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## Reshaping financial systems. New technologies and financial innovations - Evidence from the United States, Mexico and Brazil

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GDAŃSK UNIVERSITY OF TECHNOLOGY  
FACULTY OF MANAGEMENT AND ECONOMICS

# RESHAPING FINANCIAL SYSTEMS. NEW TECHNOLOGIES AND FINANCIAL INNOVATION – EVIDENCE FROM THE UNITED STATES, MEXICO AND BRAZIL

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**RESHAPING FINANCIAL SYSTEMS.**  
**NEW TECHNOLOGIES AND FINANCIAL INNOVATIONS**  
**– EVIDENCE FROM THE UNITED STATES, MEXICO AND BRAZIL**

Ewa Lechman<sup>1</sup> & Adam Marszk<sup>2</sup>

***Abstract***

The paper unveils whether ICT diffusion determines development of financial innovation in emerging economies. Particularly, we examine the impact of ICT adoption on changing values of exchange traded funds in Brazil and Mexico, comparing it to the United States as reference country (benchmark). Our methodological framework includes descriptive statistics, logistic growth models (used to estimate ETFs growth) and generalized linear models (used to check for relationship between ICT adoption and ETFs value). In each case we run country-specific estimates. Data on ICT adoption (approximated by Internet Users and Fixed Broadband Subscriptions) are exclusively derived from World Telecommunication/ICT Indicators Database 2012 (16<sup>th</sup> edition), and exchange traded funds from funds' providers and reports published by BlackRock. Analysis period is set for 2000-2012. Empirical findings collectively conclude that in all three countries, growth of ICT was pervasive, and this was accompanied by fast development of exchange traded funds in Mexico and in the United States, measured by increases in assets under management. Moreover, in the period 2002-2012 Mexico has caught up with the United States in terms of ETFs share in total investment funds (sum of assets of ETFs and mutual funds). In Brazil, even though ETFs growth rates were high, in 2012 share of ETFs in investment funds remained at a relatively lower level of 0.17%. Additionally, the relationship between ICT adoption and ETFs development was reported as strong, positive and statistically significant in each of analyzed countries.

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

***Keywords:*** emerging markets, ICT, ETFs

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## 1. Introduction

Much of the recent theoretical and empirical work concentrates on issues associated with information and communication technologies (ICT) development in developing countries, as well as on financial market development. These two aspects, encouraging in themselves, however, are rarely combined in recent studies. It might be challenging and novel question to ask whether information and communication technologies adoption and usage in emerging economies have strong and positive impact on financial development.

Over last decades, emerging economies have become great example of “success stories” in terms of socio-economic development. Even though it is not fully understood how markets (economies) emerge, the phenomenon is broadly recognized. A unique combination of specific economic policy strategies, allowing countries to become free-market and international-trade oriented, drives economic development and growth. Along with the above-mentioned factors, due to financial liberalization, financial markets emerge, increasing inflows of foreign capital (Beck *et al.*, 2013). Emerging markets undergo deep institutional and social transformation, which generates changes in behavior and consumption patterns fostering high demand for new products, innovations and technological solutions. All these processes dramatically reshaped emerging economies landscape.

In most of emerging economies, unusual growth of information and communication technologies (see International Telecommunication Union ICT Statistics, 2013), plays undeniable role in economic development acceleration. One of the main advantages of rapid expansion of ICT in emerging economies is dynamic development of financial markets. This fosters foreign capital inflows, encouraging new investors, but also provides domestic participants with an opportunity to invest abroad. In such sense, research combining level of adoption of new information and communication technologies and financial markets development constitutes a good base for further analysis of benefits and gains of their rise in emerging economies.

Following this approach, we focus on emerging markets to test their development paths on the field of information and communication technologies and financial markets. Our major contribution to present state of knowledge consists in answering crucial questions on existing empirical links between ICT adoption and financial development (with emphasis on exchange traded funds (ETFs) development). For this purpose, we have selected two advanced (Kvint, 2009) emerging economies: Brazil and Mexico, and highly developed country – the United States, which we treat as benchmark in terms of ICT and financial system development. Apart from similar level of economic development (in terms of GDP *per capita* (see World Bank, 2013b)) other reasons for selecting Brazil and Mexico may be attributed to their geographical location as well as related institutional and cultural similarities (both countries are parts of the Latin America region) and, to a lesser extent, to the similarity of their financial systems (e.g. strong links with the United States) – while both countries share some features, they differ significantly in terms of the ETF market development. Selecting countries with a number of shared aspects enables us to focus on the impact of selected factor influencing the ETF market, i.e. ICT, and allows for deep analysis of country-specific trends. The empirical evidence covers period of 2000-2012.

The paper consists of 6 essential parts. Section two, preceded by introduction, introduces concepts and definitions in the area of financial innovations and information and communication technologies (ICT). This part of the paper is followed by third section that specifies sources of data and methodological procedures. Sections four and five are purely empirical. In these parts we investigate diffusion of ICT and the process of the ETF market development in selected economies, tracing quantitative links between them. Last section contains main findings and discussion.

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

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

In the recent years, the number of new financial innovations has grown significantly. Moreover, some of the innovations from the 1970s and 1980s have retained or even increased their popularity among market participants. Some of the most notable examples are linked with the private equity industry and are crucial factors in financial system transformation – innovations with the highest impact are particularly venture capital and leveraged buyout funds (Allen, 2012). New or modified products available for investors, new financial market technologies or institutions include e.g. credit default swaps (CDS), collateralized debt obligations (CDO), structured investment vehicles (SIV) and structured equity products. Some of the financial innovations have been created in order to improve allocation of resources outside the financial sector and are used, among others, in following areas: development and housing (e.g. CDOs or similar instruments) or environment and global health (e.g. state revolving funds, debt-for-nature swaps and cap-and-trade pollution markets). Development of some recent financial innovations (used from 1990s onwards) was spurred mostly by technological changes and decreased regulation constraints. This group includes both innovative instruments (e.g. ETFs; ETFs are also regarded as one type of financial companies (ICI, 2013)) and new trading mechanisms e.g. high frequency trading (HFT), labeled together as 'high speed' finance (Diaz-Rainey and Ibikunle, 2012).

High popularity of ETFs in a relatively short period after their creation is sometimes compared to success of financial futures. ETFs are currently among instruments most widely used by financial professionals. First ETFs were available in Canada in 1989 (on Toronto Stock Exchange), four years later they were launched in the United States, in 1999 in Asia (Hong Kong Tracker Fund) and in Europe in 2001 (Euro STOXX 50) (Deville, 2008). In their basic form ETFs are funds structured in order to closely replicate (track) performance of selected financial assets (usually financial markets indexes, in the beginning only stock market ones, later also fixed income and other); such exposure is achieved by buying physical stocks or other securities (Hehn, 2005). ETFs have some common features with conventional mutual funds, but there are notable differences outlined in more details later in the text. In 2000s rising stature of less liquid markets and increasing sophistication of offered investment opportunities led to the development of modified, more complex types of ETFs based on deeply changed underlying structures. Firstly, we describe the basic advantages of ETFs, next we analyze them in more detail with reference to their mechanisms and the role played by ICT.

Using ETFs as an alternative to conventional investment products provides market participants with a number of advantages. Particularly, ETFs may be regarded as a substitute for conventional mutual funds. One of the main advantages of ETFs, when compared with index funds (subclass of mutual funds, designed and managed with aim to replicate the index), is enabling investors to track selected market indices (mostly stock market ones) at lower cost (IMF, 2011) and tracking error (deviations of fund's return from the returns of tracked index) (Athma and Raj Kumar, 2011). Due to the fact that ETFs are listed and traded on stock exchanges (in contrast with index funds), they offer other relative benefits including higher liquidity, more efficient pricing mechanisms and hedging opportunities (Ramaswamy, 2011). Moreover, ETFs are considered to be more tax efficient than mutual funds (a result of difference in the redemption method) (Aggarwal, 2012). ETFs are used by various groups of investors, both institutional and retail ones. Second category can use these financial instruments to gain access to asset classes which may be otherwise unavailable for a number of reasons (e.g. high minimum investment requirement) (Diaz-Rainey and Ibikunle, 2012). Advantages of ETFs listed above attracted attention of a significant number of investors in countries with financial systems on different development levels and were main causes of the underlying growing

demand. While some of the funds invested in ETFs had its source in increased saving or sale of assets from other investment classes (i.e. other than collective investment), the process of transferring capital from conventional mutual funds to ETFs also occurred (its scale and significance in selected economies will be analyzed in later parts of the text).

