Demand evolution of mobile and broadband telecommunication services in Eastern and Central Europe and the influence of Western Europe's penetration

Authors

Christos MICHALAKELIS, Dimitris VAROUTAS* and Thomas SPHICOPOULOS

(*University of Athens)*

Abstract

This chapter deals with the methodologies for the study of the demand for telecommunication services along with the introduction of cross-national diffusion models. A description of the theoretical models and methodologies is given and application of these models in European telecommunication market is performed. Evidence from Central and Eastern Europe outlines telecom market behavior and contributes to better understanding of the European market. Moreover, previous studies from Western Europe are used in attempting to investigate the expected diffusion process in Central and Eastern Europe telecommunications sector.

* *Corresponding author:* Dimitris VAROUTAS, Department of Informatics and Telecommunications, University of Athens, Panepistimiopolis, Ilisia, GR15784 Tel: +302107275318, Fax: +302107275601, E-mail: arkas@di.uoa.gr

1 Introduction and background

It is an undoubted fact that, especially during the last decade, the area of telecommunications merits a continuous improvement and development, as far as the offered services and products are concerned. Contemporary technology allows extended network capabilities and the development of new products, which in turn increase the quality of services offered to customers. On the other hand, convergence of telecommunication services often disorientates customers and regulators; the former concerning their potential selections among the offered products and the latter regarding market monitoring and regulation.

In addition, it is evitable that nowadays people across different countries enjoy frequent contact and communication as they interact and thus influenced in both directions. Thus, the expected life cycle and diffusion process of any high technology product will presumably be influenced by neighboring markets' consumers, who have already experienced its services.

Central and Eastern European countries (CEE) telecommunications are making their move towards increasing telecommunications development and therefore previous studies may be of substantial help, in order to plan efficient strategies in this area.

Considering the case of CEE and especially the countries that have recently become member states of the European Union, they are about to enter to a borderless, wider market. In the context of high technology and telecommunications this consideration has the meaning that they are about to face new challenges in developing their infrastructures and readjust their priorities in investing capitals in order to meet new consumer demands in telecommunication services. This is the inevitable result of joining a market where people are accustomed to the usage of high technology. The new era that has already begun indicates transition of markets from monopoly or duopoly to more competitive conditions. Findings from previous research (Gruber, 2001) indicate that the relationship between competition and diffusion is particularly emphasized in the economic literature on the diffusion of innovations: in many circumstances increasing the number of firms leads to faster diffusion of innovations. The telecommunications sector was penalized in centrally planned economies because of an ideological bias that gave predominance to material production and neglected services. The economic importance of the telecommunications sector is much smaller in CEE than in Western European countries and the contribution of telecommunications to total GDP is quite lower than the average in OECD countries and European Union countries.

The telecommunications sector in CEE was, and to some extent still is, characterized by several distortions. As Gruber states (Gruber, 2005), price setting dictated by political objectives induced inefficient resource allocation. Prices did not at all reflect the underlying costs of providing the services. Low connection and rental fees created large waiting list and an inefficient allocation of subscriber lines. Low (or zero) call charges for local calls induced inefficient usage patterns. It is therefore not surprising that the quality of service provided was very poor, with typically high call failure rates, frequent breakdowns and long waiting times for fault reparation. Revenue per line is low and for most lines the revenue does not cover the cost. In practice, business users subsidize telecommunications for private households. Politically oriented price regulation makes it difficult to adjust prices to cost. The reasons for this poor performance are mainly linked to the low priority the former economic and political system gave to the telecommunications sector because it was not recognized as a productive sector. The telecommunications network was considered primarily as a hierarchical communications tool. As a result, the needs of private users were secondary.

