An Estimation of the Internet Diffusion Process in Albania using Logistic & Bi-Logistic Model

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***Abstract* —** *Development of information technology has decreased the costs of processing information, and the internet has speeded up communication. Internet is a crucial technological innovation which has exceptional economic impact. Factual information confirms that developed countries possess higher concentrations of internet compared with undeveloped countries. For instance, in Albania for a long time, internet penetration levels have remained too low from 1995 to 2004, and have an impulse of increase in 2007. This study has the goal to analyze the diffusion process of Internet in Albania. The principal objective of this research is to model and forecast the values of Internet diffusion using the data of percentage of Internet users of World Bank database. In the first part, it was established that the diffusion of the Internet follows the S-shaped growth curve using Loglet Lab. The parameters of model give information on the Internet diffusion speed and the maximum potential percentage of Internet users. Growth projection informs providers of Internet products and service about the potential consumer base.*

Keywords — *Internet diffusion, logistic model, Loglet Lab.*

I. INTRODUCTION

Progress in information technology has reduced the costs of processing information, and the internet has facilitated communication. Internet is a key technological change which has significant economic effect. Recent studies have drawn correlation between GDP and Internet adoption levels by region [1]. Empirical evidence shows that richer countries possess higher concentrations of internet users in comparison with poorer countries. Internet gap between wealthy and poor countries becomes an insurmountable abyss, resulting in many of the negative consequences that arise from the uneven diffusion of industrial and network technologies in the world economy [2].

The operation of technological acceptance and diffusion has been widely analyzed in the literature. A quick look at data on the diffusion of varies technologies reveals that, at some moment of time, there are notable differences in the level of diffusion or adoption across countries. The data illustrate the significant disparity in Internet diffusion in different countries during the 1990-2004 period of time. Despite the fact that the percentage of the internet users was scarce in the United States in 1990 (0.8%), the usage of this technology raised 22 percent in 1997, and surpassed 63 percent by 2004. France had a slow acceptance for most of the time interval involved here, but the percentage grew very quickly, notably after the year 2000, reaching 39 percent in the year 2004. These jumps were clearly not observed in the undeveloped countries, Brazil had a limited rate of 12% by the end of the interval. In China, though Internet use increase very quickly – from a value of 0.03 percent in 1997 to 7.2 percent in 2004, the diffusion rate was still just low and, in Albania for a long time, internet penetration levels have remained too low (0.1% in 1995 and 2.4% in 2004), and have an impulse of increase to 15.3% in 2007 and to 60.1% in 2014 [3].

Internet diffusion has a great impact in telecommunication industry in Albania. In latest years, Albania has made significant advancement in the enlargement of networks and the providing of broadband facilities to subscribers. The quantity of operators offering broadband and Internet services via fixed networks of electronic communications in 2014 was 80 and 4 operators providing broadband services through mobile networks. Number of subscribers who have broadband Internet access by fixed networks by the end of 2014 was 206,000 and broadband internet access from 3G mobile networks has over 1 million subscribers. The key point for further development of broadband, are electronic communications networks based on optical fiber. Approximately 5,000 km of fiber are installed in the main street in suburban and urban areas by the end of 2014. Number of domains for 2014 was 4960 and in total are 13760 domains [4].

The objective of this research is to model and predict the level of Internet diffusion in Albania, in order to help policy makers and businesses to adopt the correct policies

Described on the base of the technology diffusion model, in the paper it is used Logistic and Bi-Logistic S-shaped curve to analyze the Internet diffusion in Albania.

II. MATERIALS AND METHODS

II.1. S - Logistic Growth as a Diffusion Model for internet technology

Diffusion examiners accept as true that a population can be divided into five types of different sections, based on their tendency to adopt a definite innovation: innovators, early adopters, early majorities, late majorities and laggards. Rogers [5] explained the

hypothetical percentages in a S-shaped logistic curve shown in Figure 1.