Supply-side factors concerning the ETF market (as well as most other financial innovations) are linked with a variety of relatively recent developments in financial sector (initially mostly in advanced economies), influencing the rate of financial innovation (Frame and White, 2004) and being a consequence of introduction of new or modified financial instruments, changes in macroeconomic conditions, taxes or regulatory environments and adoption of new technologies (with ICT among the most crucial ones; financial sector is sometimes described as the major user of new technologies (Gani and Ngassam, 2003)), is particularly important in context of this research. To the best of our knowledge, theoretical links (as well as confirming empirical research) have not been much examined much in available literature. The role played by the above-mentioned factors should be analyzed with regard to the process of creation of ETFs and transactions conducted during market turnover. The course of these processes differs depending on the type of ETF. Two broad categories of ETF products offered are (according to the returns' replication scheme) plain-vanilla (physical) and derivatives-based (synthetic) (FSB, 2011). Synthetic ETFs are complex financial instruments, based on various structures consisting of derivatives, usually total return swaps (Awrey, 2013). Synthetic ETFs and other innovations in this part of capital market (e.g. leveraged and inverse ETFs) are assessed as exposing investors to new types of risks and potential threat to the stability of financial systems (FSB, 2011). Due to regulatory concerns and lack of sufficiently developed derivatives market, synthetic ETFs are seldom used in emerging economies.

Physical ETFs are the oldest and least complex type. Two key roles in the physical ETFs operational structure as well as creation and trading are played by financial institutions that act as ETF sponsors and authorized participants (market-makers); another market participants are secondary market investors and stock exchanges (Deville, 2008). Authorized participants are responsible for purchasing the securities underlying tracked index (i.e. shares of companies included in the broad market index) and delivering them to the sponsor (fund's trustee). In its initial form creation of plain-vanilla ETFs involved the purchase of all underlying securities, but due to related transaction and market impact costs or problems with obtaining required assets, an increasing number of managers (also on emerging markets) uses portfolio sampling techniques (purchasing only securities selected according to specified rules in order to minimize tracking error) (IMF, 2011). In exchange for the basket of securities authorized participants receive creation units (these transactions take place on the primary market) (Ramaswamy, 2011).

Creation units (i.e. fund shares) received by authorized participants may then be sold on the secondary market to e.g. other institutional investors or retail market participants who can conduct transactions in ETF shares through the stock exchanges, without the intermediation of authorized participants (Aggarwal, 2012). Higher level of technological advancement of such exchange's trading system (i.e. higher speed of operations, wider access to market data and more transaction timing opportunities) is linked with adoption of ICT, and includes wider access to Internet and higher network bandwidth (i.e. organizational innovation permitted by more advanced physical technologies (Frame and White, 2004)). It should result in increased demand for these instruments as their advantages in relation to mutual funds, such as lower costs (there are no management fees or sales loads, main cost is brokerage commission), are magnified (Hehn, 2005). Another related advantage of ETFs is higher liquidity, i.e. enabling the investors to buy or redeem their shares nearly instantly during stock trading hours at a known price, established in the course of market transactions (similarly to other listed securities), in contrast with longer execution of

transactions and redemption value uncertainty characteristic for conventional mutual funds, in which it may be established even a few days after the investor's decision and based on changes asset values. As a result, potential link (concerning transactions on the secondary market) between wider introduction of ICT and the development of the ETF market may be stated. Moreover, another possible link is the increased participation of retail investors on the stock market and higher demand for available securities (including ETFs), resulting from wider usage of the Internet as well as other related communication technologies (e.g. wireless networks) and more convenient access to up-to-date market information and brokerage accounts (in some cases, mostly in less developed countries, it may be the sole opportunity for such participation in remote areas, with limited access to newspapers and bank offices). This process may be magnified due to the positive feedback between the number of market participants and financial instrument's liquidity (caused by e.g. higher probability of finding market player willing to conduct opposite transaction). In context of economic development all effects described above may be regarded as positively influencing quality of country's human capital mainly by increasing general economic knowledge (Gani and Ngassam, 2003).

Primary market for ETFs plays a vital role in enabling proper functioning of other features of analyzed instruments advantageous for investors. The crucial feature of ETFs is their "in-kind" redemption process. Investors willing to redeem owned fund shares can receive securities that comprise the ETF rather than cash ((as in method characteristic for mutual funds) (Deville, 2008). Such mechanism in many countries does not result in a taxable event, whereas mutual funds are confronted with selling securities which (during a period of increasing market prices) leads to taxable capital gains. Another benefits related to the outlined redemption process are the ability of fund managers to hold fully invested portfolios (minimum cash balances, in contrast with mutual funds) and significantly reduced trading costs during the redemption process as no assets need to be sold. Apart from lower costs, one of the most important advantages of ETFs, i.e. low tracking error is also a result of both primary and secondary market arbitrage transactions that ensure that market value of underlying fund securities (their net asset value (NAV)) and ETF's shares remain on similar levels (Aggarwal, 2012). In case of intensive market activity some departures are possible but they should be limited by actions of market makers in form of redeeming owned ETF shares (if their prices are below the NAV of securities used to create funds shares) which leads to higher prices, closer to NAV or (in the opposite scenario) depositing securities at fund sponsor and receiving overvalued ETF shares, increasing their supply. Correct functioning of the "in-kind" ETF redemption with benefits for market participants mentioned above is not possible without ample stock exchanges' trading systems, similarly to trading that takes place on the secondary market. Arbitrage transactions need to be conducted with maximally limited time delays and transaction costs (including e.g. costs linked with inability to find second party of the transaction) as well as access to up-to-date market information, particularly concerning prices of both underlying securities and shares of ETFs.

Currently, the largest category of ETFs linked with emerging economies are funds listed and traded exclusively or primarily on stock exchanges in highly developed countries, aiming to replicate foreign assets. However, rapidly growing category of ETFs, yet relatively neglected in research concerning this kind of financial innovations, are products listed on exchanges in countries other than the developed ones. Benefits of ETFs outlined in the preceding paragraphs and enabled to a large extent by the adoption of ICT are particularly significant on less advanced financial markets where use of various financial instruments is far more limited than in developed countries due to a number of factors, such as lower households' incomes. The most significant group of such economies in terms of the role played in shaping the global economy is emerging markets.

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, due to lower minimum investment required (one share of ETF) than in conventional mutual funds (in mature economies this advantage also applies, but is less important because of larger income and wealth of citizens). Moreover, relatively higher liquidity should also be perceived as one of the key factors of ETFs market development, as insufficient liquidity of various financial assets is among the most significant barriers preventing both foreign and domestic investors from investing in them (Bekaert *et al.*, 2007). ETF market development in emerging countries has also been spurred by the activity of the global financial groups (with BlackRock as the world's leader, offering iShares ETFs (BlackRock, 2012a)), which manage most such products and offer them responding to needs of various clients seeking linked benefits (including the ones from developed countries seeking exposure to markets with higher growth potential). Most such products are offered on emerging markets which attract biggest attention of global investing audience, i.e. some of BRIC (Brazil, Russian, India, China) countries or in other countries with strong economic ties with more developed economies and limited foreign investments' restrictions – as a result, financial instruments used first in developed economies are relatively quickly and on a large scale introduced in emerging economies. Example of country from the second category is Mexico, where economic situation, including financial markets, is strongly dependent upon state of the US economy and the ETFs market, as described later, is relatively developed. Introduction and increased popularity of ETFs listed on emerging stock markets managed by global investment companies was possible as a result of increased sophistication of financial markets (linked with the adoption of more technologically advanced solutions), proceeding liberalization of capital flows and changes in legal environment. Another factor increasing demand for ETFs on emerging markets is a result of introduction of ETFs with exposure to advanced markets thus allowing local investors (including retail) to gain easier indirect access to foreign investments, enabled to a large extent by the broader adoption of ICT (linkages described in the following section).

## **2.2. New technologies for financial markets development – tracing hypothetical links.**

Information and communication technologies (ICT) refer to any product that allows storing, transmitting, dissemination of information and knowledge. ICT are tools that provide enormous changes to national economy (Sung, 2009) by offering new opportunities and radically transforming economic activities, social capabilities and environment. They represent significant channels (James, 2009) of knowledge and information acquiring, allow for switching from “old” to “new” ways of doing business. Thanks to wide adoption of ICT, countries reshape their national markets, gradually transforming them into digital economies<sup>3</sup> (Tseng, 2009).

Along with huge changes in country's economy, domestic output or labor market structure, ICT contribute profoundly to reshaping global, regional and national financial markets. In globalized world, technology development is a necessary condition for financial markets advancement. Countries lagging behind in terms of technology tend to lag behind in terms of general socio-economic development and are permanently unable to join global markets, becoming peripheral regions. In the era of digital economy, broad access to new technological infrastructure and tools becomes a prerequisite for inclusion of emerging economies in the global financial systems.