The sector of mobile telecommunications is characterized by a very rapid technological change, especially in the transmission technology and efforts are focusing in exploiting to the best extend the available spectrum, which is the very scarce resource of the sector. First generation analogue systems used portions of the spectrum around the 450 MHz frequency, which was the main limit that did not allow to full exploitation of the economies of scale of the network and hence the industrial structure was characterized by natural monopolies. However, the transition to digital systems led to exploring new forms of market structure with more scope for competition, as they are able to accommodate three to four times more customers compared to analogue systems. In this way, digital technology created opportunities for overall capacity increases because of a more efficient use of the spectrum. This allowed more than one operator to exploit economies of scale. The typical market structure in mobile telecommunications became a duopoly. As the technology develops further and the capacity constraint is relaxed, more and more firms could be support by the market, increasing so the degree of competition.

Regarding the above, the scope of this chapter refers to outlining recent developments concerning the following issues:

- How can demand of CEE countries in telecommunication services be modeled, so as to have an initial estimation of what the consumers' needs will be?
- How can the, already estimated, diffusion process of Western Europe's telecommunication demand be modeled so as to use the knowledge in estimating Eastern Europe's telecommunications development?

- How can the expected influence between Western and CEE markets be modeled, so as to have an insight of the expected consumers' interaction results?

The rest of the chapter is organized as follows: Section 2 presents an overview of diffusion theory and representatives of diffusion models. Section 3 studies the concept of cross-national diffusion, while it presents the methodological concepts in constructing a corresponding model and Section 4 proceeds in evaluating the cross-national model, using the available historical data, for mobile and broadband technologies, followed by discussion of the results. Finally, Section 5 proceeds with concluding discussion and suggestions for future development in the telecommunications area.

2 Diffusion models for telecommunications

Diffusion models are mathematical functions of time that are used to estimate the parameters of the diffusion process of a product's life cycle at an aggregate level, without taking in consideration the underlying specific parameters that drive the process. They are constructed under the consideration of catching the general trends of the market reactions to an innovation's introduction. The other category of demand models are the so called "choice – based" models, which are built based on the incentive of identifying what the aggregate models don't do, the impact of the factors affecting market behavior and thus the diffusion process. Choice – based models are based on the estimation of the probability of individuals to adopt the innovation whose market behavior is driven by maximization of preferences, as modern economic choice theory assumes (Jun and Park, 1999), (Train, 2003). In this direction Jun et al (Jun, Kim, Park, Juhn, Lee, and Joo, 1997) have developed a framework for classifying telecommunication services, where independent, competitive and complementary relationships are defined according to customer needs, customer premise equipment, cost and network. This approach is necessary for constructing an aggregated forecast for telecom services.