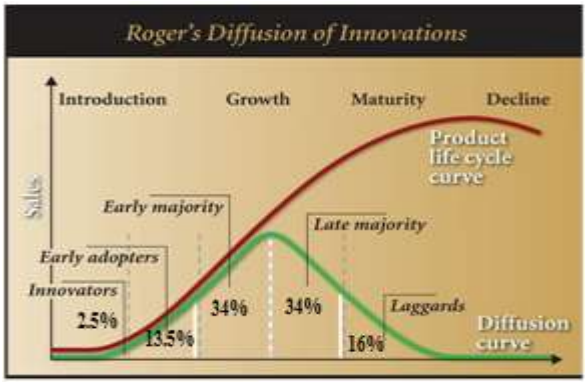

Fig 1. The Diffusion Curve (Adapted from Rogers, 2003)

The beginning of the logistic S -curve was used firstly into the analyzing of population growth by Pierre-François Verhulst in 1838, who developed Thomas Malthus population model presented in "An Essay on the Principle of Population".

The fundamental reasonable under the creation of the logistic growth model is very natural. We presume that a specified population "N" has an expected maximum value "K" based on environmental restrictions, food or water reserves shortage, or other limitations. When the population finds out all of these obtainable supplies, it enlarges but also, on the other hand, it confines a still bigger piece of its unexploited potential (K-N), thus restraining its prospect growth.

The logistic growth start with N(t) and r of the exponential growth, and a new term is added $(1 - \frac{N(t)}{K})$ named "inhibitor factor" that slow the rate of growth while the bound K is approximated:

$$\frac{dN(t)}{dt} = \underbrace{r\,N(t)}_{\text{exponential factor}} \underbrace{(1 - \frac{N(t)}{K})}_{\text{inhibitor factor}}$$

The inhibitor factor $(1 - \frac{N(t)}{K})$ is near to 1 if N(t) <<< K and tends to 0 when the population approaches the carrying capacity K, following a S-shaped (Sigmoidal) growth curve. The particular solution to the logistic differential equation is:

$$N(t) = \frac{K\,N_0}{N_0 + (K - N_0)e^{-rt}}$$

where N_0 is the population size at time t = 0.This function gives the familiar S-shaped curve. Note that three parameters r, K and N_0 specify exactly the trajectory: The growth rate parameter r determines the "width" or "slope" of the sigmoidal trajectory. The key properties of logistic growth are:

$\lim_{t\to\infty} N(t) = K$, the population will finally achieve its carrying capacity; the relative rate of growth decrease linearly when population increase; the size of population at the inflection point (the rate of growth is maximum).

$$N_{inf} = \frac{K}{2};\ \lim_{K\to\infty} \frac{KN_0}{N_0 + (K - N_0)e^{-rt}} = e^{rt}$$

It is more helpful to commute the parameters r and N_0 to two other variables that fix key time of growth process.

Δt is the time needed for the logistic curve to growth from 10% to 90% of Carrying Capacity K (named characteristic duration).

t_m is named midpoint i.e. the time t of the saturation point when the value of growth is half of saturation value K.

Using simple algebra, we have the relation between new and old parameters:

$$\Delta t = \frac{\ln 81}{r} \quad \text{and} \quad t_m = r \ln \frac{K - N_0}{N_0}$$

The three parameters K, Δt and t_m determine the parametrization of the logistic growth utilized as the fundamental block of support for Loglet analysis:

$$N(t) = \frac{K}{1 + e^{-\frac{\ln 81}{\Delta t}(t - t_m)}}$$

The parameter Δt is more helpful than r to describe the time-series data because the units are more convenient to estimate. The logistic curve is symmetric around midpoint t_m.

The parameter Δt informs us, furthermore, about the cycle duration. But the full cycle: the period of growth from 1% to 99% of the saturation value K is equal $2\Delta t$.

The growth of the population over time (t), according to the logistic growth pattern, can be illustrated by the subsequent equation:

$$N(t) = \frac{K}{1 + e^{-\frac{\ln 81\ (t - t_m)}{L_c/2}}}$$

N(t) is the number of population through time, K is the maximum quantity that the population can achieve, Lc is the life cycle of the growth i.e. the time required for the population to enlarge from roughly 1% to 99% of its maximum value K, and t_m is the inflection point or middle at which 50% of K is attained. The population growth rate tracks a Bell-shaped arch and the number of population itself, on a collective basis, pursues an S-shaped curvature.