It is undoubted that technology and financial markets development have become interrelated and reinforce each other. These two are highly complementary, as development of one of them conditions development of the second. Due to unique features of ICT, their role in fostering financial markets development is prominent. ICT disseminate

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<sup>3</sup> The concept of „digital economy” refers to an economy which functioning is based on digital technologies.



fast in emerging markets, as they usually require minimal hard infrastructure to be adopted, and can be used effectively by those with low skills and education. Information and communication technologies contribute to significant empowerment of those named as “have” *vis-à-vis* those who “have not”. By their relative cheapness and easiness to adopt, they provide people with access to new opportunities, freeing them from different forms of discrimination and limitations in access to financial markets and financial transactions. Due to the above-mentioned, financial markets gain more actors, becoming more competitive and effective. ICT allow opening domestic financial markets by attracting foreign investors, enhancing introduction of new innovative financial instruments (Frame and White, 2004), contributing to financial markets liquidity and capital market capitalization. Due to ICT usage, an important market failure, information asymmetries, can be significantly reduced. Free and unbound flow of information constitutes a prerequisite for financial markets to work efficiently. In addition, ICT usage in financial markets transactions helps to overcome barrier of physical distance, letting peripheral regions and countries become an important participant of global financial markets. Growing financial openness and deepening of domestic financial markets in emerging countries results in their gradual inclusion in globalized financial system. Out of wide range of information and communication technologies offered to the audience, access to high-speed Internet (broadband Internet) is of special importance. Communications systems based on wide bandwidth enjoy huge information-carrying capacity in different channels. Broadband connections are fast and facilitate effective information dissemination and sharing.

With regard to financial innovation presented in the previous part of the paper, i.e. ETFs, apart from the described impact of ICT on the development of the secondary ETF market (resulting from increased benefits), some other linkages can be observed on primary market, on which in-kind redemption process occurs. More sophisticated exchange turnover systems, based on widely adopted ICT, give financial institutions enhanced transactional possibilities – one basic example may include replacing open outcry systems with fully computerized, constantly improved ones, in which participants (usually through the Internet) instantly gain access to data on market prices of securities and may use such information to conduct arbitrage operations (reduced information asymmetries leading to decreased tracking error). On capital markets with undeveloped transaction systems departures of prices from the NAV may sustain, thus decreasing the attractiveness of this instrument in comparison with conventional mutual funds and being one of key barriers in the ETFs’ market development. Transferring securities between fund’s sponsor and authorized participants, part of creation, as well as redemption of ETF’s shares, requires advanced financial transactions’ clearing systems in order to ensure the timeliness and correctness of operations – such systems are constructed and operate based on fast broadband Internet connections.

The impact of ICT on the ETFs market is also linked to other benefit, i.e. possibility of gaining exposure to foreign markets by buying ETFs listed on the domestic stock exchange. Technologically advanced trading systems on both markets (i.e. also on emerging markets, which in the United States are the biggest group of ETFs in this category (ICI, 2013) are required in order to create such funds and conduct arbitrage transactions with high speed and at low costs, thus ensuring the attractiveness of ETFs. Similar feature is cross-listing of ETFs, i.e. listing given instrument on more than one stock exchange, resulting in a wider group of potential clients. Therefore, ICT are essential for fast and sustainable development of financial markets and instruments in emerging economies, including financial innovations like ETFs.

### 3. Data rationale and methodological strategy

#### 3.1. Data.

Our study covers two sets of data. Firstly, we refer to two categories of investment companies (defined in ICI, 2013):

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

We labeled investment companies from these two categories together as ‘investment funds’ (IF). Such choice was made in order to analyze changing market shares of the two investment options which can be to a large degree regarded as substitutes (particularly when the subcategory of mutual funds, i.e. index funds, is taken into account). Definition of ETFs and their detailed features were presented in the preceding sections of the paper. In the initial analysis, due to data availability issues, we also used a wider category of investment products – exchange traded products, ETPs, i.e. portfolio exposure securities that may be traded intra-day on one or more exchanges, including in addition to ETFs other similar, more recently introduced instruments (with analogous mechanisms) such as exchange traded notes (ETNs) and exchange traded commodities (ETCs) (BlackRock, 2012b). However, in the next parts of our analysis, we focused only on the ETFs market. The concept of mutual fund used in the research was based on the definition by 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 their current NAV (ICI, 2013).

For financial data, time period analyzed is from 2002 (or the year first ETFs were launched on the local market in case of Brazil) to 2012 (year-end data are used). The indicator analyzed in our research is assets under management (AUM), i.e. value of assets managed by an investment company calculated using market prices (BlackRock, 2012b); for ETFs, only funds domiciled in a given country are taken into account (cross-listings were omitted). Data for the mutual funds’ assets in the years 2002-2012 were derived from ICI Investment Company Fact Book (2008 48<sup>th</sup> and 2013 53<sup>rd</sup> editions) (ICI, 2008, 2013). For Brazil, ETFs’ assets dataset was derived from financial reports published by companies managing local funds, for Mexico it was based on our estimates calculated using data on Brazil and Latin America statistics published by BlackRock Advisors and BlackRock Investment Institute (Blackrock, 2011, 2012a). For the United States, such data were taken from BlackRock’s ETP Landscape (Blackrock, 2012a). Data for Brazil in local currency (BRL) were converted into USD using year-end official exchange rates (derived from World Bank, 2013b). Supplementary data on financial development level in Brazil and Mexico (including financial system’s assets and stock market’s indicators) were derived from The Global Financial Development Database (World Bank, 2013a) and World Development Indicators (World Bank, 2013b).

As a result, our data on AUM of mutual funds and ETFs cover period 2002-2012 in case of Mexico and the United States, and 2004-2012 in case of Brazil (first ETFs in Brazil were listed on the local exchange in 2004).

In line with main goals of the paper, we adopt second set of data, to approximate level of technological development of countries (referring to ICT). The most commonly used measures of country’s advancement on the field of adoption of ICT are:

- Internet Users (individuals) as share of total population;
- Fixed Broadband Subscriptions per 100 inhabitants.

Selected ICT variables provide direct information on ICT infrastructure (Fixed Broadband Subscribers), access and usage (Internet Users) coherently describing country’s individual achievements in the field and enabling tracing progress in technological development. Applied time-series, for the period 2000 – 2012, were exclusively derived from World Telecommunication/ICT Indicators Database 2012 (16<sup>th</sup> edition).

To complete empirical part of the paper, we developed strongly balanced dataset, covering five different variables, for selected countries (Brazil, Mexico and the United States). For further clarity, we named sequent variables as: Investment Funds –  $IF_{(i,y)}$ ; Exchange Traded Funds –  $ETFs_{(i,y)}$ ; Exchange Traded Funds share in Investment Funds –  $ETFs\_share\_IF_{(i,y)}$ ; Internet Users as share of total population –  $IU_{(i,y)}$ ; Fixed Broadband Subscriptions per 100 inhabitants –  $FBS_{(i,y)}$ , where  $i$  denotes country and  $y$  – year.

### 3.2. Empirical strategy.

Our empirical procedure adopts simple logistic growth (SLG) models (Geroski, 2000; De Guio and Kucharavy, 2007) which are traditionally applied to describe technology diffusion process (Rogers, 1962; Michalakelis *et al.*, 2010). The logistic growth model can be formally specified as:

$$G(t) = e^{\alpha t + \beta} \quad (1)$$

where independent variables is time ( $t$ ),  $\alpha$  presents growth rate, and  $\beta$  explains location parameter which shifts the growth curve horizontally (Lechman, 2013). However, in formula (1) no upper growth limits are imposed. As systems usually have limited growth capacities, we add to (1), growth limits defined by  $\kappa$ :

$$\frac{dG(t)}{dt} = \alpha G(t) \left(1 - \frac{G(t)}{\kappa}\right) \quad (2).$$

As  $G(t)$  reaches  $\kappa$ , the  $\alpha \rightarrow 0$ , and the exponential curve tends to resemble S-shaped pattern. Following (2), we formulate logistic growth model with upper limits imposed:

$$G(t) = \frac{\kappa}{1 + e^{-\alpha t - \beta}} \quad (3).$$

In equation (3),  $\kappa$  - denotes upper growth limit (upper asymptote),  $\alpha$  - specific duration (growth time from 10% to 90% of saturation), and  $\beta$  - midpoint of the curve ( $0,5\kappa$ ) (Kwaśnicki, 2013).

The (3) we can reformulate as:

$$G(t) = \frac{\kappa}{1 + \exp\left(-\frac{\ln(81)}{\Delta t}(t - t_m)\right)} \quad (4)$$

where  $t_m$  defines  $\beta = -t_m\alpha$ , and expresses midpoint of growth process ( $=\kappa/2$ ), while  $\Delta t$  specifies time needed to pass from 10% to 90% level of saturation ( $\kappa$ ).

