newspapers, which entails large time delays and only selective coverage of topics. As a result, they are more likely to invest in the stock market (van Rooij, Lusardi and Alessie, 2011). Furthermore, they can obtain information about new instruments such as ETFs and their features.

The advantages of using ETFs presented above are magnified in emerging countries with areas with limited access to newspapers or fixed phone lines. ICTs, especially Internet networks and mobile banking services, enable easier access to various financial services (Laukkanen, 2007), including the brokerage accounts necessary for investing in ETFs. It should be stressed that the fast expansion of mobile banking is regarded by researchers focusing on information systems as one of the key technological innovations in this field (Lin, 2011). In some cases, mostly in remote areas, mobile banking may provide the only channel for investing on the capital market (or even more generally, in any kind of financial assets) as there may be a very scarce number of bank offices, offering a highly limited range of financial services (for example, without distribution of mutual funds). The development of the ETF market may be further accelerated by positive feedback between the growing number of market participants and the liquidity of financial instruments (caused by, for instance, a higher probability of finding market participants willing to conduct opposite transactions). Another factor increasing the demand for ETFs on emerging markets is the introduction of ETFs with exposure to advanced markets, to a large extent enabled by increasing ICT penetration. Local investors (including retail) can gain easier indirect access to foreign investments by purchasing such ETFs (BlackRock, 2011).

Factors influencing the development of the ETF market on the supply side are linked with new possibilities on the financial markets facilitating the introduction of these instruments, as well as new and increasingly complex types of investments, such as synthetic ETFs or various kinds of ETPs. Another noteworthy example is emerging market ETFs. The impact of increasing ICT penetration on the supply side of emerging market ETFs will be described in the following paragraphs.

Transferring securities between a fund's sponsor and the authorized participants, part of trading in ETF shares, requires advanced settlement systems in order to ensure the timeliness and correctness of operations: such systems operate more cost-effectively when based on constantly upgraded technologies (Schmiedel, Malkamäki and Tarkka, 2006), with a crucial role for fast broadband Internet connections. Without such technologies, offering ETFs is either impossible or the costs are too high to compete with mutual funds; consequently, ETFs are not offered in countries below a certain threshold of ICT penetration (it should be noted that this relationship needs to be analyzed in the context of the general level of financial system development).

The introduction and increased popularity of ETFs listed on emerging stock markets managed by global investment companies became possible as a result of the increased sophistication of financial markets (linked with the adoption of more technologically advanced solutions), leading to liberalization of capital flows and changes in the legal environment. New technologies facilitate timely responses to the latest data and the transfer of funds between physically distant markets, which is particularly important for emerging market ETFs as their transaction costs are higher and their liquidity is lower than in developed markets (Blitz and Huij, 2012). Therefore, tracking error for emerging market ETFs tends to be higher, and the adoption of ICT can be regarded as a possibility to overcome one of the main barriers to ETF market development in such countries.

It should be stressed that the creation of and smooth trading in the largest (in terms of AUM) category of emerging market ETFs - funds listed on the stock exchanges of developed countries offering exposure to assets in emerging economies, poses more challenges than other types of ETFs. The reason lies in their structure: shares of ETFs are traded on one stock exchange (in a developed country) whereas the underlying tracked assets are traded on another (in an emerging economy). As a result, in order to gain the typical advantages of ETFs, such as low tracking errors and low costs, the trading and settlement systems on both exchanges must be based on advanced technologies (widely implemented ICT). Market participants must also be able to obtain timely data on exchange rates and have the possibility of conducting linked transactions in order to manage the exchange rate risk, which increases tracking error (Shin and Soydemir, 2011) – both are facilitated by technologically advanced currency markets. Moreover, a similar feature is cross-listing of ETFs, listing a given instrument on more than one stock exchange, which is very popular in European markets, where such ETFs are the major category (Calamia, Deville and Riva, 2013) as well in some emerging economy exchanges, especially Mexico (Blackrock, 2012a). An ability to cross-list ETF shares boosts the development of the ETF market as fund sponsors can expand their customer base and achieve economies of scale by spreading the fixed costs of creating and managing ETFs.

Based on the conceptual framework demonstrated above and to stay consistent with what the theory may predict, we formulate the hypothesis that increasing ICT penetration positively impacted ETF market development across analyzed countries over 2002-2012. This hypothesized relationship is henceforth empirically verified along the remainder of the paper.

3. Data and methodological framework.

3.1. Data.

To examine the hypothesized relationship between increasing ICT penetration and ETF market development, we construct an empirical sample encompassing five countries – Brazil, Japan, Mexico, South Korea and the United States – for which we define two sets of data covering the period 2002-2012. First, we consider financial data on the assets under management of exchange traded funds and mutual funds; and second, we choose two core ICT indicators, namely 'Internet Users' and 'Fixed Broadband Subscriptions'.

The time span of our analysis is mainly conditioned by the availability of financial data. As data on ETFs are broadly available from 2002 onward, we treat this year as the starting time of our empirical evidence (for Brazil, data on ETFs is available from 2004). The development indicator that we consider in this paper is assets under management (AUM), the value of the assets managed by an investment company calculated using market prices (BlackRock, 2012b). The data on the assets of mutual funds over the period 2002-2012 are extracted from the ICI Investment Company Fact Book (2008 48th and 2013 53rd editions, ICI, 2008, 2013).

For Brazil, the ETF asset dataset is derived from financial reports published by companies managing local funds, while in the case of Mexico the value of assets of ETFs used in the analysis is calculated from the relevant Latin America statistics published by BlackRock Advisors and the BlackRock Investment Institute (Blackrock, 2011, 2012a). The financial data for South Korea and Japan are derived from official statistics published by the Korea Exchange (KRX, 2013) and The Investment Trusts Association, Japan (JITA, 2014) respectively; and for the United States – from BlackRock's ETP Landscape (Blackrock, 2012a).

The data for Brazil, Japan and South Korea are converted from the national currencies into US dollars using year-end official exchange rates (derived from World Bank, 2013). Supplementary data on the stock market development levels are derived from World Development Indicators (World Bank, 2013).

In line with the main goals of the paper, we adopt a second set of data encompassing the two selected core ICT indicators, namely 'Internet Users', which refers to the 'proportion of individuals who used Internet from any location in the last three months' (ITU, 2013), and 'Fixed Broadband Internet' subscriptions per 100 inhabitants, which shows the number of fixed broadband Internet subscriptions in a country for every 100 inhabitants (ITU, 2013). These selected ICT variables provide direct information on the development of the ICT infrastructure (Fixed Broadband[2] Subscribers) and access to and use of Internet connections (Internet Users), which coherently describes a country`s individual achievements in this field. The time-series with respect to the selected ICT indicators applied are exclusively derived from the World Telecommunication/ICT Indicators Database 2013 (17th edition). These data on ICT and ETFs are considered appropriate for the aims and scope of our

[2] Fixed broadband Internet is defined as access to high-speed networks (at least 256 kb/s) by cable modem, DSL, fibre or any other fixed broadband technology (ITU, 2010).

study as they provide broad information on newly-emerged ICT infrastructure and the development of innovative financial instruments – ETFs.

Finally, to examine the empirical links between increasing ICT penetration and the ETF market development we develop a dataset covering five different variables for the selected countries. To ensure clarity of the analysis, we label these variables as: Investment Funds – $IF_{(i,y)}$; Exchange Traded Funds – $ETFs_{(i,y)}$; Share of Exchange Traded Funds in Investment Funds – $ETFs\_share\_IF_{(i,y)}$; Internet Users as share of total population – $IU_{(i,y)}$; and Fixed Broadband Subscriptions per 100 inhabitants – $FBS_{(i,y)}$, where *i* denotes country and *y* year.

3.2. Methodology.

To address our research aims, we adopt two different methodological approaches. First, to examine the patterns of ETF markets development (as defined earlier, it is understood as a growth in the AUM of ETFs in the AUM of all investment funds) we deploy innovation diffusion models, which allow for their valid and conclusive approximation over time. Second, hypothesizing that ETF market development and increasing ICT penetration may be closely related; we adopt panel analysis to examine the strength and statistical significance of the relationship between ETFs and the selected ICT variables. To provide a deeper insight into the relationship between ETFs and ICT penetration, we additionally examine the strength of the relationship for each country individually. We argue that a country-specific approach, rather than panel analysis, is more conclusive, and allows for a better understanding of the nature of the relationship between the variables.

The most widely recognized theoretical models adopted for the approximation of diffusion of innovation are the logistic growth and Bass specifications. Each of these models allows for graphical approximation of the diffusion trajectory, which is well described by an S-shaped curve (sigmoidal curve). From the late 1950s onwards, extensive empirical analysis of technological diffusion both within and between countries has been conducted (see, for example, Mansfield 1961), which has resulted in the creation of diffusion models providing theoretical framework for formal technology diffusion analysis. The pioneering work by Mansfield (1961) gave a solid basis for future studies of technology diffusion. He incorporated evolutionary ideas (Darwin, 1986) with technology diffusion theories, which *inter alia* induced a broad adoption of logistic curves in the analysis of the dynamics of innovation spread. To capture the process of diffusion, Mansfield suggests the adoption of a logistic growth equation to explain the phenomenon. Additionally, he introduces the *'word of mouth'* effect (Geroski, 2000; Lee et al., 2010) to the formal model. This emerges once potential adopters of new technology begin to communicate with the rest of the society, which transmits knowledge about the advantages of new technologies. Eq. (1) summarizes Mansfield`s technology diffusion concept, if we assume that each 'user' of new technology may freely contact a 'non-user' and that this leads to the adoption of new technology by the latter, with the probability of an 'effective' contact of η. If the total number of 'users' increases by Δt, and $\Delta t \to 0$, the time path for technology diffusion yields:

$$n(t) = N/\left(1 + \Psi \exp[-\mu t]\right)^{-1}, \quad (1)$$

or:

$$n(t) = \frac{N}{(1+ \Psi \exp[-\mu t])}, \quad (2)$$

where $n(t)$ denotes the number of 'users' at time t, and N the potential number of total 'users'. Consequently, Bass (1969) incorporated the new 'innovator perspective' in the Mansfield model. Bass assumes that diffusion is determined not only by 'imitators' but also by 'innovators' (Satoh, 2001). Thus the Bass specification is also labelled a 'mixed-information-source' model. In linear form, the Bass specification (1969) follows:

$$S(t) = p + \frac{q}{\kappa}[N(t)], \quad (3)$$

where $S(t)$ is the likelihood of the adoption of technology by a 'non-user', p denotes the imitation coefficient, q is the innovation coefficient, κ is the total potential number of users of new technology and $N(t)$ is the cumulative adoption of new technology (product) at time t. By differentiating Eq. (3), we obtain:

$$\frac{dN(t)}{dt} = \left(p + \frac{q}{\kappa} N(t)\right) \times (\kappa - N(t)). \quad (4)$$

Assuming that $F(t)$ is the fraction of potential 'users' of technology over t, then $F(t) = {N(t)}/{\kappa}$, and we rewrite Eq. (4) as:

$$\frac{dF(t)}{dt} = (p + qF(t)) \times (1 - F(t)). \quad (5)$$

The time path for new technology diffusion following the Bass specification yields:

$$N(t) = \kappa\left(\frac{1-e^{-(p+q)t}}{1+\frac{q}{p}e^{-(p+q)t}}\right), \quad (6)$$

with notation analogous to that in Eqs. (3-5).

In 1838, Pierre-Francois Verhulst (1838)[3] formalized logistic growth and introduced the logistic function that is broadly used in diffusion studies today. The formula proposed by Verhulst is a logistic equation (simple sigmoidal asymptotic function) that visually produces an S-shaped curve if data on diffusion (growth) is plotted over time. The S-shaped trajectory approximates the diffusion process well and allows for intuitive interpretation of it. The logistic growth function may be derived from an exponential growth model written as an ordinary differential equation as follows (Meyer et al*.,* 1999; Geroski, 2000; De Guio and Kucharavy, 2007):

$$\frac{dY_x(t)}{dt} = \alpha Y_x(t), \quad (6)$$

with $Y(t)$ denoting the level of x, (t) time, and α growth rate. Introducing e to Eq. (6) yields:

$$Y_x(t) = \beta e^{\alpha t}, \quad (7)$$

[3] The logistic equation is also known as the Verhulst-Pearl equation, as R. Pearl (1922) already adopted similar formulas in the biological sciences in the early 1920s.

with notation analogous to Eq. (6) and β representing the initial value of x at $t = 0$. The simple growth model is pre-defined as exponential, and thus x tends to grow infinitely in geometric progression, which is a somewhat unrealistic presumption. To address the problem of 'infinite growth', a 'resistance' parameter (Meyer, 1999; Kwasnicki, 2013; Lechman, 2013) is added to Eq. (6), which transforms the original exponential growth curve into a sigmoidal-like trajectory. The reformulated version of Eq. (6) is the logistic differential function:

$$\frac{dY(t)}{dt} = \alpha Y(t)\left(1 - \frac{Y(t)}{\kappa}\right), \tag{8}$$

where the parameter κ denotes an upper asymptote that limits the growth of Y. The 3-parameter differential logistic equation – Eq. (8) – can be rewritten as the logistic growth function:

$$N_x(t) = \frac{\kappa}{1 + e^{-\alpha t - \beta}}, \tag{9}$$

or alternatively:

$$N_x(t) = \frac{\kappa}{1 + \exp\left[-\alpha(t - \beta)\right]}, \tag{10}$$

where $N_x(t)$ is the value of x in period t. The parameters in Eqs. (9-10) explain the following: κ is the upper asymptote, which determines the limit of growth ($N(t) \rightarrow \kappa$), also labelled the 'carrying capacity' or 'saturation'; α is the growth rate, which determines the speed (rate) of diffusion; and β is the midpoint, which specifies the exact time (T_m) when the logistic pattern reaches 0.5κ. To ease interpretation, we replace α with a 'specific duration' parameter defined as $\Delta t = \frac{\ln(81)}{\alpha}$, which approximates the time needed for x to grow from 10%κ to 90%κ.