II.2. *Bi-logistical model of growth*

A lot of processes in nature and other areas follow logistic model of growth. Sometimes the simple S-shaped logistic curve gives a model correct of a system. Though the logistic growth model often is applied to processes non adequate. Practically all successful applications of the single growth model are in occurrences running in isolation. The saturation level (the capacity of environment) of a social process is limited by the present level of technology, which is always in progress. Generally, species can by chance adapt and spread their location. If the saturation level of a process varies during a period of logistic growth, another cycle of logistic growth with a different saturation level can superimpose on the first growth impulse. For instance mobile cellular telephone first replace fixed telephone and after it have another logistic growth process by itself. This system with two logistic growth pulses, existing simultaneously or in

succession, it's named "Bi-logistical" by [6]. The "Bi-logistical" is helpful in modeling many systems that include complicated growth processes not correctly modeled by the original logistic.

II.3. Fisher-Pry transformation and visualization of the logistic growth

Generally, we represent logistic curve by just plotting on a positive coordinate system. We can change the variables to transform the logistic curve in a straight line. This view is called the Fisher-Pry transform [7].

If we denote by $F(t) = \frac{P(t)}{K}$ and $FP(t) = \frac{F(t)}{1-F(t)}$ so we have:

$\text{Ln}\,(FP(t)) = \frac{\ln 81}{\Delta t}(t - t_m)$ therefore $P(t) = \frac{K}{1+e^{-\ln(FP(t))}}$

Thus, if we graph FP(t) on a semi-log scale, the S-shaped logistic curve is transformed into linear. We notice that the interval of time in which the Fisher-Pry value is among 10^{-1} and 10^{1} is equal to Δt, and the time of 10^{0} is the inflection point t_m.The right axis indicates the respective percent of saturation value 100%. Since the Fisher-Pry transform standardize every chart to the saturation point K, many logistic curves may be plotted on the chart to compare. Later, we will find out it helpful in case of analyzing more complex growth situations.

III.THE DATA

The data used for this analysis is taken from the World Bank's World Development Indicators database. This dataset contains information for Internet Users per 100 inhabitants for the period 1991-2014. Internet users are individuals who have used the Internet (from any location) in the last 12 months. Internet can be used via a computer, mobile phone, personal digital assistant, games machine, digital TV etc. For the estimation of the parameters was used Loglet Lab software [6].

IV. RESULTS AND DISCUSSION

This section illustrates graphical and statistical results of the Internet S-shaped diffusion curve. Figure 2 shows the internet diffusion rates in different Balkans countries: Albania, Greece, Croatia and Slovenia from year 1995 to year 2014, and it is clear that the diffusion process follows a S-curve pattern. Internet penetration rates have remained too low during the period 1995-2000, then the rates were increased for all the countries.

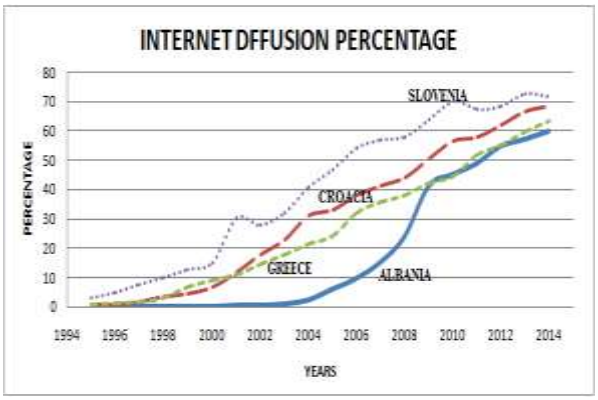

Fig 2: Internet Diffusion percentage in four Balkan countries

In Albania, for a long time, from 1995 to 2004, internet penetration rates have remained too low (0.1% in 2000 and 2.4% in 2004). The penetration rate is increased to 15.3% in 2007, a higher increase has been in year 2009 to 41.2%, and then the increase has continued and was 60.1% in 2014. As indicated in figure 2, the penetration rates for Albania are lower than other countries in the study.