Additionally, we apply generalized linear model (GLM) (Verbeke and Molenberghs, 2005), and its general form follows:

$$y_{(i)} = \gamma_0 + \gamma_1 x_{1(i)} + \dots + \gamma_n x_{n(i)} + \varepsilon_i \quad (5)$$

where the response variable is  $y_{(i)}$ , explanatory variables are  $x_{(j)}$ , while  $j = 1, \dots, n$  and  $\varepsilon_i$  is an error term. The simple form of (5), referring to hypothetical dependence on explanatory variable, is defined as:

$$y_{(i)} = \gamma_0 + \gamma_1 x_{1(i)} + \varepsilon_i \quad (6).$$

Again in (6) we specify covariates like:  $y_{(i)}$  – response variables,  $x_{(i)}$  – explanatory variables (linear predictors). For error terms we assume  $\varepsilon_i \sim N(0, \sigma^2)$ . The  $\gamma_0$  stands for constant, and  $\gamma_1$  predicts ICT potential changes in  $y_{(i)}$  for one-unit change in  $x_{(i)}$  (*ceteris paribus*). In the empirical part of the paper, we aim to test country-specific models preliminary defined as:

$$y_{(i)} = \gamma_0 + \gamma_1 FBS_{(i)} + \gamma_2 IU_{(i)} + \varepsilon_i \quad (7)$$

where  $i$  – denotes country.

#### 4. Exchange traded funds and ICT development trends – preliminary analysis

Total value (AUM) of the global ETPs market amounted (all data, unless noted otherwise, as end of September 2012) to \$1.85 trillion and the major group of ETPs were ETFs (89% of the total); the number of ETPs listed worldwide was 4748 (3297 ETFs and 1451 other products) (Blackrock, 2012a). Compared with 2002, when global assets of ETPs were \$145.7 billion, this meant a twelvefold increase and compound annual growth rate of ca. 30%. ETPs market is highly concentrated: 10 largest products account for 25% and 10 providers (ETPs managers) account for 84% of the total AUM. Most important categories in terms of AUM in 2012 were products offering exposure to: equity (69.9% of the total), fixed income (17.4%) and commodities (11.2%). ETPs with exposure to emerging markets 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, i.e. US and Canadian, and fixed income as a whole). It should be noted, though, that most of 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 of securities traded in 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).

Financial systems of the two analyzed emerging economies, Brazil and Mexico, differ significantly in terms of their size in relation to GDP – the sum of all their segments, i.e. total capitalization of capital markets (market value of all traded securities (Marszk, 2012)) and credit provided to private sector, at the end of 2011 amounted in Brazil to ca. 183% of GDP and in Mexico to ca. 99%; over the period 2002-2011 the compound annual rate of growth in Brazil was ca. 6.7% and in Mexico ca. 5.7% (World Bank, 2013a). Both systems are notably underdeveloped compared with advanced economies (total financial stock in 2011 in Brazil reached ca. 50% of the advanced systems' average value (Lund *et al.*, 2011)). Main part of the Mexican financial sector is the local stock market (with average share of the stock market capitalization in the 2002-2011 period total financial stock at ca. 35% and 61% higher value than the sum of banking credit provided to the private sector in 2012) In Brazil, despite similar average stock market's share value between 2002 and 2011, in the recent years banking sector has become the major segment (with total value ca. 25% higher). Such trend was caused mainly by sharp equity prices declines due to, among others, the euro zone crisis (Marszk, 2012). Level of the stock market development may be regarded as one of the factors influencing the ETPs market because, as noted before, most such products offer exposure to the stock prices and the process of creation and trading (including arbitrage transactions) takes place in that part of the financial system.

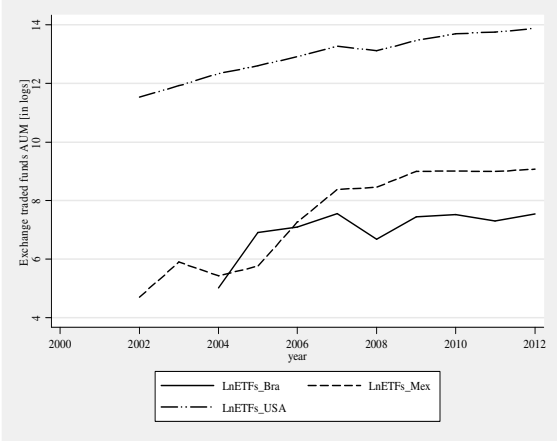
Table 1 (see below) provides an overview of the ETF market development in selected economies, in the period 2002-2012 (in Brazil since 2004). Additionally, Figures 1, 2 and 3 present graphical approximation of ETFs total values and ETFs' share in IF (sum of AUM of ETFs and mutual funds) ( $ETFs\_share\_IF_{(t)}$ ).

**Table 1. Summary statistics on assets under management of exchange traded funds. Brazil, Mexico, the United States. 2002-2012.**

	Average annual ETFs AUM growth (%)	Total growth of ETFs AUM (2002-2012) (%)	ETFs share in IF (%)2002	ETFs share in IF (%)2012	Highest value of ETFs share in IF (2002-2012) (%)	Average ETFs share in IF (2002-2012) (%)	Total growth of ETFs share in IF (2002-2012) (%pp)
Brazil (a)	31.5	1 145.50	0.00	0.17	0.21 (y2009)	0.17	0.17
Mexico	43.6	7 868.3	0.35	7.21	10.31 (y2009)	4.63	6.85
United States	23.5	1 050.3	1.57	7.6	7.6 (y2012)	4.62	6.03

Source: Own calculations based on data derived from financial statements of Brazilian ETF providers and BlackRock (2011, 2012a, 2012b), (ICI, 2008, 2013). Note: AUM – assets under management; ETFs – exchange traded funds; IF- Investment Funds. (a) – for Brazil estimates start in 2004.

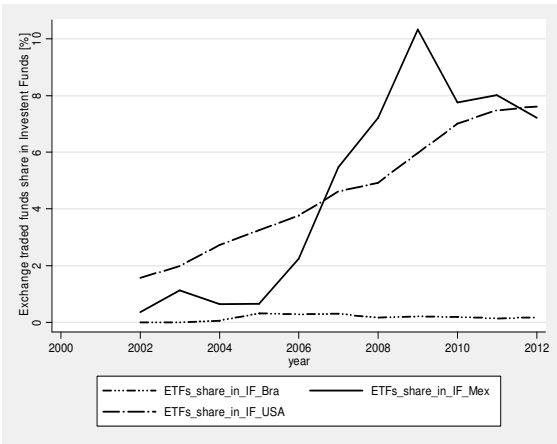
Out of the two emerging economies analyzed (Brazil and Mexico), listed ETFs with the larger AUM at the end of December 2012 were available in Mexico (\$8.73 billion), in Brazil their AUM was \$1.88 billion. In 2002 AUM of ETFs listed in Mexico was \$110.9 million (average annual growth over 10 years amounted to 43.6%). In Brazil first ETFs were introduced in 2004 – at the end of that year total assets value reached \$150.5 million (meaning 31.5% average annual growth over 8-year period). To compare, ETF market in the United States (at the end of 2012 largest in the world in terms of both AUM and number of listed products (BlackRock 2012b) from 2002 to 2012 has increased from \$102 billion to \$1.08 trillion in assets (average annual growth rate of 23.5%, however, much lower than in analyzed emerging markets, signaling possible higher saturation).



**Fig.1. Exchange traded funds’ absolute assets under management values growth trends. Estimates for Brazil, Mexico and the United States. 2002-2012.**

Source: Own estimates based on data derived from financial statements of Brazilian ETF providers and BlackRock (2011, 2012a, 2012b). Note: On Y axis – logs of exchange traded funds’ assets under management (in mln US Dollars). For Brazil data available since 2004.

Share of exchange traded funds in investment funds ( $ETFs\_share\_IF_{(t,y)}$ ) and dynamics of this metric differed significantly in selected countries (see Table 1 above) in the period 2002-2012. If we take into account changing share of exchange traded funds in total investment funds  $ETFs\_share\_IF_{(t,y)}$ , the picture revealed in Figure 2 is quite evident.



**Fig.2. Growth of shares of exchange traded funds in total investment funds. Evidence for Brazil, Mexico and the United States. 2002-2012.**

Source: Own estimates based on data derived from financial statements of Brazilian ETF providers and BlackRock (2011, 2012a, 2012b), (ICI, 2008, 2013). Note: On Y axis: exchange traded funds’ assets under management as share of total investment funds’ assets under management ( $ETFs\_share\_IF_{(t,y)}$ )(%). For Brazil data available since 2004 (for years 2002 and 2003 – zero values imposed).

Over the analyzed period 2002-2012, both in Mexico and in the United States, constant and dynamic growth of  $ETFs\_share\_IF_{(Mexico,2002-2012)}$  and  $ETFs\_share\_IF_{(U.S.A,2002-2012)}$  was reported. For the United States, growth of exchange traded funds share in investment funds is stable (see empirical line in Fig. 2), and in the period 2002-2012 grew from  $ETFs\_share\_IF_{(U.S.A,2002)}=1.57\%$  to  $ETFs\_share\_IF_{(U.S.A,2012)}=7.6\%$ . The value of  $ETFs\_share\_IF_{(U.S.A,2012)}=7.6\%$  is also the highest out of the reported in the analyzed period. In Mexico, the empirical line showing changes in  $ETFs\_share\_IF_{(Mex,2002-2012)}$  again proves high dynamism of the process. However, the growth of  $ETFs\_share\_IF_{(Mex,2002-2012)}$  is marked by three characteristic phases. In years 2002-2005 we note relative stabilization when  $ETFs\_share\_IF_{(Mex,2002-2012)}$  is low. The starting point for dynamic growth of ETFs in Mexico was year 2005. In Mexico, in the period 2005-2009, share of exchange traded funds grew from  $ETFs\_share\_IF_{(Mex,2005)}=0.6\%$ , to  $ETFs\_share\_IF_{(Mex,2009)}=10.31\%$ . It is worth noting that in 2009 in Mexico, level of ETFs' share in investment funds exceeded analogous value in the United States. After reaching the peak in 2009, in Mexico the  $ETFs\_share\_IF_{(Mex,y)}$  started to fall gradually, finally reaching in 2012 -  $ETFs\_share\_IF_{(Mex,2012)}=7.21\%$ .