In addition, to confirm the relationship between ETF market and ICT development, we use panel analysis, which is complemented by the estimation of analogous country-wise regressions. First, we try using the fixed effects regression, which yields:

$$\varphi_{iy} = \alpha_i + \gamma_1 x_{1iy} + \cdots + \gamma_n x_{niy} + \varepsilon_{iy}, \tag{11}$$

where i denotes country and y year. Eq. (11) may be rewritten with country dummies included as follows:

$$\varphi_{iy} = \alpha_i + \gamma_1 x_{1iy} + \cdots + \gamma_n x_{niy} + \delta_2 C_2 + \cdots + \delta_n C_n + \varepsilon_{iy}. \tag{12}$$

In Eqs. (11)-(12), α_i denotes unobserved and time-invariant fixed effects, δ_n is the coefficient for binary-country regressors, C is the country-dummy, and n accounts for the number of countries in the sample. For Eqs. (10-11) to satisfy the exogeneity assumption, we assume that $E\left(\varepsilon_{iy} / x_{iy},\ \alpha_i\right) = 0$, with x_{iy} standing for the explanatory variable. As our empirical sample encompasses very few randomly chosen items from a large population, the use of a random effects regression may turn out to be more appropriate. Hence, to confirm the adequacy of the fixed effects regression, we perform the Hausman test, which verifies the null hypothesis $H_0: cov\left(\alpha_i, x_{iy}\right) = 0$ if a random effects regression is asymptotically more efficient compared with

a fixed effects model, otherwise a fixed effects regression is more suitable. In the case that the random effects model turns out to be more appropriate, we estimate:

$$\varphi_{iy} = \gamma_0 + \gamma_1 x_{1iy} + \cdots + \gamma_n x_{niy} + \alpha_i + \varepsilon_{iy}\,, \tag{13}$$

with analogous notations to Eqs. (11)-(12). By convention, in random effects models it is assumed that variation across countries (or other entities) is random and thus uncorrelated with the explanatory variables. To confirm results generated from panel analysis, we introduce an instrumental variables (IV) estimator (Bound et al., 1995), which cuts a potential correlation between the error term and the explanatory variables. Assuming we have the regression $\varphi_{iy} = \gamma x_{iy} + \varepsilon_{iy}$, and $E(x_{iy}, \varepsilon_{iy}) = 0$ is not satisfied, then $E(x_{iy}, \varepsilon_{iy}) \neq 0$. To control for endogeneity, we define z_{iy} as an instrument such that $E(z_{iy}, x_{iy}) \neq 0$ and $E(z_{iy}, \varepsilon_{iy}) = 0$. With this transformation and using the 2SLS method, we get unbiased regression coefficients. Additionally, to trace country-specific characteristics with respect to the relationships analyzed, we estimate individual country regressions, which have the general econometric form:

$$\theta_i = \omega_0 + \omega_{1,i} + \cdots + \omega_{mi} + \varepsilon_i, \tag{14}$$

where *i* denotes the country and *m* is the number of explanatory variables.

4. Preliminary evidence.

4.1. ETF markets – descriptive analysis.

The level of stock market development may be regarded as one of the factors influencing the ETF market because, as noted before, such products offer exposure to stock prices and the process of creation and trading (including arbitrage transactions) takes place in that part of the financial system. Capitalization of the local stock market (in relation to GDP) in the countries under study was at the end of 2012 highest in the United States and lowest in Mexico and Brazil (see Table 2).

[Table 2 about here]

Table 2 (above) summarizes statistics describing ETF market development over the period 2002-2012 (2004-2012 in Brazil). Figure 1 shows a graphical approximation of total ETF assets and Figure 2 additionally plots the share of country-specific ETFs in IF growth patterns, providing a deeper understanding of the changes in $ETFs\_share\_IF_{(i,y)}$ (the share of ETFs in the total value of the AUM of investment funds – ETFs and mutual funds – in each individual country).

[Figure 1 about here]

Of the three emerging economies analyzed (Brazil, Mexico and South Korea), the most listed ETF AUM at the end of December 2012 were in South Korea ($13.07 billion), with fewer in Mexico ($8.73 billion), and still significantly fewer in Brazil

(only $1.88 billion). The South Korean ETF market was also the largest at the beginning of the period studied: in 2002 the total value of these assets was $275.3 million and they grew at an average annual rate of 38.6% over the next ten years. The corresponding figures for Mexico are $110.9 million in 2002 and average growth of 43.6%, and for Brazil $150.5 million when ETFs were first introduced in 2004 and 31.5% average annual growth over the next 8 years. In comparison, the ETF market in the United States (which was the largest in the world in terms of both AUM and the number of listed products at the end of 2012; BlackRock 2012b) grew from $102 billion in 2002 to $1.08 trillion AUM in 2012 with an average annual growth rate of 23.5%, which is much lower than in the analyzed emerging markets. Average growth in Japan was even lower (below 10%), mainly due to a large decline in AUM in 2008-9. At the end of 2012, the AUM of ETFs listed in Japan was $52.82 billion.

It is apparent that in all the countries analyzed there was an absolute increase in the AUM of ETFs, which was strongest in the three emerging economies and weakest in the two developed ones. This difference can be attributed to the emerging economies catching up – in Japan and the United States the sizes of the ETF markets were considerable in 2002, whereas in South Korea and Mexico ETFs were only starting to gain popularity, and in Brazil there were no such instruments before 2004. Due to the differences in the size of the financial systems, the absolute values of the AUM of ETFs should not be used for comparative purposes. Instead, the analysis of the ETF markets development will be performed, using the indicators described in the following paragraphs.

The share of exchange traded funds in investment funds *(ETFs_share_IF$_{(i,y)}$)* and the dynamics of this metric differed significantly in the countries selected (see Table 1) over the period 2002-2012. If we take the changing share of exchange traded funds in total investment funds (*ETFs_share_IF$_{(i,y)}$*) into account, the picture revealed in Figure 2 is quite evident.

[Figure 2 about here]

Figure 2 shows fast increases of *ETFs_share_IF$_{(Mexico,2002-2012)}$*, *ETFs_share_IF$_{(South\ Korea,2002-2012)}$*, and *ETFs_share_IF$_{(USA,2002-2012)}$* over the period 2002-2012 in Mexico, South Korea and the United States. However, the growth rates and starting points of accelerated development differ. For the United States, the growth of the share of ETFs in investment funds is stable (empirical line in Fig. 2), growing from *ETFs_share_IF$_{(USA,2002)}$*=1.57% to *ETFs_share_IF$_{(USA,2012)}$*=7.6%. The latter value (7.6%) was also the highest among the countries selected at the end of the period analyzed.

Detailed analysis of the factors influencing the share of ETFs in investment funds in the five selected countries may be used to list the most important causes of the observed differences: regulation, diversity of investment options, including new types of ETFs (for example, synthetic ETFs, with modified returns based on derivatives; (KRX, 2011)), competition among ETF providers and ICT adoption. All factors are closely interrelated, for instance, offering new ETF products depends on the local regulation.

Financial regulation shaped the structure and values of AUM of ETFs and other categories of investment funds. One notable example is Brazil. Low share of ETFs in this country was a consequence of the Brazilian financial regulation forbidding the creation of ETFs other than equity-linked ones, as well as cross-listing of ETFs (BlackRock, 2012a; Stuber, 2013). In contrast, in two other emerging economies analyzed, Mexico and South Korea, changes in regulations towards more flexible and ETF-

providers-friendly environment accelerated the relative development of the ETF market mostly through introduction of new products.

Another significant factor was the variety of investment options available on a capital market. Access to more diversified group of ETFs increased demand for these type investments among various group of investors – domestic and foreign, retail and institutional. In Mexico rapid development after 2005 was initially spurred by the introduction of cross-listed ETFs tracking US stock market indexes (BlackRock, 2011) and, in the next years, by growing popularity of ETFs domiciled in Mexico, tracking fixed-income indexes. As a result, share of ETFs in investment funds reached in 2009 one of the highest levels in the world (the next few years marked a decline, mainly caused by stagnation on the ETF market (BlackRock, 2012a)). Similar changes led to increased demand for ETFs in South Korea – the new group of products were ETFs tracking emerging stock markets other than South Korean (for example, in mainland China).

Apart from ETFs offering returns based on various indexes, product innovation had a profound impact on some ETF markets. Expansion of ETFs in South Korea was linked to similar causes as in Japan where a revival of the ETF market was observed since 2011 (Urakabe, 2014). In both countries the most important reason was the rapidly increasing popularity of synthetic ETFs, allowed by changes in the ETF regulation. As a result, the South Korean ETF market has evolved differently to that in other emerging economies in recent years; it is one of the few of these markets with such a prominent role for synthetic ETFs. Relative development of the South Korean ETF market was mostly caused by an inflow of funds to synthetic ETFs from individual investors attracted by a wide offer of ETFs seeking returns higher than those from normal ETFs or equity mutual funds (KRX, 2013).

Importance of the competition among ETF providers for the market development could be observed based on comparison of Brazil and South Korea. For most of the time period analyzed (2002-2007) only one ETF was listed in Brazil; by 2012 the number had increased but it was still the lowest among the countries analyzed (due to financial regulations). In South Korea the competition among ETF providers was much more intensive. Lower competition among ETF providers in Brazil, combined with a less developed capital market infrastructure (higher transaction costs or a lack of timely data, both linked with insufficient adoption of ICT) led to tracking costs relatively higher than in Mexico or South Korea (ca. 100-150% higher, BlackRock, 2012b), decreasing the attractiveness of these instruments.). As a result, despite a considerable initial increase of their share in investment funds (the peak value was, however, very small compared with other economies) in 2005, over the following years ETFs in Brazil remained an investment option of minimal significance, used mostly by local financial institutions (BM&F BOVESPA, 2013).

4.2. ETF markets development patterns.

To shed light on the development patterns and dynamics of $ETFs\_share\_in\_IF_{(i,y)}$, we adopt a logistic growth model, which allows an easily interpreted approximation of the evolution of any variables (Kwasnicki, 2013). The use of a simple logistic growth model visually generates the S-shaped curves that are the favoured tool for describing the growth of different variables in various systems characterized by 'natural' growth limits (Meyer, 1999; Kwasnicki, 2013). As Kucharavy and De Guio argue (2007 and 2011), the S-shaped curve perfectly approximates variable behaviour which by definition is subject to time. They also claim that in addition logistic models return relatively good forecasts for future

variable development as they generically rely on a 'natural growth' logic (Darwin, 1986) and allow the characteristic phases of logistics growth described by continuous patterns in different systems to be captured. In line with this, we approximate growth trajectories for $ETF\_share\_IF_{(i,y)}$ by adjusting Eq. (9), and estimating country-specific logistic growth model parameters (see Table 3)[4].

[Table 3 about here]

Figure 3 (below) plots the theoretical and empirical development trajectories of $ETF\_share\_IF_{(i,y)}$ in Japan, Mexico, South Korea and the United States separately over the period 2002-2012. Brazil has been deliberately excluded from the specification provided in Figure 3, as compared with the other four countries $ETFs\_share\_IF_{(Bra,y)}$ was extremely low over the period analyzed, which would make the Brazilian development trajectory hardly visible. What is important to note is that for all the consecutive estimates the underlying assumption is that in the respective financial markets the development of $ETF\_share\_IF_{(i,y)}$ strictly follows the S-shaped trajectory generated by the logistic growth model.