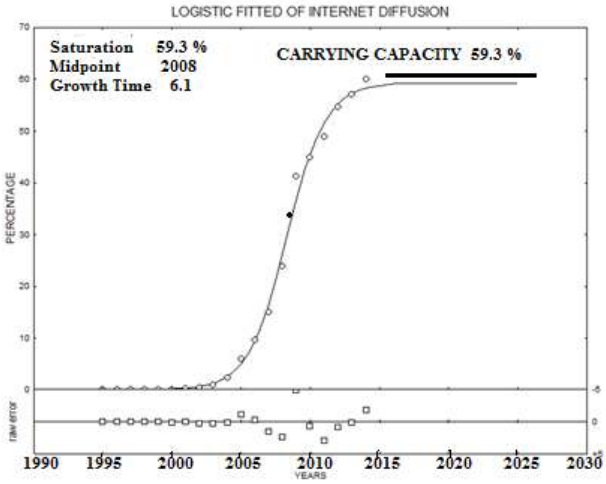

Fig 3. Logistic fitted curve of internet diffusion in Albania

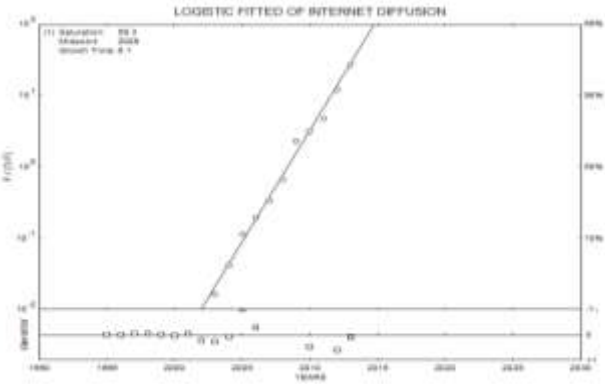

Fig 4. Fisher-Pry Visualization of growth of Internet adopters in Albania

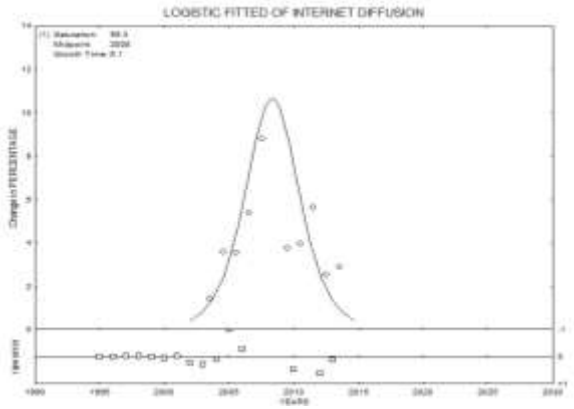

Fig 5. Bell shaped curve of growth of Internet adopters in Albania

Estimated parameters of Logistic Model of Internet Diffusion in Albania by Loglet Lab Software are indicated in table 1.

This values show that, according to the simple Logistic Growth Model, the percentage Diffusion of Internet in Albania has reached saturation level 59.3 %, the diffusion nowadays expands slowly and the cumulative value is going to be steady. The estimated parameters of the Internet diffusion pattern per other countries in study can be observed in the subsequent table.

Table 1. Estimated parameters of the Internet adoption model per countries

	Saturation	Midpoint	Growth time
Albania	59.3%	2008	6.1
Croatia	70.6%	2006	13.5
Greece	72 %	2007	16.4
Slovenia	73.7%	2003	13

Of course, Internet diffusion rates in all countries in observation show an S-shaped behavior pattern. However, each of these countries are in different stages of the diffusion process. The characteristic parameters in the table confirm that the saturation level of diffusion percentage in Albania has a gap of 10% from three other countries and the growth time is less than half of them.

For the best conclusions about the internet diffusion path in Albania the Bi-logistic model is used.