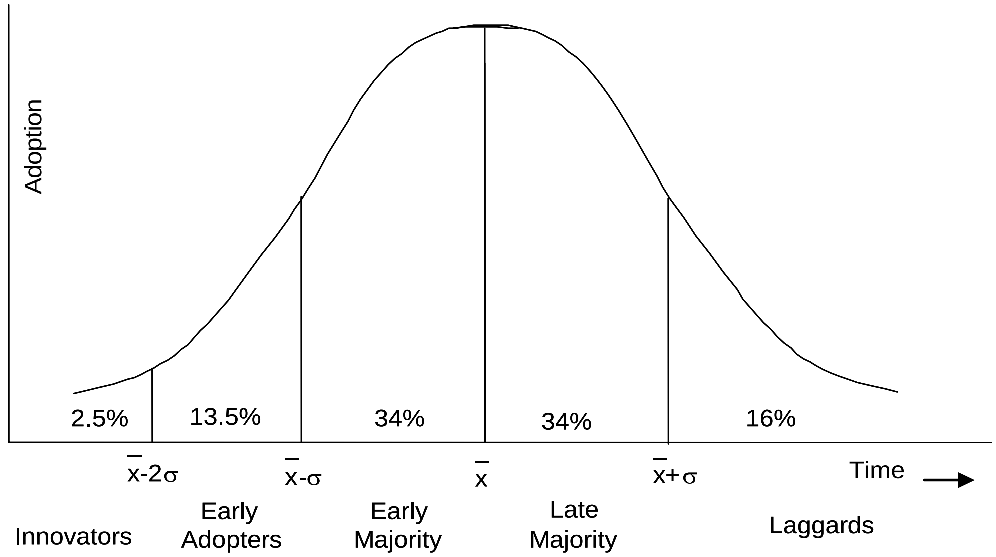

Figure 1 Diffusion process and life cycle of an innovation

For building the theoretical background for a product's diffusion process, the main assumption made is that by the time a new product is introduced there is an initial number of adopters, the "innovators", who proceed in adopting the product, independently of the decisions of the rest of the people in the social system. The size of this critical mass of initial adopters is crucial for the parameters of the diffusion process, such as the maximum expected penetration and the time of market saturation. Apart from innovators, adopters are influenced in the timing of adoption by the interaction with the social system, like advertising and influence from the early adopters. This group is referred to as "imitators". Imitators make diffusion process to take off and start the transition from introduction to growth stage. At this latter stage the adoption rate becomes higher and usually allocates the bigger part in the whole process, as regarding to the parameter of time. Finally, market moves to saturation, as the number of new adopters decreases. After that point the product is either substituted by another one, or by its descendant generation. The above are graphically represented in Figure 1, where the group of innovators is indicated, whereas the rest groups of adopters are considered to be the imitators. The horizontal axis refers to time variable and the vertical to penetration for each unit of time. The graph can be easily transformed to show the cumulative penetration, which produced the so called S-shape curves, which are presented in the following paragraphs.

The most widely used representatives of the aggregate models developed for diffusion estimation, are the Bass model (Bass, 1969), Fisher – Pry model (Fisher and Pry, 1971), logistic family models (Bewley and Fiebig, 1998), as well as the Gompertz model (Rai, 1999). Logistic models and variations of the Gompertz model provide "S- shaped" curves which are used in common in forecasting diffusion of products or services. S-shaped patterns derive from the following differential equation

$$\frac{dF(t)}{dt} = \delta * F(t) * [S - F(t)] \qquad \text{(Eq. 1)}$$

In (Eq. 1), Y(t) represents total penetration at time t, S the saturation level of the specific technology and δ is a constant of proportionality, the so-called coefficient of diffusion. Penetration is defined as the proportion of the population that uses the product or service being examined. In that sense, the diffusion rate of a product is proportional to the already recorded penetration as well as to the remaining potential of the market's users.

At the time that the particular technology is introduced (t=0), there exists a critical mass, the innovators, that initially adopt it. This number influences the rate and the shape of the expected diffusion process, until the time of market saturation is met.

In the context of this work, the Fisher-Pry Model is used, which after necessary development accommodates the cross-area influence.

The general form of the logistic models family is:

$$F(t) = \frac{S}{1 + e^{f(t)}}, \qquad \text{(Eq. 2)}$$

where F(t) is the estimated diffusion level and S the saturation level. f(t) is given by the following formula:

$$f(t) = -a - b * t(m,k), \qquad \text{(Eq. 3)}$$

where t(m,k) is generally a non-linear function of time (except the linear logistic model, where t(m,k)=t) and is given by one of the following formulations, according to the model's construction.

The Linear instance of the model is given by

$$t(m,k) = t, \qquad \text{(Eq. 4)}$$

The linear logistic model is also known as Fisher - Pry model (Fisher, 1971).

3 Development of a cross-national diffusion methodology

3.1 Cross-national diffusion

Introduction of a new product or service into a potential market is related to a considerable amount of effort spent on promoting, analyzing and forecasting the diffusion process of that particular product, not only after introduction time but also during the time prior to it. Consequent studies focus mainly on estimating the adoption rate and the parameters of the product's life cycle within the boundaries of the targeted market. This approach applies to telecommunications market as well. In this area, a theoretical framework on business telecommunications demand is provided by Taylor (Taylor, 1994), where is it pointed out that determinants of demand may vary widely depending on the size, the activity sector and the localization of the business. This arises mainly from the fact that the standard approach, which considers telecommunications as an input of a production function along with capital and labor, is often too inflexible to describe the variety of different telecommunications needs existing among firms. A relevant contribution in this field is the work of Ben-Akiva and Gershenfeld (Ben-Akiva and Gershenfeld, 1989) focusing on different types of access-lines and considering a discrete choice framework to estimate price elasticities with respect to the choice of different telephone systems.