[Figure 3 about here]

As Figure 3 shows, in the cases of Mexico and the United States the growth of the share of ETFs in investment funds is well described by the logistic growth model and there are relatively good fits to the logistic curve. In both cases the characteristic phases of the S-shaped curve are easily distinguishable, and the reported *R-squares* of the model are 0.98 and 0.99 respectively, which reflects good fitting of the empirical data to the theoretical logistic line. An initially slow increases of $ETF\_share\_IF_{(i,y)}$ is followed by an exponential phase, finally reaching the stabilization phase. As reported in Table 3, for Mexico and the United States the hypothetical upper asymptotes (ceiling) are estimated as $\kappa_{(Mex)}$=8.26% and $\kappa_{(USA)}$=9.97% respectively. The κ parameter explains the potential (maximum) level of $ETF\_share\_IF_{(i,y)}$, based, however, on the rigid assumption that the development pattern of $ETF\_share\_IF_{(i,y)}$ follows the theoretical trajectory generated by the logistic growth model. The estimated midpoints for Mexico and the United States are $\beta_{(Mex)}$=2006.5 and $\beta_{(USA)}$=2007.5, which are the exact time points when $ETF\_share\_IF_{(i,y)}$ reached 0.5κ and the development pattern was half complete. Therefore, in Mexico the value of $ETF\_share\_IF_{(i,y)}$ reached 0.5κ approximately one year earlier than in the United States. These estimates are mainly determined by a significant difference in the α parameter levels – $\alpha_{(Mex)}$=1.67 for Mexico and $\alpha_{(USA)}$=0.29 for the United States – indicating the speed of development. Consequently, crucial differences in the specific duration (Δt) in Mexico and the United States are reported. For Mexico, the estimated $\Delta t_{(Mex)}$=2.62 years, and for the United States $\Delta t_{(USA)}$=14.91 years, which suggests that in Mexico it takes only 2.62 years for $ETF\_share\_IF_{(i,y)}$ to pass from κ=10% to κ=90% , while in the United States it takes 14.91 years. However, these relatively huge differences between the $\Delta t_{(Mex)}$ and $\Delta t_{(USA)}$ estimates are strictly determined by a

[4] Despite the widespread use of the Bass specification in diffusion studies, we argue that this approach is of little relevance to the 'diffusion' of the $ETF\_share\_IF_{(i,y)}$ variable. The nature and 'market' behaviour of the $ETF\_share\_IF_{(i,y)}$ variable examined does not actually meet the Bass model requirements. By definition, the Bass model was designed to describe the diffusion of durables and, on the basis of the diffusion dynamic and product lifecycle, to forecast future sales or cumulative adoption of the durable in question (Bass, 1969). As ETFs, which are the object of our analysis, are hardly comparable with 'conventional' goods or services, estimates from the Bass specification might be misleading and hard to interpret. ETFs show high over-time variability in terms of their market value and are easy to buy and sell, which is why their 'diffusion' may rise and fall over short time intervals. This does not occur in the case of durables, which are systematically acquired by individuals with their saturation growing in the way that the Bass model was designed to show. Moreover, the shares of ETFs are highly heterogeneous due to differences in the compositions of the portfolios underlying these instruments.

difference in the estimates of parameter (α) and thus may be misleading and inconclusive to a certain extent. What is important is that the development path of $ETF\_share\_IF_{(i,y)}$ in the USA is approximated by a relatively steep rising line compared with the respective path for Mexico. In Mexico, the rapid development of $ETF\_share\_IF_{(i,y)}$ (which in 2009 reached 10.31% and exceeded the respective value in the United States) was interrupted by a decline (2009-2010) followed by a rebound in 2011. Conversely, the development pattern of $ETF\_share\_IF_{(i,y)}$ in the United States revealed more stability over time (compare Figure 2 – the trend is close to linear), which strongly affects the final logistic growth model estimation results.

[Table 4 about here]

To evaluate the future prospects of ETFs, we estimate the hypothetical scenario of further $ETF\_share\_IF_{(i,y)}$ development in Mexico and the United States (see Table 4, and for a visual inspection see Figure 8 in Annex B). Fixing the critical saturation level (κ) at 10%, 15%, 20%, 30%, 50%, 75% and 100%, we forecast the respective logistic growth model parameters under, however, the *rigid assumption* that the $ETF\_share\_IF_{(i,y)}$ development path will follow the S-shaped trajectory. The forecast for Mexico is, surprisingly, more optimistic than that for the United States. Due to the reported higher average annual $ETF\_share\_IF_{(i,y)}$ growth rate (see Table 2) and consequently a higher estimated (α) parameters, Mexico should, potentially, reach a critical saturation level sooner than the United State. The estimated midpoints, approximating the time points when saturation reaches 0.5κ along with the specific duration times, confirm the previous supposition and again confirm higher dynamics of the $ETF\_share\_IF_{(i,y)}$ development in Mexico compared with the United States. According to the estimates summarized in Table 4, we can forecast that, for instance, under an assumed κ=15% the midpoints for Mexico and the United States are 2009.8 and 2011.1 respectively. The respective Δts are estimated at 13.7 years in Mexico 20.6 years in the United States. Comparing analogous forecasts for κ=20%, we get $Tm_{(Mex)}$=2012 and $Tm_{(USA)}$=2013,9 with the specific durations estimated as $\Delta t_{(Mex)}$=16.9 years and $\Delta t_{(USA)}$=23.54 years. Consecutive predictions reveal analogous differences in estimated logistic growth model parameters. Arguably, the forecasts for Mexico are more promising in terms of $ETF\_share\_IF_{(i,y)}$ development, however it should also be noted that the R-squares of the models generating consecutive predictions for Mexico are lower than those for the United States. This shows that the forecast for Mexico may be of less relevance than that for the United States. The predictions for saturation levels higher than 20% provided in Table 4 should be considered purely hypothetical (note that the estimated times for reaching 90-100% saturation are 2040-2050). It should be remembered that ETFs are not close substitutes for all types of mutual funds – it is a very wide category, encompassing (apart from index funds resembling ETFs) actively invested equity funds as well as bond funds or money market funds. Moreover, ETFs are one type of tools used in passive investing (tracking returns of selected assets) which must be contrasted with active investing (attempting to outperform such assets) – discussion on advantages and disadvantages of both types lies outside the scope of this article. Yet in our research, due to significant data limitations (lack on AUM of index funds in most countries), we use statistics regarding the whole mutual funds category. In fact, in none of the countries analyzed does $ETF\_share\_IF_{(i,y)}$ exceed approximately 10.31% (the case of Mexico), while in the United States, which we treat as the benchmark economy, $ETF\_share\_IF_{(i,y)}$ achieved its highest level of

7.6% in 2012. Changes in $ETF\_share\_IF_{(i,y)}$ are determined by a variety of factors, such as the development of various types of ETFs and similar financial instruments, the regulatory and legal environment, the activities of large investors on capital markets (including demand from foreign entities), differences in investment costs (costs of trading in ETFs), and the adoption of ICT. All these fundamentally shape the development patterns of ETFs in the countries analyzed.

Finally, the ETF market development is far from automatic, and the forecasts provided reporting on the general development tendencies of $ETF\_share\_IF_{(i,y)}$ are biased due to simplifications and may significantly differ from reality.

The development trajectory of $ETF\_share\_IF_{(i,y)}$ in Japan tended to be highly unstable over 2002-2012. The $ETF\_share\_IF_{(i,y)}$ development pattern is marked by a period of stability (2002-2005) interrupted by a sudden fall (2006-2010) followed by an upswing (from 2011 onward). The instability of the $ETF\_share\_IF_{(i,y)}$ pattern greatly affects the logistic growth model estimates, which turn out to be statistically insignificant, with dramatic overestimates of the κ, Tm and Δt parameters. As predictions of the further development of $ETF\_share\_IF_{(i,y)}$ are unreliable, they are not reported in Table 4. Similar overestimates are reported for the South Korean $ETF\_share\_IF_{(i,y)}$ development trajectory (see Table 3). Although the model R-square is 0.96, the estimated κ, Tm and Δt parameters are statistically insignificant. The κ estimated, explaining the hypothetical saturation point that the $ETF\_share\_IF_{(i,y)}$ variable is heading towards, is controversial and questionable. Clearly, the reported overestimates of κ are caused by the abrupt increase in $ETF\_share\_IF_{(i,y)}$ in 2010-2011 (1.8pp)[5] and 2011-2012 (0.81pp) observed in the South Korean market. Visual inspection of the development pattern of $ETF\_share\_IF_{(i,y)}$ (see Figure 8 in Annex B) suggests that for South Korea the period 2010-2012 may be identified as an early exponential growth phase. However, imposing an upper growth limit (fixing the κ) for $ETF\_share\_IF_{(i,y)}$ development pattern allows for more reliable logistic growth estimates, which are summarized in Table 4. As the predicted (α) is relatively high in the case of South Korea compared to those reported for Mexico and the United States, it basically shapes the values of the midpoints (Tm) and specific duration (Δt). If the predictions for South Korea are reliable, the $ETF\_share\_IF_{(i,y)}$ should hypothetically reach a critical saturation point sooner than in other countries. However, these promising forecasts are again dramatically affected by the high dynamics of $ETF\_share\_IF_{(i,y)}$ development over the time period considered and thus should be interpreted with caution. In Brazil, the development of $ETF\_share\_IF_{(i,y)}$ remained at an extremely low level over the period 2004-2012. In none of the years analyzed did it exceed 1% and so the logistic growth model would not seem to be applicable to this case. Although the parameters κ, β and α are reported in Table 3, the R-square of the model is zero, which demonstrates the impossibility of fitting the empirical data to an S-shaped trajectory. As the development of $ETF\_share\_IF_{(i,y)}$ is still in its very early stages in the Brazilian market, the use of logistic curve models to forecast its future development is precluded. Consequently, the predicted $ETF\_share\_IF_{(i,y)}$ development scenarios are not reported in Table 4 as they would be highly unreliable.

As a general conclusion, it has been seen that the growing share of ETFs in the total investment funds analysed (relative ETF market development) in both Mexico and the United States can be explained in line with the logistic model. However, the rate of growth of the ETF share in investment funds in Mexico was dramatically higher than in the United States, despite significantly lower absolute AUM values and stock market capitalization. However, the most prominent conclusion from the

[5] Authors' calculations.

empirical evidence on ETF market development is that in the last years of the analysis Mexico caught up with the United States in terms of the share of ETFs in IF. This is evidence that in this respect the emerging Mexican financial market has undergone significant changes and has moved towards structures that are observed in developed countries, with convergence in terms of $ETF\_share\_IF_{(i,y)}$ development.

4.3. Changes in ICT penetration.

It was hypothesized that the evolution of $ETF\_share\_IF_{(i,y)}$ is preconditioned and eased by increasing ICT penetration. Universal and unbounded access to and use of ICT was expected to facilitate introduction of financial innovations like ETFs, for the reasons explained in sections 2.2 and 2.3.

Figure 4 (below) provides a graphical evidence of access to Fixed Broadband Internet Subscriptions ($FBS_{i,y}$) and use of basic ICTs (Internet Users – $IU_{i,y}$) in the countries analyzed over the time span 2002-2012; and Table 5 (below) summarizes descriptive statistics on changes in ICT penetration in the economies selected over the analogous period.

[Figure 4 about here]

[Table 5 about here]

The empirical evidence on changing ICT penetration in Brazil, Japan, Mexico, South Korea and the United States over the period 2002-2012 reveals high dynamics in each case. Analyzing changes in the Internet penetration rates $IU_{(i,y)}$ over the period 2002-2012, Brazil and Mexico follow similar development paths, achieving high average annual growth rates of 16.9% and 11.7% respectively. As reported in Table 5, the proportion of the population using Internet increased from $IU_{(Bra,2002)}$=9.15% to $IU_{(Bra,2012)}$=49.8% in Brazil, and from $IU_{(Mex,2002)}$=11.09% to $IU_{(Mex,2012)}$=38.4% in Mexico. However, the dynamics of the growth of the Internet penetration rate were visibly lower in the remaining three countries. In Japan, South Korea and the United States, average annual $IU_{(i,y)}$ growth was relatively low compared to Brazil and Mexico, at about 5.28%, 3.47% and 3.20% respectively[6]. The reason behind this is that in these three countries in 2002 (the initial year of the period that our analysis covers) the level of $IU_{(i,y)}$ was already high ($IU_{(Jpn,2002)}$=46.6%, $IU_{(Kor,2002)}$=59.4%, $IU_{(USA,2002)}$=58.8%). In the final year (2012), the rates in these countries were 79.05%, 84.1% and 81.03% respectively.