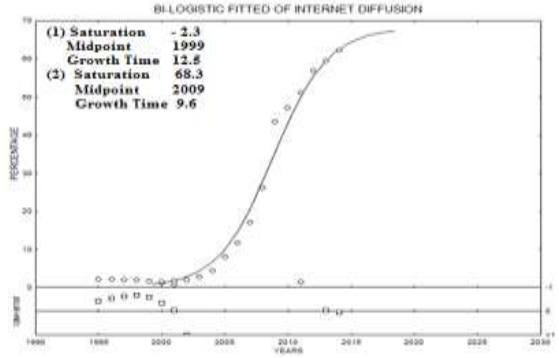

Fig 6.Internet diffusion in Albania curve fitted with Bi-Logistic model

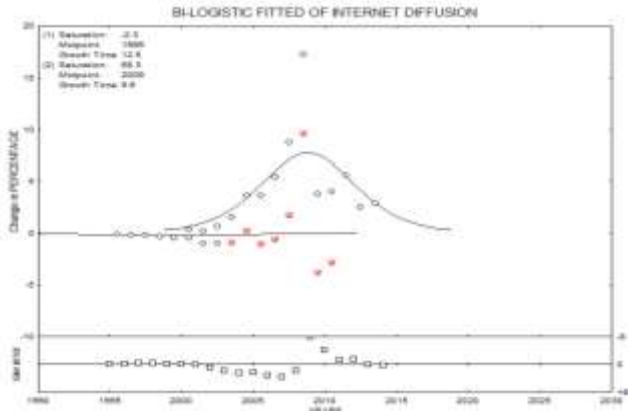

Fig 7. Bell shaped curves of two pulses of Internet diffusion in Albania

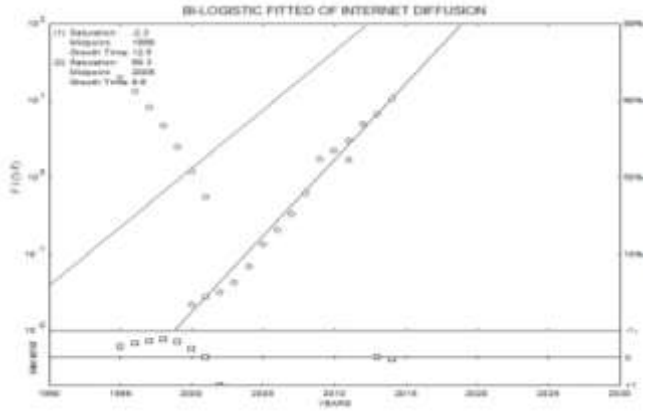

Fig 8.Fisher-Pry visualization of two pulses of Internet diffusion in Albania

According to Bi-Logistical pattern, there are two components growth curves. The first pulse with parameters:

- Saturation: -1.6 %
- Midpoint: 1999
- Growth Time: 12.5

The second pulse parameters are:

- Saturation: 68.3 %
- Midpoint: 2009
- Growth Time: 9.6

Figure 6 shows a sequential Bi-logistic, the first pulse smaller and negative saturates at a K = - 2.3% and the midpoint at 1999, this was when Albania was affected by troubles of pyramids schemes. After that the second, principal logistic pulse started in 2000 when the first pulse has reached about 90% of saturation and has had a higher saturation level 68.5 %, the point of inflection at 2011 and growth time, Δt of 9.6 years. This pulse represents the social-economic boom after pyramids crisis.

V. CONCLUSIONS

In this paper, it is used logistic and Bi-Logistic growth models to analyze, fit and predict the Internet diffusion in Albania. According to simple logistic growth model, diffusion internet in Albania has a saturation level between 11% - 13.4 % smaller than three other Balkan countries, respectively Albania

59.3 %, Croatia 70.1 %, Greece 72 % and Slovenia 73.7%. Furthermore, the growth time of internet diffusion logistic curve in Albania is about half the growth time in other countries in study. This is the result of an high rate of growth of internet spreading in Albania, in comparison with Croatia, Greece and Slovenia. It is known that the concentration of Internet use is significantly affected by government strategies, community's levels of earnings, instruction, occupation, general progress and economic situation. Albania has to elaborate appropriate policies to boost the level of Internet diffusion in the country. These policies should to concentrate on diminishing internet access costs, growing recognition about the power of the technology and internet instruction in schools and universities.

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