However, it is very likely that the same product is introduced, either simultaneously or after a time lag, into a number of different markets (Kumar, Ganesh and Echambadi, 1998).This is quite frequent when high technology products are considered, because they usually target to international markets. In such cases, it is quite important to study the diffusion procedure in well defined groups of markets, according to their characteristics, and their interaction. This kind of market groups can be defined either as a group of neighboring countries, as a number of areas within the boundaries of the same country, or any other kind of geographical segmentation in general, according to various geographical or social characteristics imposed.

The effects of simultaneous introduction are related to the influential behavior between users of the corresponding markets, as a result of people interaction (Bass, 1969). This fact is usually not taken into account when estimating the diffusion process of the product and the penetration among studied population. Thus, the effect of market interaction and the consequent co-influence in the diffusion rates is overlooked, although it can be able enough to modify the initially estimated diffusion process.

The following sections focus on introducing, analyzing, developing and evaluating a methodology, for modeling this cross-national or, more generally, cross-area interaction influence in this kind of diffusion processes. This is achieved by developing a framework and a corresponding methodology to accommodate the interaction and influence in the diffusion process (Michalakelis, Dede, Varoutas and Sphicopoulos, 2005). The result is the development of an aggregate diffusion model which is used to estimate the amount of influence, in each direction. The case of Central and Eastern Europe areas is studied, as it is a case of great interest because of the transitions expected, which are the results of the joining of these countries to the European Union. This is a natural consideration that follows the already made studies, regarding the markets of Western Europe. In these cases the findings revealed that even between the more technologically mature countries there are unidirectional influences, able to adjust the diffusion processes of high technology products.

3.2 Factors affecting cross – national diffusion processes

Since the analysis of new products growth rate was given attention, enough research was carried out, considering diffusion in targeted markets and areas (Mahajan, Muller and Bass 1990), (Stremersch and Tellis, 2004). Considering the telecommunications sector, whenever a new product is introduced among number of areas, either at the same time or with a time lag, diffusion processes can be initially estimated as stand-alone procedures in each market. Each curve constructed to depict the diffusion process is expected to reveal the characteristics of the market to which it refers. These characteristics are heavily related, among others, to introduction prices (Baliamoune, 2002) household incomes (Kauffman and Techatassanasoontorn, 2003), product advertising, marketing strategies, or other characteristics of the target population and areas. By completing the analysis and estimation procedure the results should be able to describe adequately the penetration process. However this stand-alone procedure should go under an adjustment procedure that will accommodate the influence between markets. Not only in the case of simultaneous product introduction, but also in the case of a "lead-lag" situation, where there is a time lag between introductions of a new product in the corresponding markets, should be considered. When such an introduction happens it is expected to affect the product's penetration among the population of the neighboring areas, even if the product will be introduced there in some future time.

The main reason that causes this phenomenon is that nowadays people from various countries, or areas in the same country, interact with each other thus being bidirectionally influenced (Fisher and Pry, 1971). This behavior affects the diffusion progress of many products, especially high technology and telecommunication products in particular.

Despite the fact that cross-national diffusion turned out to be an important and interesting field of research, especially for market managers dealing with international markets, not much of work has literature to present. (Gatignon, Eliashberg and Robertson, 1989), (Takada and Jain 1991), and (Helsen, Jedidi and DeSarbo, 1993) have done some significant work while studying the cross-national diffusion process. Their results can be summarized in the following:

- New product's diffusion process is based mainly on the market's culture, and differences in penetration are explained by factors describing the specific country, such as mobility, cosmopolitanism, percentage of employed women etc.
- The later a product is introduced in a country's market, the faster the expected adoption rate. A "lead-lag" influence exists that explains the fast adoption rate in the lag country. This refers to the so called "time-lag" influence.
- Market segments, based on the diffusion parameters, are not constant. Instead they are dependent on the nature of the considered product, each time.