The picture arising from the empirical evidence on Fixed Broadband Internet Subscriptions in the countries under focus reflects considerable growth in this dimension. As Table 5 shows, the average annual growth of $FBS_{(i,y)}$ in Brazil and Mexico was 31.12% and 38.81% respectively, which resulted in absolute increases in fixed broadband penetration rates to 9.15% in Brazil and 10.52% in Mexico. In Japan, South Korea and the United States, the dynamics of the growth of fixed broadband penetration rates was lower than in Brazil and Mexico. However, in absolute terms the three countries outshone Brazil and Mexico, achieving – in 2012 – unquestionably higher FBS penetration rates: $FBS_{(Jpn,2012)}$=27.7%, $FBS_{(Kor,2012)}$=37.6% and $FBS_{(USA,2012)}$=28.6%. In short, in terms of the average annual growth of the selected ICT indicators, the two emerging countries

[6] Authors` calculations.

– Brazil and Mexico – performed considerably better, but in terms of absolute levels they were still lagging behind Japan, South Korea and the United States. Our focus in this research is on an assessment of ETF market development and changes in access to and use of basic ICTs in the five countries analyzed over the period 2002-2012. The empirical evidence reveals growth tendencies, both for the AUM of ETFs (in absolute values and considered as share of total investment funds)[7] and Internet Users per 100 inhabitants and Fixed Broadband Internet Subscriptions per 100 inhabitants. This suggests that ETF market development and increases in ICT penetration may be intimately related, which we examine in the forthcomming section.

5. Regression results.

The main target of this section is to empirically verify the hypothesis that increasing ICTs penetration positively impacted ETF market development across analyzed countries over 2002-2012 (for conceptual framework also section 2.3). To provide a coherent and deep insight into the relationship examined, we explore it both visually and using panel analysis. First, we graphically analyze the assumed relationship using locally weighted scatter plot smoothing (LOWESS). Figures 5 and 6 display the relationship between $ETFs_{(i,y)}$ (ETF market development level - absolute values of the AUM of ETFs) and the two ICT indicators, $IU_{(i,y)}$ and $FBS_{(i,y)}$.

[Figure 5 about here]

[Figure 6 about here]

The existence of positive relationships between $ETFs_{(i,y)}$ and $IU_{(i,y)}$ and between $ETFs_{(i,y)}$ and $FBS_{(i,y)}$ in the countries analyzed is strongly supported by visual inspection, especially of Figure 6, which provides country-specific evidence. Growths of $IU_{(i,y)}$ and $FBS_{(i,y)}$ are accompanied by increases in the AUM of ETFs. In the United States and Mexico for both $IU_{(USA,y)}$ and $FBS_{(USA,y)}$, the correlations with $ETFs_{(USA,y)}$ are high, with respective correlation coefficients of 0.94 and 0.96 for the United States and 0.92 and 0.89 for Mexico. It can be observed that in Mexico the variable $ETFs_{(Mex,2005)}$ set out on an exponential growth path in 2005 and after a peak of growth in 2009 it reached a stabilization phase. It is worth noting that Mexican $ETFs_{(Mex,y)}$ started to follow the logistic growth trajectory when $IU_{(Mex,y)} \cong 15\%$ and $FBS_{(Mex,y)} \cong 2$ (per 100 inhabitants). Evidence from Mexico, analyzed separately from other factors affecting the ETF market, would suggest that this 'saturation' level of society with new technologies is sufficient for ETFs to start to expand. In South Korea, the statistical relationship is as high as in the previous two countries. The analogous correlation coefficients are approximately 0.88 and 0.96 for ETFs against $IU_{(Bra,y)}$ and $FBS_{(Bra,y)}$ respectively. The relatively weakest connections between the paired variables are found in the cases of Brazil and – surprisingly – Japan. In Brazil, over the period 2004-2014, despite a dynamic growth of $IU_{(Bra,y)}$ and $FBS_{(Bra,y)}$, the level of $ETFs_{(Bra,y)}$ hardly changed. Similarly weak linkages between ETF market and ICT penetration are observed for Japan. The pair-wise correlations are 0.33 and 0.36 for $ETFs\text{-}IU_{(Jpn,y)}$ and $ETFs\text{-}FBS_{(Jpn,y)}$ respectively. The main reason for these unexpectedly low correlation coefficients is probably the unstable growth path of the AUM of ETFs (for details, see the evidence in section 4.1).

[7] The exception was Brazil, where $ETF\_share\_IF_{(i,y)}$ did not even reach 1%.

The general conclusions derived from the graphical analysis of the relationship between ETF market development and ICT`s increasing penetration are confirmed by quantitative analysis. To explore the potential relationship between the ICT penetration and the value of the AUM of ETFs, we apply panel analysis. The response covariate is defined as $ETFs_{(i,y)}$; while $U_{(i,y)}$ and $FBS_{(i,y)}$ are the explanatory variables, which is driven by the supposition that increasing ICT penetration is likely to positively impact ETF market development. The empirical results are based on data available for Brazil, Japan, Mexico, South Korea and the United States over the period 2002-2012. The descriptive statistics of the variables used for the regression were outlined in section 4. Tables 6 and 7 display the panel regression analysis. By adopting a panel analysis, we expect to trace the potential impact of increasing ICT penetration, approximated by two core ICT indicators – Internet Users and Fixed Broadband Internet Subscriptions – on ETF market development in the countries analyzed. However, considering that detection of collinearity between the explanatory variables is highly probable, we examine a correlation matrix (see Figure 7 in Annex A) of the corresponding pairs of variables to support or reject this possibility.

From Figure 7, we hypothesize that a two-way statistical relationship exists between the variables $IU_{(i,y)}$ and $FBS_{(i,y)}$. The correlation coefficients calculated for the corresponding pairs of variables are the following: $(IU_{(Bra,y)}$ *versus* $FBS_{(Bra,y)})$ = 0.98, $(IU_{(Mex,y)}$ *versus* $FBS_{(Mex,y)})$ = 0.94, $(IU_{(USA,y)}$ *versus* $FBS_{(USA,y)})$ = 0.95, $(IU_{(Jpn,y)}$ *versus* $FBS_{(Jpn,y)})$ =0.97 and $(IU_{(Kor,y)}$ *versus* $FBS_{(Kor,y)})$ =0.94. These findings imply that the regression analysis should be restricted to one explanatory variable, because otherwise the regression coefficients would be statistically insignificant. Assuming that causality exists between the variables $IU_{(i,y)}$ and $FBS_{(i,y)}$, for example, access to a broadband network $FBS_{(i,y)}$ determines the percentage of individuals using Internet $IU_{(i,y)}$, we estimate the respective regressions (for details see sections 3.2). The results obtained from the models are displayed in Tables 6-8.

[Table 6 about here]

[Table 7 about here]

[Table 8 about here]

Table 6 summarizes the panel regression estimates regarding the relationship between ICT penetration and ETF market development in the five analyzed countries, over the period 2002-2012. First, we use pooled OLS (ignoring how the observations are grouped among the countries) and a fixed effects regression. The results obtained are statistically significant, but in the case of the pooled OLS specification[8] the fit of the model is weaker compared with the fixed effects estimation. For both regressions the coefficients are positive and relatively high (in terms of absolute values), which may suggest that the impact of increasing ICT penetration, approximated by the share of individuals using Internet, contributes strongly to ETF market development. The coefficient on $LnIU_{(i,y)}$ equals 3.29, which implies that an increase in $IU_{(I,y)}$ of 1% potentially generates an increase in the value of the AUM of ETFs of about 3.29%, *ceteris paribus*. To check whether fixed or random effects are required we perform the Hausman specification test. This returns Prob>chi2=0.77, which indicates that the random effects estimator may be free from significant biases and thus that a random effects approach would be preferred in our case. Therefore, we re-

[8] By applying the Ramsey test after the pooled OLS regression, we obtain Prob>F = 0.59, which suggests that there are no omitted variables in the model.

estimate the models using the random effects regression. To control for endogeneity in the random effects regression, we test the stability of our results by introducing the random effects instrumental variables regression (G2SLS IV RE) using two types of instruments – a lagged explanatory variable and, alternatively, the Fixed Broadband Internet Subscriptions ($FBS_{(i,y)}$) variable, as access to broadband networks particularly affects Internet penetration rates (see regression results reported in Table 7). Additionally, by means of the Breusch-Pagan test we check if any panel effects are identified in our sample, whether the use of panel analysis is the appropriate approach or simple OLS is a more consistent solution. The test result is Prob>chi2=0.00 so we reject the null hypothesis and conclude that the OLS estimator would be inconsistent in this case. The results obtained from random effects and random effects instrumental variables regressions (with two types of instruments used) re-confirm the hypothesis that increasing ICT penetration resulted in boosting the value of AUM of ETFs on financial markets in the five countries. In each model, the $LnIU_{(i,y)}$ coefficients are still above 3.00, representing the average response of $LnETFs_{(i,y)}$ to changes in $LnIU_{(i,y)}$ both over time and between countries for one unit change.

Since the countries in our sample are arguably highly heterogeneous, it is reasonable to exploit the country-specific effects with respect to the relationships examined. We therefore develop country-wise regressions to explore whether and to what extent $ETFs_{(i,y)}$ against $IU_{(i,y)}$, and $IU_{(i,y)}$ against $FBS_{(i,y)}$ were interrelated over the period analyzed. To check for the relationship we use a simple OLS estimator, and to control for the possibly of emerging endogeneity between the covariates we adopt an instrumental variable regression (IV 2SLS). The results, summarized in Table 8, show that in each of the countries analyzed, the covariates are strongly interrelated, meaning that increases in the amount of the population which uses Internet, $IU_{(i,y)}$, result in a growth of $ETFs_{(i,y)}$.

Our examination of individual countries shows that for each regression[9] the variable $IU_{(i,y)}$ has a positive and statistically significant coefficient, which confirms the results generated by the panel analysis. However, a relatively weaker relationship, yet still statistically significant, is revealed in the cases of Brazil and Japan when $IU_{(i,y)}$ is regressed on $ETFs_{(i,y)}$. This was already suggested by the graphical analysis – see Figure 6 for comparison. In Brazil and Japan, the relatively low regression coefficients for the impact of increasing Internet penetration on ETF market development are probably determined by: low dynamics of the growth of $ETFs_{(Jpn,y)}$ and $IU_{(Jpn,y)}$ (compared with the other countries analyzed) – in the case of Japan; and low penetration of $ETFs_{(Bra,y)}$ accompanied, though, by high average annual growth of the Internet user rates – in the case of Brazil. In the remaining three economies – Mexico, South Korea and the United States – the relationship explored emerges as much stronger, with regression coefficients of $LnIU_{(Mex,y)}$= 3.9, $LnIU_{(Kor,y)}$=9.98 and $LnIU_{(USA,y)}$=7.57 respectively, according to the OLS estimates (see Table 8). This means that 1% growth in Internet penetration potentially induces growth in the value of the AUM of ETFs of about 3.9% in Mexico, 9.98% in South Korea and 7.57% in the United States. In each case, the positive and significant effects of $IU_{(i,y)}$ growth on the development of $ETFs_{(i,y)}$ are additionally confirmed by the IV 2SLS regression results.

In addition, we provide empirical evidence on the country-specific regression estimates with respect to the relationship between changing access to fixed broadband networks and Internet penetration rates. Using the OLS estimates for Brazil, Japan, Mexico, South Korea and the United States, the regression coefficients on the explanatory variables are respectively $LnFBS_{(Bra,y)}$=0.50,

[9] Only in two cases were statistically insignificant coefficients reported: for Brazil when regressing $IU_{(i,y)}$ on $ETFs_{(i,y)}$ (OLS); and for the analogous relationship in Japan (IV 2SLS).

$LnFBS_{(Jpn,y)}$=0.45, $LnFBS_{(Mex,y)}$=0.27, $LnFBS_{(Kor,y)}$=0.59 and $LnFBS_{(USA,y)}$=0.19. Although the coefficients differ slightly when the IV 2SLS regression is used, the results are still statistically significant, and their qualitative interpretation remains unchanged. In each of the countries analysed, growth in access to fixed broadband networks generates significant increases in Internet penetration. On the basis of the regression results, improving access to fixed broadband Internet connections contributes most to growth in Internet use by individuals in South Korea, Japan and Brazil; while the weakest impacts are detected for the United States and Mexico.

The results of the empirical analysis demonstrate that in the time span 2002-2012 in Japan, Mexico, South Korea and the United States the relationship between changes in the value of AUM of ETFs and ICT penetration was positive, strong and significant. These outcomes allow confirmation of the hypothesis that increasing ICT penetration impacts the development of ETF markets. However, in case of Brazil, although country-specific estimates seem to confirm the hypothesis that increasing ICT penetration positively impacts ETF market development, these results shall be interpreted carefully. It should be born in mind that the level of ETF market development in Brazil over analyzed period was negligible (especially if compared to other countries in scope), and thus concluding on strong and positive impact of increases in ICT penetration on ETF market development would be a definite overstatement.