Dramatically different picture is revealed in case of Brazil. Over the whole period, 2004-2012, no significant growth in value of  $ETFs\_share\_IF_{(Bri,2004-2012)}$  was reported. In 2004, when ETFs were firstly introduced to financial market in Brazil, the share of these instruments in investment funds was at 0.06%, and in 2012 it grew only to 0.17%. Together with data concerning the value of assets it may indicate that Brazilian market was the least developed one. Comparing to countries such as Mexico and the United States, share of Brazilian ETFs in total investment funds remained at considerably low level.

To shed more light on growth trajectories of  $ETFs\_share\_in\_IF_{(i,y)}$ , we follow the empirical procedure specified in section 3.2 and approximate growth trajectories of ETFs expressed as share of total investment funds –  $ETF\_share\_IF_{(i,y)}$ . We treat  $ETFs\_share\_IF_{(i)}$  as estimated level of saturation expressed by  $\kappa$  in logistic growth model (see equation 3). To examine growth patterns of ETFs in investment funds, we adjust equation (3), and run country-specific logistic growth models estimates, defined as:

$$G(t) = \frac{\kappa(i,y)}{1 + e^{-\alpha(i,y)t - \beta(i,y)}} \quad (8)$$

where  $i$  – denotes country, and  $y$  – year.

Figure 3 (below) plots theoretical and empirical “diffusion” trajectories of  $ETF\_share\_IF_{(i,y)}$  in Brazil, Mexico and in the United States separately, in the period 2002-2012<sup>4</sup>. Using individual countries' empirical data on  $ETF\_share\_IF_{(i,y)}$ , we have estimated (*ceteris paribus*) the logistic growth model parameters. The results are presented in Table 2 below.

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<sup>4</sup> For Brazil: 2004-2012.



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

Source: Own elaboration based on data derived from financial statements of Brazilian ETF providers and BlackRock (2011, 2012a, 2012b), (ICI, 2008, 2013). Note: Logistic growth estimates using LogLet Lab2 software. Black dots and line represents Brazil; blue – Mexico; green – the United States. For Brazil – data available since 2004. Solid line represents theoretical line.

As shown in Figure 3, in case of Mexico and the United States, growth of share of ETFs in investment funds is well described by exponential function and presents good fits to the logistic curve. In case of Mexico, the characteristic phases of S-shaped curve are easily distinguishable. The logistic curve, however, cannot be modeled for Brazil, as we observe high frequencies of changing  $ETF\_share\_IF_{(Bra,y)}$  values in the period 2004-2012 (individual curve for Brazil is put in Appendix, see end of the paper).

**Table 2. Exchange traded funds share in total investment funds growth estimates. Brazil, Mexico and the United States. 2002-2012.**

	Saturation ( $\kappa$ ) (%)	Midpoint ( $\beta$ ) (year, months)	Specific duration ( $\alpha$ ) (years)	R-square
<i>Brazil</i>				
Logistic growth estimates (1)	0.18	2007.6	6.08	0.00
Logistic growth estimates (2)	11	not applicable	not applicable	not applicable
<i>Mexico</i>				
Logistic growth estimates (1)	8.26	2006.6	2.59	0.948
Logistic growth estimates (2)	11	2007.5	7.91	0.831
<i>United States</i>				
Logistic growth estimates (1)	8.55	2006.6	13.14	0.992
Logistic growth estimates (2)	11	2008.3	16.45	0.991

Source: Own estimates based on data derived from financial statements of Brazilian ETF providers and BlackRock (2011, 2012a, 2012b), (ICI, 2008, 2013). Note: Logistic growth model fits. Saturation ( $\kappa$ ) – stands for actual/potential level of  $ETF\_share\_IF_{(i,y)}$ ; midpoint ( $\beta$ ) – indicates specific time (year, month) when  $ETF\_share\_IF_{(i,y)}$  reaches  $0,5\kappa$ ; specific duration ( $\alpha$ ) – expressed in years, specific time needed for  $ETF\_share\_IF_{(i,y)}$  to pass from 10% to 90% of  $ETF\_share\_IF_{(i,2012)}$  in 2012. Logistic growth estimates (2) – estimates of  $\beta$  and  $\alpha$  parameters with assumed theoretical  $\kappa = 11\%$  (hypothetical value). Estimates completed applying LogLet Lab2 and ILSA software.

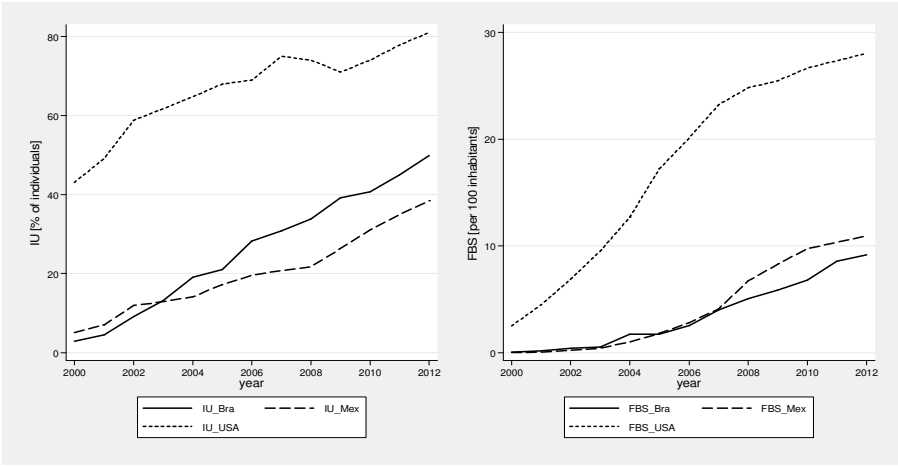
As stated previously, in case of Brazil, it is hardly possible to estimate reliable logistic growth model parameters (following equation (8)), which is mainly due to significant rises and falls in  $ETF\_share\_IF_{(Bra,y)}$  values. Volatility of the Brazilian market precludes the use of the logistic curve models. Although the parameters  $\kappa$ ,  $\beta$  and  $\alpha$  are reported in Table 2, the R-square = 0 which demonstrates inability of fitting empirical data to S-shaped trajectory. However, estimated parameters for Mexico and the United States are reasonable and values of R-square close to 1 reflects good

fitting of empirical data to theoretical logistic line. The maximum share of ETFs in investment funds in Mexico, approximated by  $\kappa$ , equals  $\kappa_{(Mex)}=8.26\%$ , while in the United States -  $\kappa_{(USA)}=8.55\%$ . If ETFs in investment funds evolved as predicted by country's individual logistic growth model, in Mexico  $\beta_{(Mex)}=2006.6$  and  $\alpha_{(Mex)}=2.59$ , while in the United States -  $\beta_{(USA)}=2007.5$  and  $\alpha_{(USA)}=13.14$ . Differences in  $\alpha$  parameter estimates are caused by higher rate of “diffusion” of  $ETFs\_share\_IF$  in Mexico than in the United States in the analyzed period.

In Table 2, estimates denoted as *Logistic Growth Estimates (2)* present predictions for Mexico and the United States, imposing upper limit of growth of  $ETFs\_share\_IF_{(t,y)}$  as  $\kappa=11.0\%$ . The possible scenarios of  $ETFs\_share\_IF_{(t,y)}$  growth evolution with  $\kappa$  fixed, is characterized by different  $\beta_{(t)}$  and  $\alpha_{(t)}$ . Again, in case of Mexico, specific time needed to pass from  $\kappa_{(t)}=10\%$  to  $\kappa_{(t)}=90\%$  is considerably lower.

As general conclusion, it can be declared that growing share of the ETFs in the sum of two analyzed investment options (ETFs and mutual funds, i.e. investment funds) in both Mexico and the United States can be explained in line with the logistic model. However, the rate of growth of ETFs' share in investment funds in Mexico (their “diffusion”) was much higher, despite significantly lower absolute AUM values and financial system underdevelopment. In final years of the 2002-2012 period, Mexico has caught up with the United States in terms of ETFs share in IF. In 2009 value ETFs share in IF in Mexico was higher than in the United States.