Factors, like GDP (Gross Domain Product), culture, political beliefs, age characteristics, social and economical situation, competition, differences in technology and in technological infrastructure turned out to responsible for the observed market behavior and future trends. Moreover, the time of introduction of a new product, cosmopolitanism, standard of living, education, advertisement, uncertainty, religion, mobility and the role of woman in the purchasing power result in different adoption rates of diffusion in each market.

Finally and in order to provide the means of better study of market responses and behaviors, any identified factors can be grouped into two major groups: product-specific and area (or market)-specific.

3.3 Methodology

As presented in the initial sections, cross-national diffusion modeling studies the diffusion processes of products or services introduced simultaneously or with a time lag into different markets. In each of these cases, whenever an interaction is expressed between the populations there an adjustment occurs to the initially estimated penetration of the product. The former case is presented in Figure 2 and the latter in Figure 3.

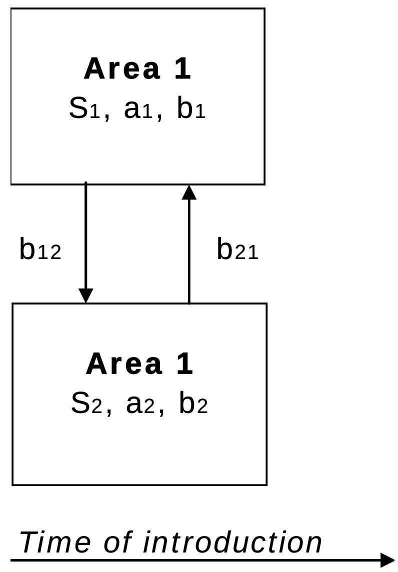

Figure 2 Simultaneous introduction. Areas influence each other

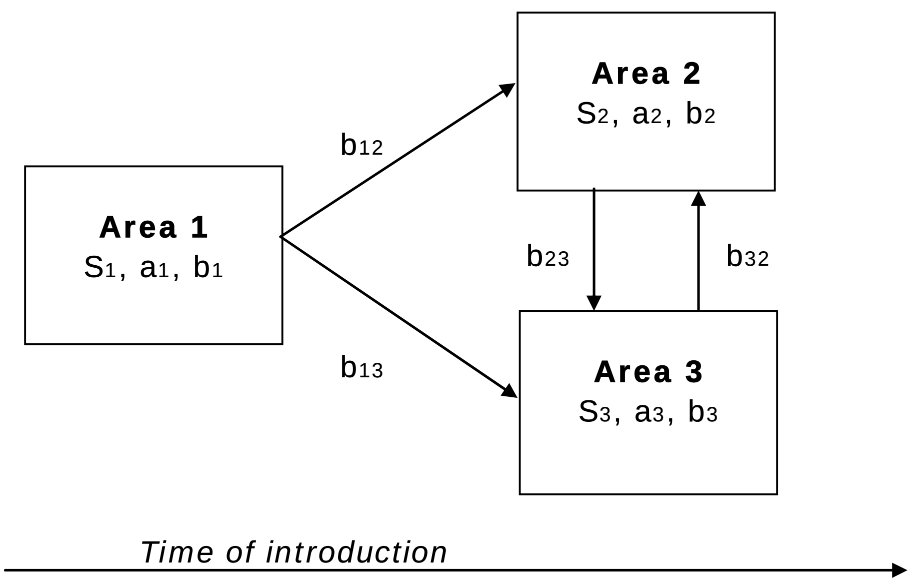

Figure 3 Product introduced in Area1 first. After a time lag is introduced in Areas 2 and 3 simultaneously. Area1 influences Areas 2 and 3. Areas 2 and 3 are influenced each other.