In section 4.1, observed links between increasing ICT penetration and the ETF market development in the economies selected were presented among other factors influencing the emergence of these markets and differences between countries. On the basis of the preceding analysis and that in this section, the most significant links are: wider access to brokerage accounts (through Internet services); the introduction of new types of ETF (for instance, synthetic, with high technological requirements – this link seems to be of high significance; see the analysis of the differences between ETF markets in Brazil, Mexico and South Korea in section 4.1); a reduction in investment costs (mostly due to the effect of decreased costs of trading and access to information on the prices of ETFs and underlying assets); and cross-listing (listing on more than one exchange) of ETFs (technologically advanced trading and settlement systems are necessary in all the countries involved). To sum up, the links are noticeable both on the demand and supply sides of the ETF markets.

In our analysis, we have taken the United States as a reference country as its financial market is one of the most developed worldwide. Consequently, we presume that it is reasonable to compare the development paths of emerging economies – in our study Brazil and Mexico – with the United States. Additionally, to provide deeper insights into the issues involved in our analysis, we have examined the cases of Japan and South Korea. This approach allows two crucial problems to be addressed: whether increases in ICT penetration in developing economies fosters the introduction of new financial instruments, and whether – thanks to extensive ICT penetration – emerging countries manage to achieve a level of the share of AUM of ETFs in total investment funds comparable with that in the United States. On the basis of our overall results, however, the answers to these questions are ambiguous. In Brazil, even though the dynamics of ICT penetration were comparably high (in 2012 almost 50% of individuals had access to Internet, the share of AUM of ETFs in total investment funds remained at a very low level, with saturation ($ETF\_share\_IF_{(i,y)}$) at barely 0.17% in 2012. A dramatically different picture is revealed in the case of Mexico. In the period 2000-2012, the Mexican economy underwent a 'technological revolution', enjoying fast growing penetration of

Internet and broadband networks. Huge changes in ICT penetration were accompanied by a dynamic growth in the share of AUM of ETFs in investment funds. At the end of 2002, the first year of ETF listings in Mexico, $ETF\_share\_IF_{(i,y)}$ was 0.35%, while by 2012 it had grown to $ETF\_share\_IF_{(i,y)}$=7.21%. The highest value, 10.3%, of $ETF\_share\_IF_{(i,y)}$ was reached in 2009, when it exceeded the analogous value in the United States. It is worth remembering that in 2002 in the United States $ETF\_share\_IF_{(i,y)}$ was 1.57% and in 2012 7.6%. This shows that both Mexico and the United States advanced in terms of the share of AUM of ETFs in investment funds, following a similar development pattern.

In South Korea, a relationship between increasing ICT penetration and ETF market development is also observed. According to our estimates, the impact of ICT on the growth of AUM of ETFs was even stronger than in Mexico. Moreover, $ETF\_share\_IF_{(i,y)}$ in South Korea grew from 0.18% in 2002 to 4.65% in 2012. However, despite the high penetration of ICT, the position of ETFs in comparison with mutual funds was still weak: $ETF\_share\_IF_{(i,y)}$ was lower than in Mexico or the United States. In the case of Japan, the impact of ICT on the ETF market was the weakest among the countries studied: variations in the absolute or relative value of AUM of ETFs in the time period considered were mostly unrelated to changes in ICT penetration (the penetration of ICT was already high in 2002), with a growing popularity of synthetic ETFs being one of the exceptions.

Enormous changes in the Mexican financial markets with regard to the development of ETFs prove its high efficiency, its ability to change quickly and benefit from the opportunities offered by ICT. The Mexican case shows that it is possible to follow the path of highly developed countries for an emerging economy. However, the question arises of what went wrong in Brazil. Hypothetically, Brazilian ETFs should follow a similar path to those in Mexico in 2002-2012. However, the role of information and communication technologies in fostering the ETF market development in emerging markets does not seem to be straightforward and direct. There are a multitude of prerequisites – which are often hard to quantify – and local factors (legal systems, the situation of foreign markets, market structure) which condition the development of financial markets, and ICT is only one of them. Undoubtedly growing ICT penetration is only a part of the explanation of ETF market development. Other (linked with ICT to a smaller or larger degree) factors that caused notable variations in the development of the Brazilian and Mexican ETF markets were differences in: financial system regulations (limiting the scope of ETFs available in Brazil); the roles of ETFs tracking local markets listed in developed countries (a major category of ETFs based on Brazilian stocks); tracking (investment) costs (much greater in Brazil); and competition among ETF providers (lower in Brazil).

Finally, a few important issues should be mentioned with regard to the evidence provided earlier in this section. With respect to examined relationships, the outcomes of the analysis may be heavily affected by short data time series, and henceforth should be interpreted with caution as their robustness may be violated. Moreover, bearing in mind the complexity of the two processes, it is not fully tenable to draw rigid conclusions about a straightforward dependence of ETF market development on ICT. Arguably, increases in ICT penetration represent a necessary but *not* sufficient condition for sustainable ETF market development. This kind on interdependency may be essentially conditioned by multiple factors, which foster or – reversely – impede both increases in ICT penetration and ETF market development. Level of economic development, legal regulation and financial market institutions, level of competition and liberalization, learning capabilities of market agents and their absorptive capacities to adopt both technological and financial innovations, country`s openness to foreign capital inflows, financial market

structure essentially predetermine the causal links between the process of ICT deployment and ETF market development. Finally, some country-specific characteristics, for instance, religion, language, culture, social attitudes or moral norms, level of education and human capital determine the strength and the nature of examined relationships. The numerical results of the examined impact of increasing ICT penetration on ETF market development are at best rough approximation, as extreme variability in the dynamics of two processes accounts for a mountain of different factors that are not always easy to capture and isolate. Bearing in mind all the issues mentioned above, the future work on these relationships would be highly recommended, to unveil the specificity of analyzed relationships and provide broader and more robust evidence on that field.

6. Conclusions.

This paper was designed to empirically verify the hypothesis that increasing ICT penetration positively impacted ETF market development across analyzed countries over 2002-2012. To the best of our knowledge this is the first study where the authors intend to verify the impact of increasing ICT penetration on ETF market development, and one of the first where the most important contemporary issues related to development of financial innovations are tackled. The results of the analysis demonstrate that over the period 2002-2012 in Japan, Mexico, South Korea and the United States the relationship between ETF market development and ICT penetration was positive, strong and significant. The results for Brazil seem to confirm the hypothesized relationships; however it shall be born in mind that the value of AUM of ETFs in Brazil over analyzed period was negligible, and thus concluding on strong and positive impact of increases in ICT penetration on ETF market development might be too far reaching conclusion. Moreover, the period of analysis was unique in its extraordinarily high rates of ICT penetration, which coincided with a dynamic development of financial markets. In the cases of Mexico and the United States, we have found that increases in ICT penetration was accompanied by a dynamic growth in the AUM of ETFs, and similar trend has been observed for South Korea. Despite huge disparities in their general economic performance, both countries achieved a comparable level of the share of ETFs in investment funds (on average 7.4%) in 2012. In Japan, the level of this indicator was similar in 2012, but during the time period considered it strongly fluctuated. The evidence is much weaker in the case of Brazil, which also underwent an ICT 'revolution'. However, in 2012 the Brazilian ETF market was still poorly developed (value of the AUM of ETFs was low and the ETF share in investment funds was at a mere 0.17%). Importantly to emphasize is that the examined relationship is hypothetical, and demonstrated results basically unveil statistical links, which does not necessarily prove causalities. The evidence might not be robust and reveals sensitivity for inclusion of other control variables in the model. Finally, the numerical results of the examined ICT impact on ETF market development are at best rough approximations, depend on a large group of factors not captured here, which shall be born in mind when drawing conclusions and formulating recommendations.

References:

1.A. Agapova, Conventional mutual index funds versus exchange-traded funds, Journal of Financial Markets 14(2) (2011) 323 343.

2.R. Aggarwal, The Growth of Global ETFs and Regulatory Challenges, NSE Working Paper 4 (2012).

3.F. Allen, Trends in Financial Innovation and Their Welfare Impact: An Overview, European Financial Management 18 (4) (2012) 493 514.

4.M. Andrianaivo, K. Kpodar, ICT, financial inclusion, and growth evidence from African countries, International Monetary Fund, 2011.

5.P. Athma, K. Raj Kumar, ETF vis-à-vis index funds: An evaluation, Asia Pacific Journal of Research in Business Management 2 (1) (2011) 188 205.

6.D. Awrey, Toward a supply-side theory of financial innovation, Journal of Comparative Economics 41 (2013) 401 419.

7.J. Bass, F. Bass, A New Product Growth Model For Consumer Durables, Management Science 15 (1969) 215 227.

8.C.S. Berkey, D.C. Hoaglin, F. Mosteller, G.A. Colditz, A random-effects regression model for meta-analysis, Statistics in medicine 14(4) (1995) 395 411.

9.M. Binswanger, Stock markets, speculative bubbles and economic growth: New dimensions in the co-evolution of real and financial markets, Edward Elgar, Cheltenham, 1999.

10.R.R. Biswas, Making a technopolis in Hyderabad, India: the role of government in IT policy, Technological Forecasting and Social Change 71 (2004), 823-835.

11.BlackRock, BlackRock 2013 Annual Report, New York, 2014.

12.BlackRock Investment Institute, ETP Landscape: Global Handbook 2012 (2012a).

13.BlackRock Investment Institute, ETP Landscape: Industry Highlights December 31, 2012 (2012b).

14.BlackRock Advisors, ETF Landscape: Latin America Industry Review (2011).

15.D. Blitz, J. Huij, Evaluating the performance of global emerging markets equity exchange-traded funds, Emerging Markets Review (13) 2012 149 158.

16.BM&F BOVESPA, ETF Bulletin June 2013 (2013).

17.J. Bound, D.A. Jaeger, and R.M. Baker, Problems with instrumental variables estimation when the correlation between the instruments and the endogenous explanatory variable is weak, Journal of The American Statistical Association 90(430) (1995) 443 450.

18.A. Calamia, L. Deville, F. Riva, Liquidity in European equity ETFs: What really matters?, Bankers, Markets & Investors 124 (2013) 60 73.

19.S. Claessens, S. Djankov, J.P. Fan, L.H. Lang, Disentangling the incentive and entrenchment effects of large shareholdings, The Journal of Finance 57(6) (2002) 2741 2771.

20.C. Darwin, On the origin of species by means of natural selection, Murray, London, 1986

21.L. Deville, Exchange Traded Funds: History, Trading and Research, in: M. Doumpos, P. Pardalos, C. Zopounidis (Eds.), Handbook of Financial Engineering, Springer US, 2008, pp. 67-98.

22.I. Diaz–Rainey, G. Ibikunle, A Taxonomy of the 'Dark Side' of Financial Innovation: The Cases of High Frequency Trading and Exchange Traded Funds, International Journal of Entrepreneurship and Innovation Management 16 (1) (2012) 51-72.

23.M. Falahaty, M.B. Jusoh, Financial Development and Information Communication Technology Another look at the Evidence from Middle East and North African Countries, 3rd International Conference on Business, Economics, Management and Behavioral Sciences (ICBEMBS'2013) April 29-30 (2013) Singapore

24.Financial Stability Board, Potential financial stability issues arising from recent trends in Exchange-Traded Funds (ETFs) (2011).

25.A. Gani, C. Ngassam, Effect of Information and Communication Technology on Stock Market Development: Evidence from Emerging Markets and High-Income Economies, International Journal of Economic Development 5 (1) (2003).

26.P.A. Geroski, Models of technology diffusion, Research Policy 29 (2000) 603-625.

27.E. Hehn, Introduction, in: E. Hehn (Ed.), Exchange Traded Funds: Structure, Regulation and Application of a New Fund Class, Springer Berlin, Heidelberg, 2005, pp. 1-6

28.T. Hendershott, C.M. Jones, A.J. Menkveld, Does algorithmic trading improve liquidity?, The Journal of Finance 66(1) (2011) 1 33.

29.A. Ilyina, R. Samaniego, Technology and financial development, Journal of Money, Credit and Banking 43(5) (2011) 899 921.

30.International Monetary Fund, Global Financial Stability Report: Durable Financial Stability. Getting There from Here, World Economic and Financial Surveys (2011).

31.ITU (2013), ITU World Telecommunication/ICT Indicators 2013 (on-line version).

32.Investment Company Institute, 2008 Investment Company Fact Book: Review of Trends and Activity in the Investment Company Industry (2008).

33.Investment Company Institute, 2013 Investment Company Fact Book: A Review of Trends and Activities in the U.S. Investment Company Industry (2013).