Figure 4 (below) reports on ICT (approximated by: Internet Users –  $IU_{i,y}$ ; Fixed Broadband Subscriptions –  $FBS_{i,y}$ ) diffusion patterns in Brazil, Mexico and the United States, in the period 2000-2012. Additionally Table 3 (below) summarizes descriptive statistics on ICT development in selected economies (in the same period).



**Fig.4. Information and communication technologies diffusion patterns in Brazil, Mexico and the United States. 2000-2012.**

*Source: Own elaboration based on data derived from World Telecommunication/ICT Indicators Database 2012 . Note: variables: IU - Internet Users (% of individuals using Internet), FBS - Fixed Broadband Subscribers (per 100 inhabitants). On Y axis – absolute values.*



**Table 3. Internet Users ( $IU_{(i,y)}$ ) and Fixed Broadband Subscriptions ( $FBS_{(i,y)}$ ) summary statistics. Brazil, Mexico and the United States. 2000-2012.**

	$IU_{(i,y)}$ in 2000	$IU_{(i,y)}$ in 2012	$IU_{(i,y)}$ average annual growth rate (%)	$FBS_{(i,y)}$ in 2000	$FBS_{(i,y)}$ in 2012	$FBS_{(i,y)}$ average annual growth rate (%)
Brazil	2.9	49.8	23.7	0.06	9.2	42.2
Mexico	5.01	38.4	16.8	0.02	10.9	54.9
United States	43.08	81.03	5.3	2.5	28.03	20.1

*Source: own calculations based on data derived from World Telecommunication/ICT Indicators Database 2012. Note: IU – Internet Users (% of individuals using Internet); FBS – Fixed Broadband Subscriptions (per 100 inhabitants).*

The evidence on development of ICT diffusion in Brazil, Mexico and the United States proves high dynamics of the process in each case. Analyzing changes in  $IU_{(i,y)}$  values over the period 2000-2012, it is clear that both Brazil and Mexico follow similar development path, achieving high average annual growth rates, at  $IU_{(Bra,2000-2012)}=23.7\%$  and  $IU_{(Mex,2000-2012)}=16.8\%$ , respectively. As shown in Table 3, in Brazil and Mexico the share of population using Internet grew from  $IU_{(Bra,2000)}=2.9\%$  to  $IU_{(Bra,2012)}=49.8\%$  (46.7 pp. of absolute growth) in Brazil, and from  $IU_{(Mex,2000)}=5.01\%$  to  $IU_{(Mex,2012)}=38.4\%$  (33.39 pp. of absolute growth) in Mexico. The United States have experienced similar growth in  $IU_{(i,y)}$  in analogous period, accounting for a total change in share of population using Internet at 37.95 pp. However, in the United States, average dynamic of  $IU_{(i,y)}$  diffusion was approximately 5.3% annually, which is relatively low when compared to Brazil and Mexico. This is mainly due to the fact that initial level of  $IU_{(i,y)}$  in the United States was  $IU_{(U.S.A,2000)}=43.08\%$ , and in 2012 -  $IU_{(U.S.A,2012)}=81.03\%$  which accounts for almost full saturation of American population with this ICT tool. Analogous statistics referring to  $FBS_{(i,y)}$  variable seem to be even more impressive. Again Brazil and Mexico follow similar  $FBS_{(i,y)}$  diffusion path, experiencing astonishingly high pace of changes in  $FBS_{(i,y)}$  absolute values. Average annual rate of growth of Fixed Broadband Subscriptions (per 100 inhabitants), that is to say, was at 42.2% and 54.9% in Brazil and Mexico respectively. In effect, number of  $FBS_{(i,y)}$  rose from  $FBS_{(Bra,2000)}=0.06\%$  to  $FBS_{(Bra,2012)}=9.2\%$  in Brazil, and from  $FBS_{(Mex,2000)}=0.02\%$  to  $FBS_{(Mex,2012)}=10.9\%$  in Mexico. In the United States, the  $FBS_{(U.S.A,2000)}=2.5\%$  and it grew to  $FBS_{(U.S.A,2012)}=28.03\%$ , which resulted in average annual dynamic at 20.1%.

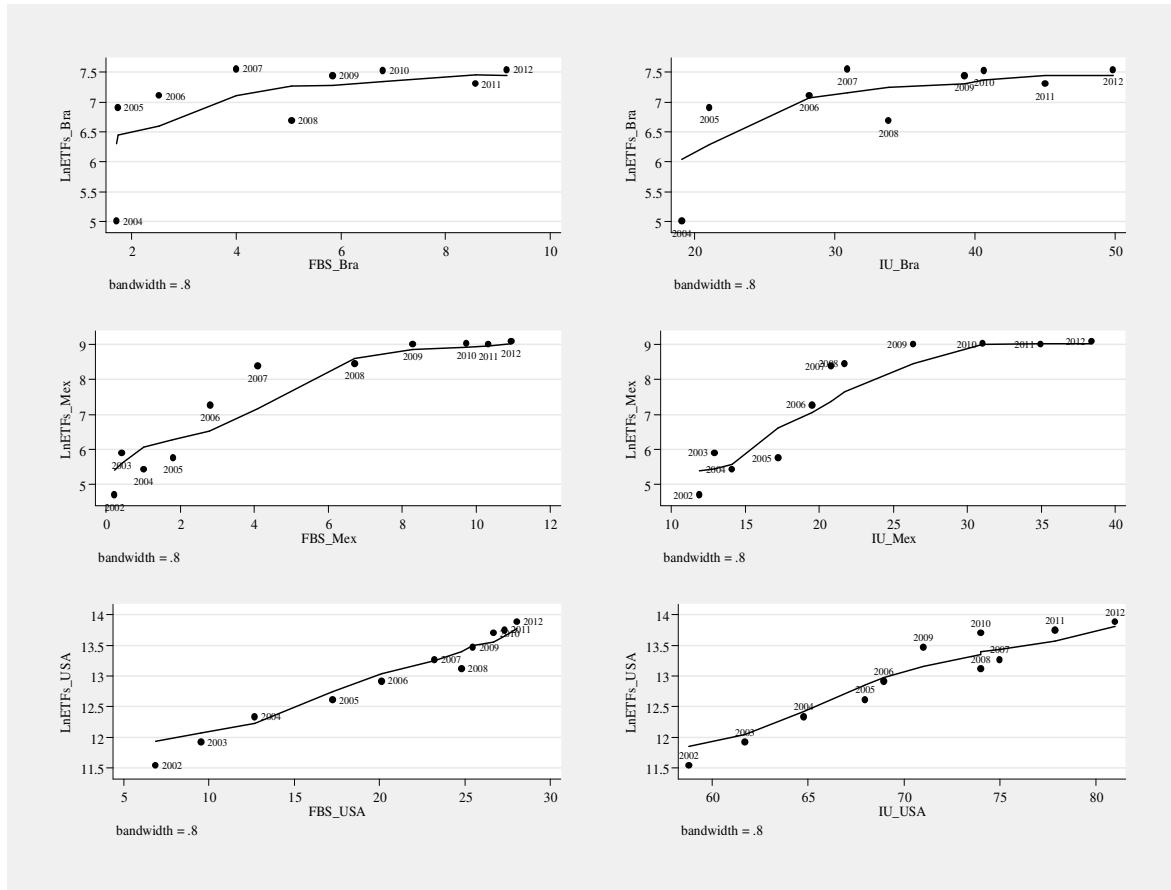
In 2012, Brazil and Mexico were still relatively lagging behind (compared to the United States) in terms of  $FBS_{(i,y)}$  and  $IU_{(i,y)}$  adoption and usage; however, they enjoyed higher average annual growth rates. It is a *promise for success*, and creates great possibility of fast catching-up with US by emerging economies in terms of ICT diffusion.

Basing on the previous analysis, it is right to conclude, that both in emerging and developed countries, process of ICT diffusion was fast and dynamic. Over the 12-year period, in each of analyzed countries, a great part of societies gained access to recently developed new technologies, being able to adopt and use them.

## **5. Exchange traded funds growth *versus* information and communication technologies usage – empirical evidence from Brazil, Mexico and the United States**

Section 5 presents empirical analysis outcomes of relationship between ETFs and ICT adoption. As already indicated, we hypothesize that information and communication technologies ( $IU_{(i,y)}$  and  $FBS_{(i,y)}$ ) diffusion shall correlate positively with  $ETF_{(i,y)}$ .

Preliminary, we graphically analyze assumed relationship using locally weighted scatter plot smooth (LOWESS). For this, we develop country-specific plots (see Figure 5 below), which combine  $ETF_{(i,y)}$  against  $IU_{(i,y)}$  and  $FBS_{(i,y)}$ .