If the case of simultaneous effect among the diffusion processes of a new product in two countries is considered then, in order to capture the effect of diffusion in one country on diffusion in the other, the diffusion in each country is modeled as (Kumar and Krishnan, 2002):

$$\frac{dF_i(t)}{dt} = \delta_i * F_i(t) * [S_i - F_i(t)] * x_i(t) \text{ ,} \qquad \text{(Eq. 5)}$$

where $F_i(t)$ is the total penetration at time t and $x_i(t)$ is the current marketing effort term which should include only those effects that are happening at time t and influence the adoption rate. In order to model the impact of diffusion of the second country on the first country's diffusion, $x_i(t)$ is modeled as (Kumar, 2002):

$$x_2(t) = 1 + (b_{21} * \text{change at time t in diffusion rate of 2nd country}) \qquad \text{(Eq. 6)}$$

In (Eq. 6), 1 represents the natural time, the diffusion force is simply the cumulative adoption up to t, and b_{21} measures the impact of Country 2's diffusion on Country 1's diffusion. This can be represented by:

$$x_2(t) = 1 + (b_{21} * \frac{dF_2(t)}{dt}) \qquad \text{(Eq. 7)}$$

By considering the same differential equation for the other country, the following set of equations is derived:

$$F_1(t) = S_1 * \frac{1}{1 + \mathrm{e}^{-a_1 - b_1 * (t + b_{21} F_2(t))}} \qquad \text{(Eq. 8)}$$

$$F_2(t) = S_2 * \frac{1}{1 + \mathrm{e}^{-a_2 - b_2 * (t + b_{12} F_1(t))}} \qquad \text{(Eq. 9)}$$

The above set of equations can be extended so as to accommodate the case of "lead-lag" areas. In this case, if the innovation is introduced at some time t_1 in the first area (lead) and at time t_2 is introduced in the second one (lag) then the following relationships hold for the lead area:

$$F_1(t) = S_1 * \frac{1}{1 + e^{-a_1 - b_1 * t}}, \quad t_1 \leq t \leq t_2 \qquad \text{(Eq. 10)}$$

$$F_1(t) = S_1 * \frac{1}{1 + e^{-a_1 - b_1 * (t + b_{21} F_2(t))}}, \quad t \geq t_2 \qquad \text{(Eq. 11)}$$

In other words, and as long as the innovation is not introduced in the lag country the cross-area effect will not take place, thus the diffusion process will be described by (Eq. 10). By the time the introduction will occur, (Eq. 11) should be used to accommodate the interaction and influence effect.

It is obvious that the equation that describes the lag area's diffusion process remains the same as in (Eq. 9).

The set of equations (Eq. 8) and (Eq. 9) are coupled and solved, in an iterative way, using the following algorithm:

1. Assign a value of 0 to $F_1(t), F_2(t)$ on the right-hand side of Equations (8) and (9).
2. Estimate a_i, b_i, S_i of the two resulting equations. Call them $(a_1, b_1, S_1, a_2, b_2, S_2)_0$.

3. Using $(a_i, b_i, S_i)_0$ and using 0 for F1 and F2 on the right-hand sides, evaluate $F_1(t), F_2(t)$ of Equations (8) and (9). Call these $(F_1(t), F_2(t))_1$.

4. Assign $(F_1(t), F_2(t))_0$ to the F1(t) and F2(t) on the right-hand side of Equations (8) and (9) and estimate $a_1, b_1, S_1, b_{21}, a_2, b_2, S_2, b_{12}$. Call them $(a_1, b_1, S_1, b_{21}, a_2, b_2, S_2, b_{12})_1$.

5. Using $(a_1, b_1, S_1, b_{21}, a_2, b_2, S_2, b_{12})_1$ and using $(F_1(t), F_2(t))_1$ for F1(t) and F2(t) on the right-hand sides, evaluate $F_1(t), F_2(t)$ of Equations (8) and (9). Call these $(F_1(t), F_2(t))_2$.