34.Korea Exchange, KRX ETF Monthly 1 (2011).

35.Korea Exchange, KRX ETF Monthly 19 (2013).

36.V. Kvint, The Global Emerging Market: Strategic Management and Economics, Routledge, New York, 2009

37.W. Kwasnicki, Logistic growth of the global economy and competitiveness of nations, Technological Forecasting and Social Change 80(1) (2013) 50 76.

38.D. Kucharavy, R. De Guio, Application of S-shaped curves, in: *7th ETRIA TRIZ Future Conference* (2007), pp. 81-88

39.D. Kucharavy, R. De Guio, Logistic substitution model and technological forecasting, Procedia Engineering 9 (2011) 402 416.

40.T. Laukkanen, Internet vs mobile banking: comparing customer value perceptions, Business Process Management Journal 13(6) 2007 788 797.

41.E. Lechman, New technologies adoption and diffusion patterns in developing countries. An empirical study for the period 2000-2011, Equilibrium 8(4) (2013) 79 106

42.M. Lee, K. Kim, Y. Cho, A study on the relationship between technology diffusion and new product diffusion, Technological Forecasting and Social Change 77(5) (2010) 796 802.

43.H.-F. Lin, An empirical investigation of mobile banking adoption: The effect of innovation attributes and knowledge-based trust, International Journal of Information Management 31 (2011) 252 260.

44.A. Madhavan, Exchange-Traded Funds, Market Structure, and the Flash Crash, Financial Analysts Journal 68(4) 2012 20 35.

45.E. Mansfield, Technical change and the rate of imitation, Econometrica: Journal of the Econometric Society 29 (4) (1961) 741 766.

46.P.S. Meyer, J.W. Yung, J.H. Ausubel, A primer on logistic growth and substitution: the mathematics of the Loglet Lab software, Technological Forecasting and Social Change 61(3) (1999) 247 271.

47.C. Michalakelis, D. Varoutas, T. Sphicopoulos, Innovation diffusion with generation substitution effects, Technological Forecasting & Social Change 77 (2010) 541 557.

48.G. Molenberghs, G. Verbeke, Models for discrete longitudinal data, Springer Series in Statistics, 2005.

49.R. Morck, B. Yeung, W. Yu, The information content of stock markets: why do emerging markets have synchronous stock price movements?, Journal of financial economics 58(1) (2000) 215 260.

50.K.G. Nishimura, Electronic trading and financial markets, November 29, 2010, Bank of Japan.

51.C. Perez, Technological revolutions and financial capital: The dynamics of bubbles and golden ages, Edward Elgar Publishing, 2011.

52.F. Pozzi, T. Di Matteo, T. Aste, Spread of risk across financial markets: better to invest in the peripheries, Scientific reports 3, Art No 1665 (2013), Macmillan Publishers Limited.

53.S. Ramaswamy, Market structures and systematic risks of exchange-traded funds, BIS Working Papers 343 (2011)

54.M.E. Rogers, Diffusion of innovation, The Free Press, London, 1962.

55.M. van Rooij, A. Lusardi, R. Alessie, Financial literacy and stock market participation, Journal of Financial Economics 101 (2011) 449 472.

56.S. Sassi, M. Goaied, Financial development, ICT diffusion and economic growth: Lessons from MENA region Telecommunications Policy 37(4) (2013) 252 261.

57.D. Satoh, A discrete bass model and its parameter estimation, Journal of the Operations Research Society of Japan-Keiei Kagaku 44(1) (2001) 1 18.

58.H. Schmiedel, M. Malkamäki, J. Tarkka, Economies of scale and technological development in securities depository and settlement systems, Journal of Banking & Finance 30(6) (2006) 1783 1806.

59.F. Shamim, The ICT environment, financial sector and economic growth: a cross-country analysis, Journal of Economic Studies 34(4) (2007) 352 370.

60.S. Shin, G. Soydemir, Exchange-traded funds, persistence in tracking errors and information dissemination, Journal of Multinational Financial Management 20(4-5) (2011) 214 234.

61.A. Singh, Financial liberalization, stock markets and economic development, The Economic Journal 107(442) (1997) 771 782.

62.State Street Corporation, 2012 Annual Report to Shareholders, Boston, 2013.

63.G.J. Stigler, The economics of information, The Journal of Political Economy (1961) 213 225.

64.W. Stuber, Brazil: New Rules on the Brazilian Exchange Traded Funds (ETFs), http://www.mondaq.com/ (accessed: 10.01.2014) (2013).

65.The Investment Trusts Association, Japan JITA, Changes in Assets of Publicly Offered Open-Type Stock Investment Trusts (2014).

66.A. Urakabe, Domestic ETF market's rapid growth driven by short-term traders, NRI Financial Research Paper 197 (2014).

67.World Bank, World Development Indicators 2013 (2013).

68.J. Wurgler, Financial markets and the allocation of capital, Journal of Financial Economics 58(1) (2000) 187 214.

69.P. F. Verhulst, Notice sur la loi que la population suit dans son accroissement, Correspondance Mathématique et Physique Publiée par A.Quetelet 10 (1838) 113 121.

70.C.A. Yartey, Financial development, the structure of capital markets, and the global digital divide, Information economics and Policy 20(2) (2008) 208 227.

TABLES

Table 1. Exchange traded funds and mutual funds: main differences.

Feature	Exchange traded funds	Mutual funds
distribution channels	broker-dealer on stock exchange	various channels, including investment professionals (for instance, bank representatives) and fund company
tracking cost	very low; mostly exchange transaction costs	depends on fund's management and distribution costs; higher than ETFs'
tracking error (deviations of fund's return from returns of tracked asset)	low (particularly for synthetic ETFs) due to arbitrage transactions	higher than ETFs'
pricing	continuously determined on a stock exchange (during trading hours); price depends on supply and demand for ETFs' shares	determined once a day – all orders placed during that day receive the same price; price computed by investment company
tax efficiency	in some countries (for example, USA) ETFs' shares can be sold without incurring taxes	redemption includes selling securities and can lead to taxable gains

Source: Authors` compilation based on (Agapova, 2011), (Aggarwal, 2012), (Athma and Raj Kumar, 2011), (IMF, 2011), (Ramaswamy, 2011).

Table 2. Summary statistics on assets under management of exchange traded funds. Brazil, Japan, Mexico, South Korea and the United States. 2002-2012.

	Stock market	Average	ITFs' share in IF	ITFs' share in IF	Highest value of	Average ETFs'	Total growth of

	capitalization (% GDP) 2012	annual growth of ETFs AUM (%)	(%)2002	(%)2012	ETFs' share in IF (2002-2012) (%)	share in IF (2002-2012) (%)	ETFs' share in IF 2002-2012) (pp)
Brazil*	54.69	31.56	0.00	0.17	0.32 (y2005)	0.21	0.10
Japan	61.99	9.70	6.60	7.15	7.31 (y2003)	5.67	0.55
Mexico	44.25	43.65	0.36	7.21	10.31 (y2009)	4.63	6.85
South Korea	96.54	38.59	0.18	4.65	4.65 (y2012)	1.41	4.47
The United States	114.92	23.51	1.57	7.60	7.60 (y2012)	4.62	6.03

*Source: Authors` calculations based on data derived from financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013), (World Bank, 2013). Note: AUM – assets under management; ETFs – exchange traded funds; IF- Investment Funds. * – for Brazil results since 2004.*

Table 3. Exchange traded funds' share in total investment funds growth estimates. Brazil, Japan, Mexico, South Korea and the United States. 2002-2012.

	Logistic growth estimates		
	Brazil	**Mexico**	**South Korea**
κ (ceiling/upper asymptote)	*0.21*	8.26	*1 131 658.01*
Tm (midpoint)	*-10 457*	2006.5	*2045.7*
α (rate of diffusion)	*140.42*	1.67	*0.36*
Δt (specific duration)	*0.031*	2.62	*11.98*
R of the model	*0.00*	0.98	*0.96*
	Japan	**USA**	
κ (ceiling/upper asymptote)	*698 608.48*	9.97	
Tm (midpoint)	*1760.61*	2007.5	
α (rate of diffusion)	*-0.04*	0.29	
Δt (specific duration)	*-92.27*	14.91	
R of the model	*0.26*	0.99	

Source: Authors` estimates based on data derived from financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: Estimates completed applying LogLet Lab2 and IIASA software. In italics – misspecifications (under-, or over estimates).

Table 4. Predicted exchange traded funds' share in total investment funds development scenarios. Brazil, Japan, Mexico, South Korea and the United States.

κ (upper asymptote) - *fixed*	Tm (midpoint)	Δt (specific duration)	α (rate of diffusion)	R of the model
	Brazil			
	Not applicable			
	Japan			
	Not applicable			
	Mexico			
10%	2006.9	4.7	0.93	0.90
15%	2009.8	13.7	0.32	0.74
20%	2012.0	16.9	0.25	0.71
30%	2015.2	20.0	0.21	0.71
50%	2019.2	22.4	0.19	0.67
75%	2022.2	23.6	0.18	0.67
100%	2024.2	24.2	0.18	0.67
	South Korea			
10%	2012.3	8.8	0.49	0.96
15%	2013.8	9.8	0.44	0.96
20%	2014.8	10.42	0.42	0.96
30%	2016.2	10.94	0.42	0.96

50%	2017.8	11.36	0.38	0.96
75%	2019.1	11.55	0.38	0.96
100%	2019.9	11.67	0.37	0.96
	The United States			
10%	2007.6	14.95	0.29	0.99
15%	2011.1	20.62	0.21	0.98
20%	2013.9	23.54	0.18	0.97
30%	2017.8	26.48	0.16	0.97
50%	2022.5	28.84	0.15	0.96
75%	2026.2	30.01	0.14	0.96
100%	2028.7	30.60	0.14	0.96

Source: Authors` estimates.

Table 5. Selected ICT core indicators summary statistics. Internet Users *($IU_{(i,y)}$)* and Fixed Broadband Subscriptions *($FBS_{(i,y)}$)*. Brazil, Japan, Mexico, South Korea and the United States. 2002-2012.

	$IU_{(i,y)}$ in 2002	$IU_{(i,y)}$ in 2012	$IU_{(i,y)}$ average annual growth rate (%) over 2002-2012	$FBS_{(i,y)}$ in 2002	$FBS_{(i,y)}$ in 2012	$FBS_{(i,y)}$ average annual growth rate (%) over 2002-2012
Brazil	9.15	49.85	*16.95*	0.41	9.15	*31.12*
Japan	46.59	79.05	*5.28*	7.44	27.73	*13.15*
Mexico	11.90	38.42	*11.72*	0.22	10.52	*38.81*
South Korea	59.40	84.10	*3.47*	22.42	37.25	*5.07*
The United States	58.79	81.03	*3.20*	6.85	28.35	*14.20*

Source: Authors` calculations based on data derived from World Telecommunication/ICT Indicators Database 2013. Note: IU – Internet Users (% of individuals using Internet); FBS – Fixed Broadband Subscriptions (per 100 inhabitants).

Table 6. Panel regression estimates. ETF market development *($ETF_{(i,y)}$)* and Internet Users *($IU_{(i,y)}$)*. Evidence for Brazil, Japan, Mexico, South Korea and the United States. Period 2002-2012.

$LnETFs_{(i,y)}$					
	Pooled OLS	FE	GLS RE	G2SLS IV RE	G2SLS IV RE
$LnIU_{(i,y)}$	2.63 (0.37)[a]	3.29 (0.77)[b]	3.26 (0.71)[b]	3.74 (1.62)[b]	3.21 (1.31)[b]
Hausman test (Prob>chi2)	-	0.77	-	-	-
Breusch-Pagan test (Prob>chi2)	-	-	0.00		
R-squared	0.35	0.58 (within)	0.58 (within)	0.58 (within)	0.49 (within)
Country-fixed effects	No	Yes	No	No	No
Instruments – $FBS_{(i,y)}$	No	No	No	Yes	No
Instruments – lagged $IU_{(i,y)}$	No	No	No	No	Yes
# of countries	5	5	5	5	5
# of observations	53	53	53	53	51

Source: Authors` estimates based on data derived from World Telecommunication/ICT Indicators Database 2013, financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: [a] – robust SE at 5% significance level; [b] – bootstrap SE (1000 replications). For pooled OLS and fixed effects regression: constant included – not reported. For random effects – constant term suppressed.

Table 7. Panel regression results. Internet User ($IU_{(i,y)}$) and Fixed Broadband Internet Subscriptions ($FBS_{(i,y)}$). Evidence for Brazil, Japan, Mexico, South Korea and the United States. Period 2002-2012.