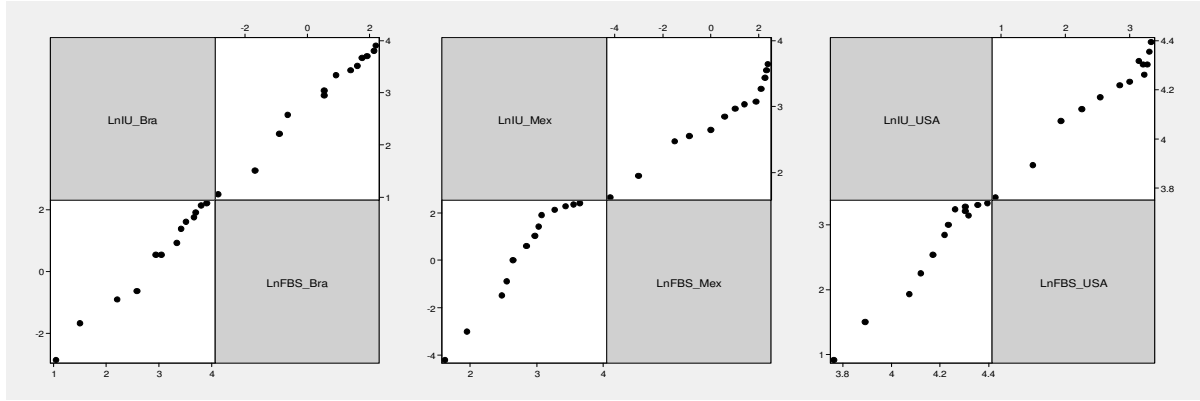
**Fig. 5. Relationship between Internet usage and exchange traded funds' absolute assets under management values. Brazil, Mexico and the United States. 2002-2012.**

*Source: Own elaboration based on data derived from World Telecommunication/ICT Indicators Database 2012, financial statements of Brazilian ETF providers and BlackRock (2011, 2012a, 2012b). Note: Nonparametric graphical approximation using linear polynomial (mean: running-mean smooth).  $FBS_{country}$  – Fixed Broadband Subscribers (per 100 inhabitants) – raw data;  $IU_{country}$  – Internet Users (% of individuals);  $LnETFs$  – natural logarithm of exchange traded funds' assets under management absolute values (in mln US Dollars).*

Individual plots in Figure 5 show that there might exist quantitative links between  $ETFs_{(i,y)}$ ,  $IU_{(i,y)}$  and  $FBS_{(i,y)}$  in each of analyzed countries. Growths in values of  $IU_{(i,y)}$  and  $FBS_{(i,y)}$  are accompanied by increases in values of ETFs. In the United States, both for  $IU_{(US,A,y)}$  and  $FBS_{(US,A,y)}$ , correlation with  $ETFs_{(US,A,y)}$  is high. Correlation coefficients are 0.98 for  $FBS_{(US,A,y)}$  and  $ETFs_{(US,A,y)}$ ; and 0.95 for  $IU_{(US,A,y)}$  and  $ETFs_{(US,A,y)}$ . In Mexico, respective coefficients are 0.92 and 0.86. In 2005, in Mexico, variable  $ETFs_{(Mex,2005)}$  entered exponential growth path and, after the “peak” in 2009, it reached “stabilization” phase. What is worth noting, is that Mexican  $ETFs_{(Mex,y)}$  started to follow 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, might suggest that such level of “saturation” of society with new technologies is sufficient for ETFs start to expand. The weakest “connections” between paired variables are revealed in case of Brazil. In the period 2004-2014, despite increased values of  $IU_{(Bra,y)}$  and  $FBS_{(Bra,y)}$ ,  $ETFs_{(Bra,y)}$  hardly changed. Conclusion drawn basing on Figure 5 shall, however, be confirmed by quantitative analysis. To explore potential relationship between adoption of ICT and value of ETFs, we apply formula (7) (see section 3.2). Response covariate is defined as  $ETFs_{(i,y)}$ , while  $IU_{(i,y)}$  and  $FBS_{(i,y)}$  as explanatory variables, which is supported by the hypothesis that information and communication technologies adoption is likely to impact positively ETFs development. Empirical

results are based on data available for Brazil, Mexico and the United States in the period 2002-2012. Descriptive statistics of variables used for regression were outlined in the previous section.

In model (7), tracing country-specific effects, we examine impact of ICT ( $IU_{(i,y)}$  and  $FBS_{(i,y)}$ ) on ETFs' assets changes ( $ETF_{s(i,y)}$ ). However, detection of collinearity between explanatory variables is highly probable, therefore, to support or reject the previous, we explore correlation matrix (see Figure 6 below) for corresponding pairs of variables.



**Fig. 6. Correlation of variables  $IU_{(i,y)}$  and  $FBS_{(i,y)}$ . Brazil, Mexico and the United States. 2000-2012.**

Source: Own elaboration based on data derived from World Telecommunication/ICT Indicators Database 2012.

Analyzing Figure 6, we see that between variables  $IU_{(i,y)}$  and  $FBS_{(i,y)}$  exists two-way statistical relationship. Calculated correlation coefficients for corresponding pairs of variables are following: ( $IU_{(Bra,y)}$  versus  $FBS_{(Bra,y)}$ ) = 0.99; ( $IU_{(Mex,y)}$  versus  $FBS_{(Mex,y)}$ ) = 0.97 and ( $IU_{(USA,y)}$  versus  $FBS_{(USA,y)}$ ) = 0.98.

Such results suggest that estimates of equation (7) shall be restricted to one explanatory variable. Assuming that between variables  $IU_{(i,y)}$  and  $FBS_{(i,y)}$  exists causality, i.e. access to broadband network  $FBS_{(i,y)}$  determines percentage of population using Internet  $IU_{(i,y)}$ , it is necessary to rearrange equation (7), so it is now specified as:

$$ETF_{s(i)} = \gamma_0 + \gamma_1 IU_{(i)} + \varepsilon_i \quad (8).$$

To examine to what extent diffusion of broadband network influences use of Internet by individuals, we also estimate model defined as:

$$IU_{(i)} = \gamma_0 + \gamma_2 FBS_{(i)} + \varepsilon_i \quad (9).$$

In that sense, we assume that coefficient  $\gamma_1$  in (8) explains the strength of impact of  $IU_{(i,y)}$  on  $ETF_{s(i,y)}$ , but it also indirectly captures the influence of  $FBS_{(i,y)}$  on  $ETF_{s(i,y)}$ .

Results obtained from the models (8) and (9) are summarized in Table 4 (see below).

**Table 4. Relationship between Internet Use ( $IU_{(i,y)}$ ), Fixed Broadband Subscriptions ( $FBS_{(i,y)}$ ) and exchange traded funds ( $ETFs_{(i,y)}$ ). Country – specific estimates for Brazil, Mexico and the United States. Period 2002-2012.**

MODEL (8)					
$LnETFs_{Bra}$	Coeff.	$\hat{\gamma}$ -stat	$P>/\hat{\gamma}$	(95% Conf. Interval)	
$LnIU_{Bra}$	<b>1.8</b>	2.89	0.004	[0.58; 3.03]	
			<i>log likelihood</i>	<i>AIC</i>	<i>BIC</i>
			-6.79	1.95	-12.99
$LnETFs_{Mex}$	Coeff.	$\hat{\gamma}$ -stat	$P>/\hat{\gamma}$	(95% Conf. Interval)	
$LnIU_{Mex}$	<b>3.9</b>	7.1	0.000	[2.82; 4.98]	
			<i>log likelihood</i>	<i>AIC</i>	<i>BIC</i>
			-10.49	2.27	-17.24
$LnETFs_{USA}$	Coeff.	$\hat{\gamma}$ -stat	$P>/\hat{\gamma}$	(95% Conf. Interval)	
$LnIU_{USA}$	<b>7.57</b>	10.65	0.000	[6.18; 8.97]	
			<i>log likelihood</i>	<i>AIC</i>	<i>BIC</i>
			2.05	-0.0097	-21.13
MODEL (9)					
$LnIU_{Bra}$	Coeff.	$\hat{\gamma}$ -stat	$P>/\hat{\gamma}$	(95% Conf. Interval)	
$LnFBS_{Bra}$	<b>0.55</b>	26.02	0.000	[0.51; 0.60]	
			<i>log likelihood</i>	<i>AIC</i>	<i>BIC</i>
			10.28	-1.27	-28.05
$LnIU_{Mex}$	Coeff.	$\hat{\gamma}$ -stat	$P>/\hat{\gamma}$	(95% Conf. Interval)	
$LnFBS_{Mex}$	<b>0.27</b>	15.89	0.000	[0.23; 0.30]	
			<i>log likelihood</i>	<i>AIC</i>	<i>BIC</i>
			9.34	-1.12	-28.03
$LnIU_{USA}$	Coeff.	$\hat{\gamma}$ -stat	$P>/\hat{\gamma}$	(95% Conf. Interval)	
$LnFBS_{USA}$	<b>0.23</b>	0.013	0.000	[0.20; 0.25]	
			<i>log likelihood</i>	<i>AIC</i>	<i>BIC</i>
			26.03	-3.69	-28.20

Source: Own estimates based on data derived from World Telecommunication/ICT Indicators Database 2012, financial statements of Brazilian ETF providers and BlackRock (2011, 2012a, 2012b.). Note: Generalized Linear Models (GLM) estimations (variance function:  $v(u)=1$ ; link function:  $g(u)=u$ ). Standard errors – default. Significance level – 0.95%. Constant – not reported.