6. Assign $(F_1(t), F_2(t))_2$ to $F_1(t), F_2(t)$ on the right-hand side of Equations (8) and (9) and estimate $(a_1, b_1, S_1, b_{21}, a_2, b_2, S_2, b_{12})_1$ of the two resulting equations. Call them $(a_1, b_1, S_1, b_{21}, a_2, b_2, S_2, b_{12})_2$

7. Repeat Steps 5 and 6 until no changes in the estimates of $a_1, b_1, S_1, b_{21}, a_2, b_2, S_2, b_{12}$ are found.

In this study, the above procedure is implemented using a genetic algorithms approach. The objective function is the minimization of the squares of the residuals whereas the constraints are the expected value spaces of the parameters. After a number of iterations (usually 7-8) the algorithm converges, in the sense that the resulting estimations of the parameters provide no change in their values, within a predefined accuracy (for example in the 5th decimal place).

At this point is worth explaining shortly the concept of genetic algorithms, which are search algorithms based on the mechanisms of natural selection and natural genetics in a process that is in many analogous to the Darwinian process of natural selection. (Venkatesan and Kumar, 2002). The key points to the process are reproduction, crossover and mutation, which are performed according to a given probability, just as it happens in real world. The mechanics of a genetic algorithm consist of "reproduction" which involves copying (reproducing) solution vectors, crossover which involves swapping partial solution vectors and mutation which is the process of randomly changing a cell in the string of the solution vector preventing the possibility of the algorithm being trapped. The process continues until it reaches the optimal solution to the fitness function. For cases like the present work, the fitness function is constructed as the minimum of the sum of squares of the distances between the observed and the estimated values.

4 Model evaluation and discussion

As mentioned above, the case of Western – CEE areas is of major interest. Thus, this particular section presents an evaluation case of the so far developed methodology, over two representative cases of high technology products: mobile telephony subscriptions and ADSL lines. The first is the case of simultaneous introduction and the second is the case of an almost two year's time lag. The countries that were considered into these two groups are, in alphabetical order, for the CEE: Bulgaria, Croatia, Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia, and for Western Europe: Austria, Belgium, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Netherlands, Norway, Spain, Sweden, Switzerland and United Kingdom.

4.1 Mobile penetration

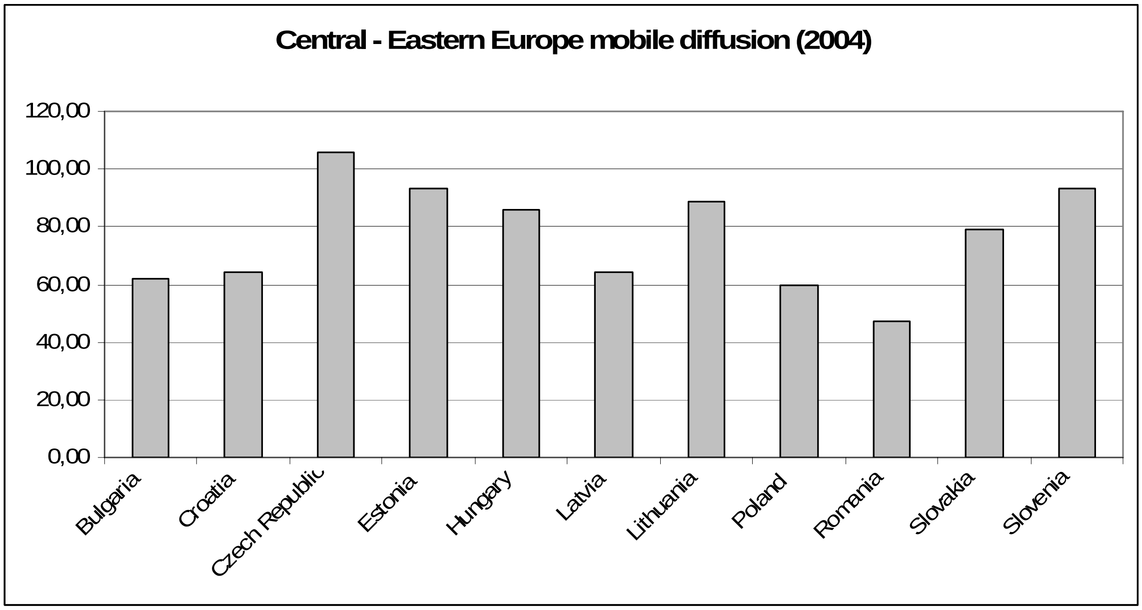

Figure 4 **Diffusion of mobile telecommunications in CEE countries, 2004**
(Source: Eurostat)