$LnIU_{i,y)}$				
	Pooled OLS	FE	FE (IV)	FE (IV)

$LnFBS_{(i,y)}$	0.46 (0.026)[a]	0.31 (0.01)[c]	0.35 (0.07)[b]	0.52 (0.02)[c]
Hausman test (Prob>chi2)	-	0.00	-	
R-squared	0.89	0.84 (within)	0.85 (within)	0.82 (within)
Country-fixed effects	No	Yes	Yes	Yes
Instruments – lagged $FBS_{(i,y)}$	No	No	Yes	Yes
# of countries	5	5	5	5
# of observations	53	53	51	51

Source: Authors` estimates based on data derived from World Telecommunication/ICT Indicators Database 2013, financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: [a] – robust SE at 5% significance level; [c] – SE; [b] – bootstrap SE (1000 replications). Constant included – not reported.

Table 8. Country-specific estimates. ETF market development *($ETF_{(i,y)}$)* and Internet Users *($IU_{(i,y)}$).* Internet User *($IU_{(i,y)}$)* and Fixed Broadband Internet Subscriptions *($FBS_{(i,y)}$).* Evidence for Brazil, Japan, Mexico, South Korea and the United States. Period 2002-2012.

	OLS	IV 2SLS	IV		OLS	IV 2SLS
	LnETF_Brazil				**LnIU_Brazil**	
$LnIU_{(Bra,y)}$	*1.8 (0.84)*	1.64 (0.71)	0.68 (0.11)	$LnFBS_{(Bra,y)}$	0.50 (0.03)	0.47 (0.03)
R-squared	0.54	0.53	0.32	R-squared	0.97	0.96
instruments – lagged $IU_{(Bra,y)}$	No	No	Ye	instruments – lagged $FBS_{(Bra,y)}$	No	Yes
instruments – $FBS_{(Bra,y)}$	No	Yes	N			
# of observations	9	9	8	# of observations	9	8
	LnETF_Japan				**LnIU_Japan**	
$LnIU_{(Jpn,y)}$	0.74 (0.3)	0.82 (0.34)	*0.53 (0.47)*	$LnFBS_{(Jpn,y)}$	0.45 (0.50)	0.54 (0.30)
R-squared	0.30	0.30	0.1	R-squared	0.95	0.95
instruments – lagged $IU_{(Jpn,y)}$	No	No	Ye	instruments – lagged $FBS_{(Jpn,y)}$	No	Yes
instruments – $FBS_{(Jpn,y)}$	No	Yes	N			
# of observations	11	11	10	# of observations	11	10
	LnETF_Mexico				**LnIU_Mexico**	
$LnIU_{(Mex,y)}$	3.9 (0.46)	4.26 (0.54)	3.73 (0.57)	$LnFBS_{(Mex,y)}$	0.27 (0.03)	0.32 (0.03)
R-squared	0.84	0.84	0.8	R-squared	0.88	0.88
instruments – lagged $IU_{(Mex,y)}$	No	No	Ye	instruments – lagged $FBS_{(Mex,y)}$	No	Yes
instruments – $FBS_{(Mex,y)}$	No	Yes	N			
# of observations	11	11	10	# of observations	11	10
	LnETF_South Korea				**LnIU_South Korea**	
$LnIU_{(Kor,y)}$	9.98 (1.63)	11.6 (2.09)	12.97 (3.	$LnFBS_{(Kor,y)}$	0.59 (0.09)	0.48 (0.06)
R-squared	0.79	0.77	0.7	R-squared	0.88	0.91
instruments – lagged $IU_{(Kor,y)}$	No	No	Ye	instruments – lagged $FBS_{(Kor,y)}$	No	Yes
instruments – $FBS_{(Kor,y)}$	No	Yes	N			
# of observations	11	11	10	# of observations	11	10
	LnETF_USA				**LnIU_USA**	
$LnIU_{(USA,y)}$	7.57 (0.44)	8.05 (0.49)	7.83 (0.70)	$LnFBS_{(USA,y)}$	0.19 (0.01)	0.21 (0.02)
R-squared	0.92	0.92	0.8	R-squared	0.90	0.86
instruments – lagged $IU_{(USA,y)}$	No	No	Yes	instruments – lagged $FBS_{(USA,y)}$	No	Yes

instruments – $FBS_{(USA,y)}$	No	Yes	No			
# of observations	11	11	10	# of observations	11	10

Source: Authors` estimates based on data derived from World Telecommunication/ICT Indicators Database 2013, financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: in parenthesis – robust SE at 5% significance level; in italics – results statistically insignificant. Constant included – not reported.

FIGURES

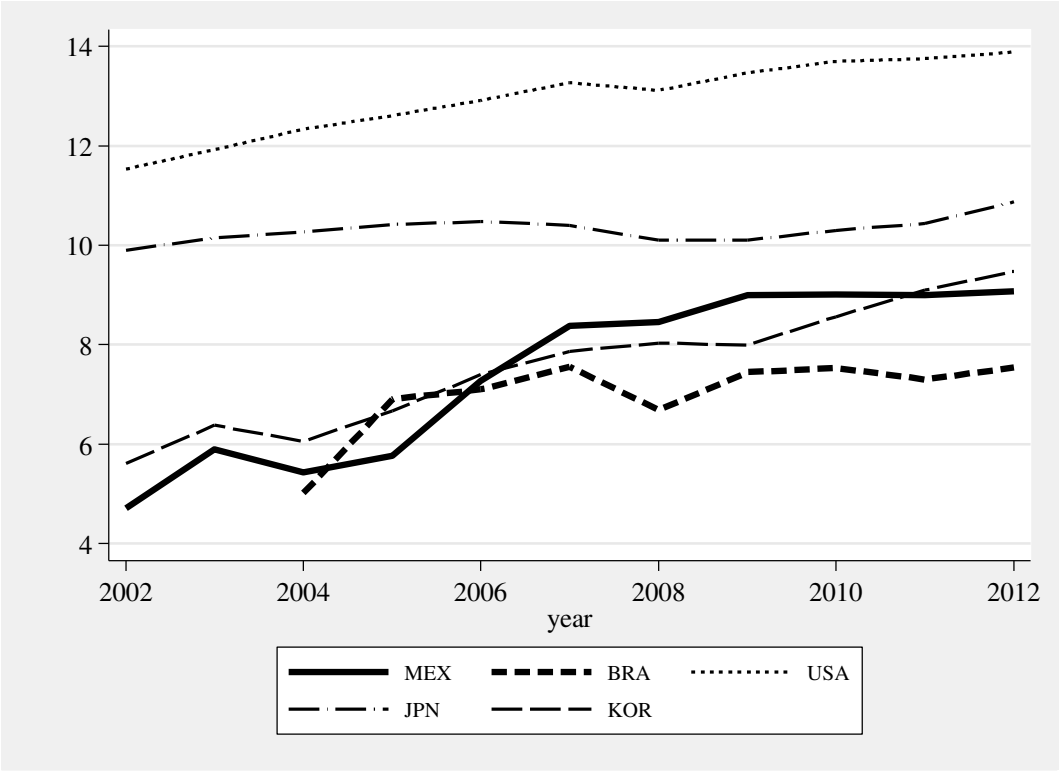

Fig.1. Exchange traded funds' absolute assets under management values growth trends. Estimates for Brazil, Japan, Mexico, South Korea and the United States. 2002-2012.
Source: Authors` estimates based on data derived from financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: On Y axis – logs of exchange traded funds' assets under management (in mln US Dollars). For Brazil data available since 2004.

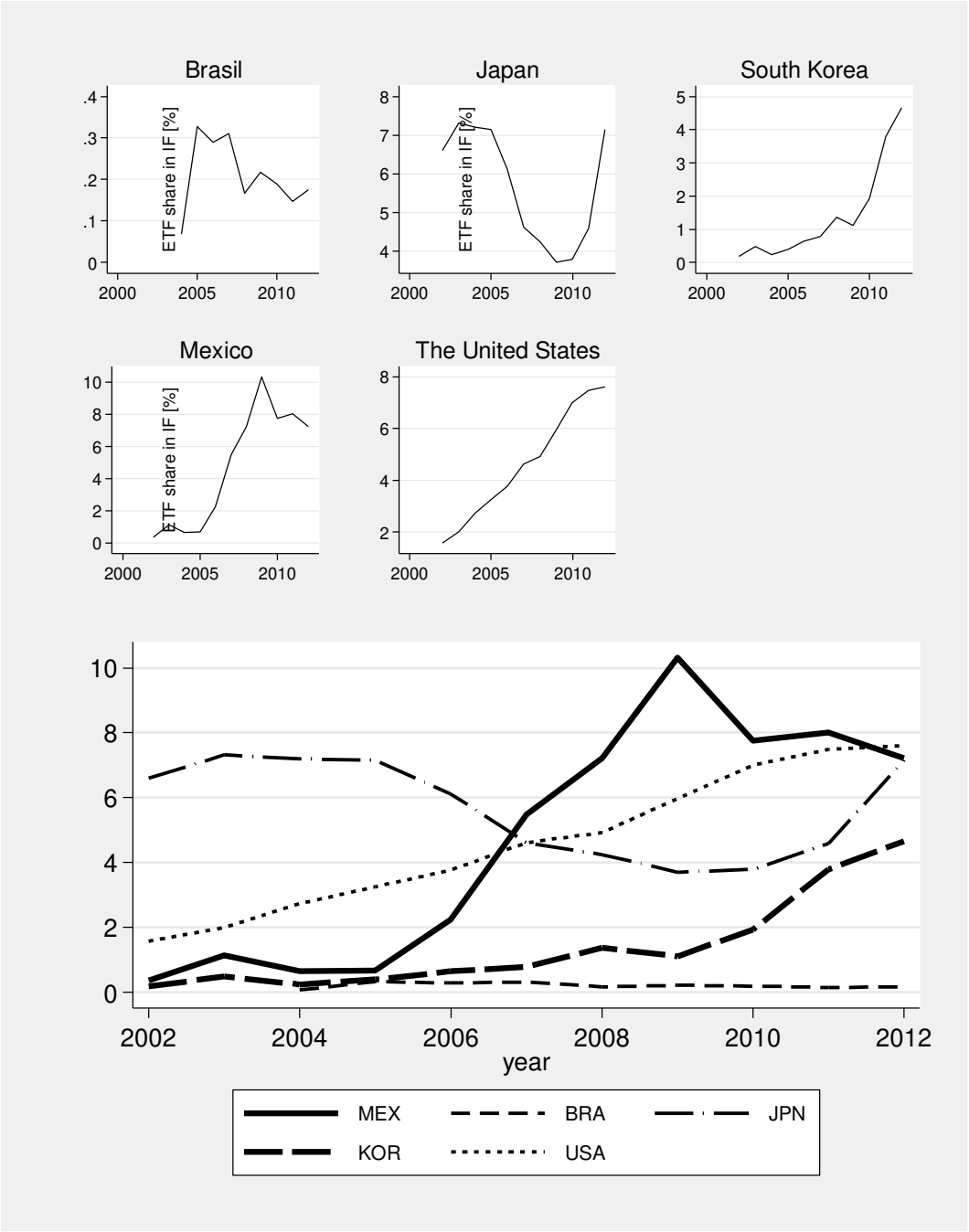

Fig.2. Growth of shares of exchange traded funds in total investment funds. Estimates for Brazil, Japan, Mexico, South Korea and the United States. 2002-2012.

Source: Authors` estimates based on data derived from financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: On Y axis: exchange traded funds' assets under management as share of total investment funds' assets under management (ETFs_share_IF$_{(i,y)}$)(%). For Brazil data available since 2004 (for years 2002 and 2003 – zero values imposed).

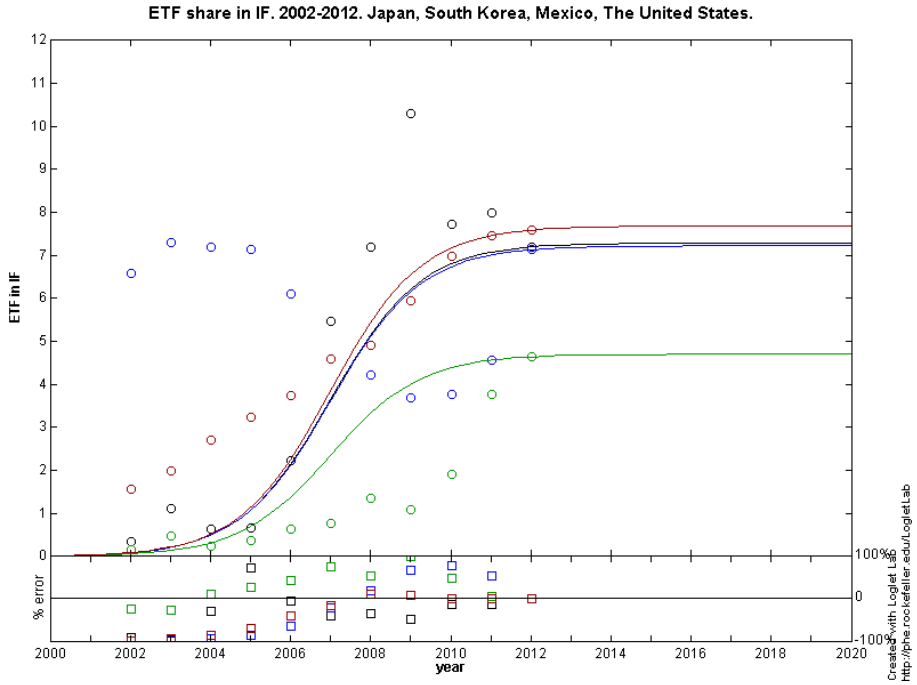

Fig. 3. Exchange traded funds' share in total investment funds. Japan, Mexico, South Korea and the United States. 2002-2012.