Estimating (8) we have examined the influence of Internet use,  $IU_{(i,y)}$ , on values of ETFs ( $ETFs_{(i,y)}$ ). We modeled the relationship as country-specific effects. Our results show evidently that chosen covariates are strongly inter-correlated, so that increases of population which uses Internet  $IU_{(i,y)}$  result in growth of  $ETFs_{(i,y)}$ . In each of analyzed countries, variable  $IU_{(i,y)}$  enters with positive and statistically significant coefficient -  $\gamma$ . For Brazil, Mexico and the United States respective coefficient are:  $\gamma_{1(Bra)}=1.8$ ;  $\gamma_{1(Mex)}=3.90$  and  $\gamma_{1(USA)}=7.57$ . Coefficients' values can be interpreted like an increase by 1% of Internet use  $IU_{(i,y)}$ , contributes to  $ETFs_{(i,y)}$  growth by  $\gamma_{(i)}$ % (*ceteris paribus*), compared with the initial value of  $ETFs_{(i,y)}$ . For instance, in Mexico,  $\gamma_{1(Mex)}=3.9\%$ , which implies that growth of 1% in  $IU_{(i,y)}$  potentially leads to growth in  $ETFs_{(i,y)}$  by 3.9%. The impact of  $IU_{(i,y)}$  on  $ETFs_{(i,y)}$  in Brazil is relatively the weakest (however, still positive and statistically significant), while in the United States the strongest. Results of similar kind are obtained in model (9) (see Table 4) examining relationship between diffusion of broadband network  $FBS_{(i,y)}$  and usage of Internet by individuals  $IU_{(i,y)}$ . Again, we test for country-specific effects. For Brazil, Mexico and the United States reported coefficients -  $\gamma_2$  – are positive and statistically significant. This supports the supposition that changes in  $FBS_{(i,y)}$  are likely to impact changes in  $IU_{(i,y)}$ . For example in Brazil, increase by 1% in value of  $FBS_{(i,y)}$  generates increase in  $IU_{(i,y)}$  of 0.55%. In all three countries, potential impact of  $FBS_{(i,y)}$  on  $IU_{(i,y)}$  seems to be similar in strength. Analysis outcomes clearly show that, in years 2000-2012, in Brazil, Mexico and in the United States, relationship between changes in values of ETFs and ICT diffusion was positive, strong and significant. This confirms the hypothesis that ICT diffusion is important factor determining development of ETFs.

In our analysis, we have determined that the United States as reference country, as their financial market is one of the most developed in world. Consequently, we presumed that is reasonable to compare development paths of emerging

economies – in our study Brazil and Mexico, with the United States. Such approach allowed addressing two crucial problems: whether ICT diffusion in developing economies fosters introduction of a new financial instrument in their financial markets making these countries more “visible” globally and enabling them to become an important actor worldwide; and whether – thanks to broad ICT adoption – emerging countries manage to achieve level of ETFs share in total investment funds comparable with that in the United States. Basing on overall results, answers for these questions are, however, ambiguous. In Brazil, although – in years 2000-2012 – dynamics of new technologies diffusion were high (in 2012 in Brazil almost 50% of individuals had access to Internet, while in Mexico *only* 38.4%), ETFs’ share in total investment funds remained at a very low level, and achieved only  $ETFs\_share\_IF_{(Bra,2012)}=0.17\%$  in 2012. Dramatically different picture is revealed in case of Mexico. In the period 2000-2012, Mexican economy has undergone “technological revolution”, enjoying fast diffusion of Internet and broadband networks. Huge changes on the ground on ICT adoption were accompanied by dynamic development of ETFs. At the end of 2002, the year of first ETFs’ listings in Mexico, the  $ETFs\_share\_IF_{(Mex,2002)}=0.35\%$ , while in 2012 it grew to -  $ETFs\_share\_IF_{(Mex,2012)}=7.21\%$ . The highest value of  $ETFs\_share\_IF_{(Mex,y)}$  Mexico was reached in 2009, when  $ETFs\_share\_IF_{(Mex,2009)}=10.3\%$ , exceeding analogous value in the United States (*sic*). It is worth to remind that in 2002 in the United States the  $ETFs\_share\_IF_{(U.S.A,2002)}=1.57\%$  and in 2012 -  $ETFs\_share\_IF_{(U.S.A,2012)}=7.6\%$ . It shows that both Mexico and the United States have advanced in terms of ETFs’ share in investment funds, following similar development pattern.

Enormous changes on the Mexican financial markets with regard to ETFs’ development prove its high efficiency, great ability to change at high pace and taking advantages from opportunities that information and communication technologies offer to the public. Mexican case shows that following the path of highly developed countries is possible for emerging economy. However, a question arises: what went wrong in Brazil? Hypothetically, Brazilian ETFs shall follow similar path as Mexican did in 2002-2012. Highlighted role of information and communication technologies in fostering ETFs growth in emerging markets does not seem, though, to be straightforward and direct. There are multitude prerequisites – often hard to quantify – and local factors (i.e. legal systems<sup>5</sup>, market structure, economy’s general performance and many others) which condition financial markets development and ICT are just one of them. It is undoubted that ICT adoption is only a part of the explanation of the ETFs markets development. One of the factors that could have caused notable differences in the growth of Brazilian and Mexican ETF markets were varying financial system structures– all ETFs listed in Brazil in the analyzed period offered exposure to domestic equity and with relatively lesser role of the equity market their attractiveness may be decreased (due to linkages outlined in the theoretical sections of the paper).

Yet another thing to stress is that our empirical analysis covers short period and limited data. This can strongly affect statistical reliability of the results, which might not be robust. Years 2000-2012 are unique due to unprecedented dynamic diffusion of ICT which, in many cases, was accompanied by introduction of new financial instruments, i.e. ETFs. Revealed statistical relationship does not automatically imply causality. Nevertheless, in case of ICT and ETFs’ development, existence of such links is highly possible.

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<sup>5</sup>One example of such factors are legal differences between Brazil and Mexico - Brazilian regulations concerning ETFs until 2013 were more strict than Mexican e.g. ETFs with fixed income exposure were not allowed (Stuber, 2013); there are also no cross-listings of ETFs in Brazil, while in Mexico hundreds of such products, listed primarily on foreign exchanges, are available (BlackRock, 2012a).

## 6. Conclusions

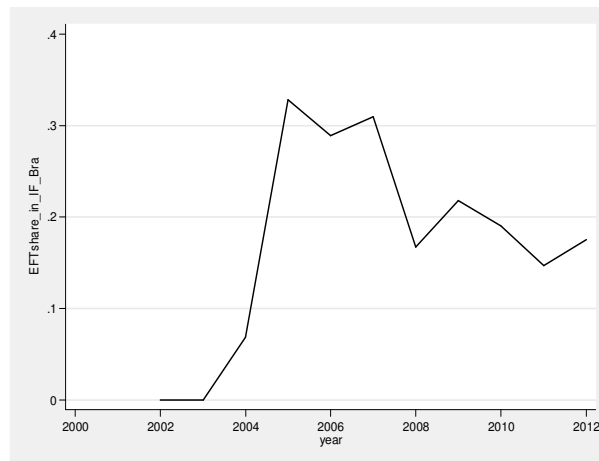
This paper was designed to provide broad look at relationships that may emerge when information and communication technologies and development of exchange traded funds is taken into account. It is no doubt that diffusion of ICT is a great phenomenon which allows hypothesizing that it brings new possibilities, beneficial for all members of the society. Hand-in-hand development of ICT and financial markets is beneficial for all, even though country's integration with global systems tends to increase economy's exposure to external shock and turmoil (Razin and Rose, 1994).

Although empirical results coincide with what was initially expected, it is possible that the evidence might not be robust. We have analyzed only three countries, and reported regularities might not apply to other economies. Analyzed period was unique due to extraordinary high rates of adoption of ICT, which came along with dynamic development of financial markets. In case of Mexico and the United States, we have found that ICT diffusion was accompanied by dynamic development of ETFs (in absolute values and as a share of investment funds). Despite huge disparities in general economic performance, in 2012 both countries achieved comparable level of ETFs' share in investment funds (on average 7.4%). The evidence is much weaker in case of Brazil. Brazil underwent fast ICT "revolution", however in 2012 the ETFs market was still poorly developed (ETFs share in investment funds was 0.17%). Taking into account complexity of both processes, it is not fully eligible to draw rigid conclusions that dependence of ICT and ETFs market development is straightforward. However, we may conclude that new technologies are necessary but not sufficient condition for sustainable ETFs market growth.

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**Fig. 6. Exchange traded funds' share in investment funds. Brazil. 2004-2012.**

*Source: Own elaboration based in data derived financial statements of Brazilian ETF providers and ICI (2008, 2013)*



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