Source: Authors` elaboration based on data derived from financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: Logistic growth estimates using LogLet Lab2 software. Black dots and line represents Mexico; blue – Japan; green – Korea; red – the United States. Brazil – excluded from the specification. Dots represent observed values. Solid lines represent theoretical lines.

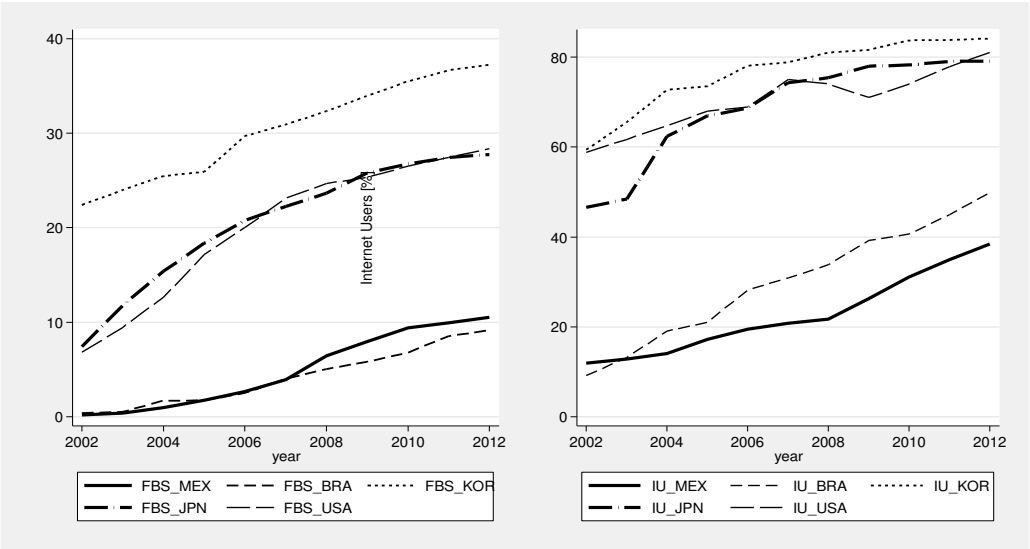

Fig.4. Information and communication technologies diffusion patterns in Brazil, Japan, Mexico, South Korea and the United States. 2002-2012.

Source: Authors` elaboration based on data derived from World Telecommunication/ICT Indicators Database 2013. Note: variables: IU - Internet Users (% of individuals using Internet), FBS - Fixed Broadband Subscribers (per 100 inhabitants). On Y axis – absolute values.

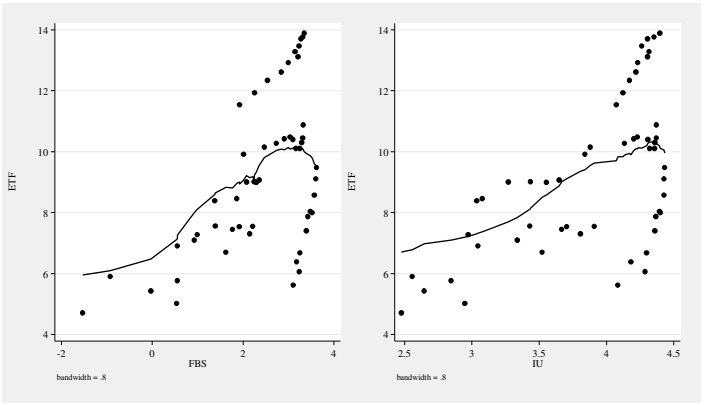

Fig.5. ETF market and ICT development. Brazil, Japan, Mexico, South Korea and the United States. 2002-2012.
Source: Authors` elaboration based on data derived from World Telecommunication/ICT Indicators Database 2013, financial statements of Brazilian ETF and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: Nonparametric graphical approximation using linear polynomial (mean: running-mean smooth). FBS – in logs; IU – in logs; LnETFs – log of exchange traded funds' assets under management absolute values (in mln US Dollars).

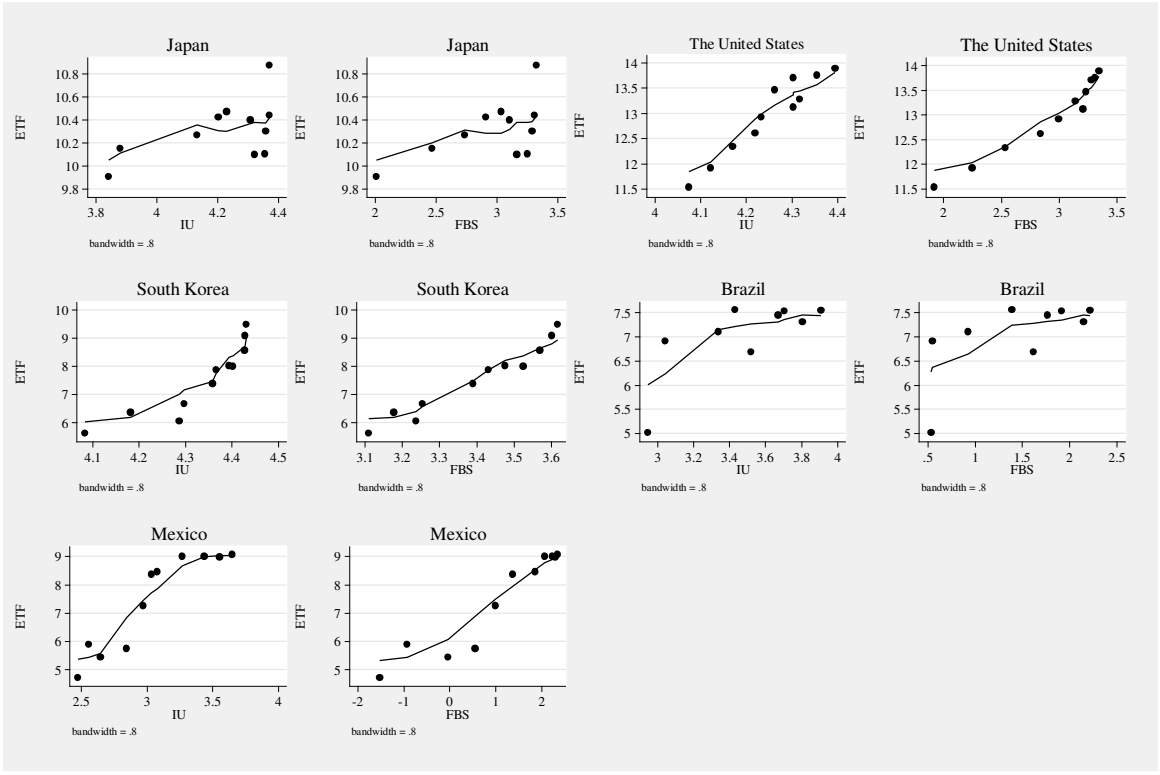

Fig. 6. Core ICT indicators *versus* exchange traded funds' absolute assets under management values. Brazil, Japan, Mexico, South Korea and the United States. 2002-2012.
Source: Authors` elaboration based on data derived from World Telecommunication/ICT Indicators Database 2013, financial statements of Brazilian ETF providers and other sources: (BlackRock 2011, 2012a, 2012b), (ICI, 2008, 2013), (JITA, 2014), (KRX, 2013). Note: Nonparametric graphical approximation using linear polynomial (mean: running-mean smooth). FBS – in logs; IU – in logs; LnETFs – log of exchange traded funds' assets under management absolute values (in mln US Dollars).

ANNEX A

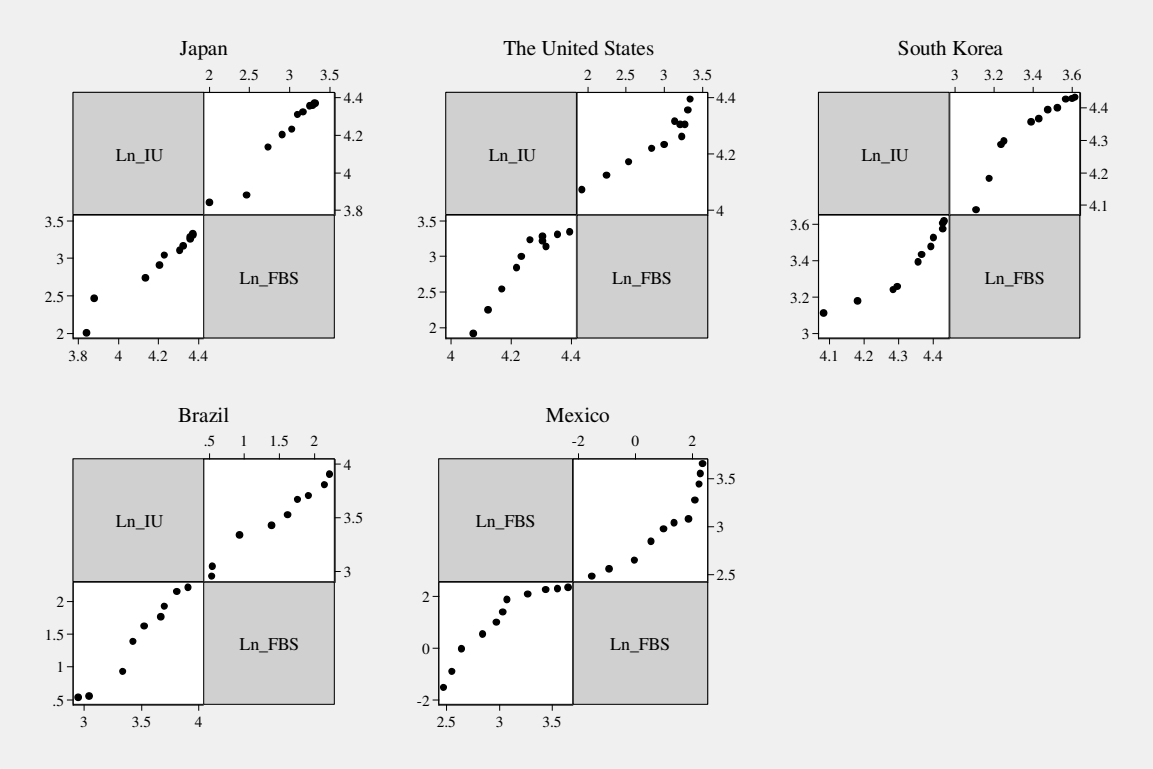

Fig. 7. Pair-wise correlations for $IU_{(i,y)}$ and $FBS_{(i,y)}$. Brazil, Japan, Mexico, South Korea and the United States. 2002-2012. *Source: Authors` elaboration based on data derived from World Telecommunication/ICT Indicators Database 2013.*

ANNEX B

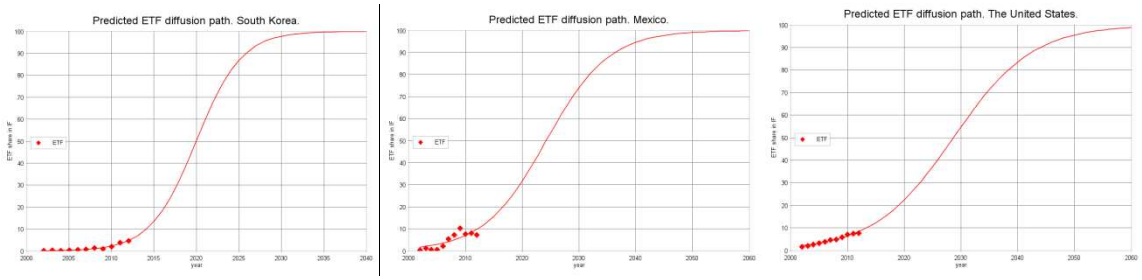

Fig. 8. Predicted (with fixed κ=100%) relative ETF market development patterns. Mexico, South Korea and the United States. *Source: Authors` elaboration using IIASA software.*