Table 1 shows the percentage of cumulative penetration of subscriptions to public mobile telecommunication systems using cellular technology. The average penetration was considered, across the countries that constitute each group. Active pre-paid cards are treated as subscriptions. In that sense, as one person may have more than one subscription, saturation level can reach a value greater than 100 percent. Figure 4 presents the diffusion of mobile telecommunications in each of the CEE countries in 2004.

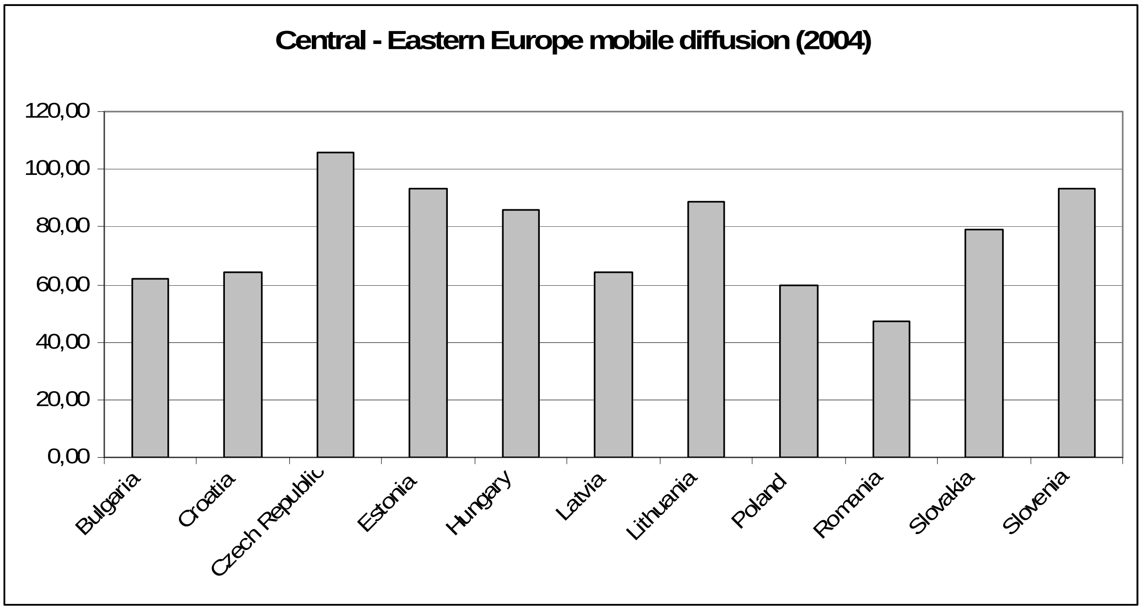

Figure 4 Diffusion of mobile telecommunications in CEE countries, 2004 (Source: Eurostat)

Table 1: Diffusion of mobile subscriptions over population, Eastern – Central (actual data) *(Source: Eurostat)*

Year	Central Eastern Europe F1(t)	Western Europe F2(t)
1993	0,09	3,79
1994	0,09	5,64
1995	0,73	8,79
1996	1,82	13,36
1997	3,91	19,64
1998	7,64	31,36
1999	14,27	45,93
2000	25,55	65,71
2001	40,64	77,07
2002	52,55	82,79
2003	63,45	89,36
2004	76,65	97,14

Table 2: Initial estimation of parameters

	Central – Eastern Europe	Western Europe
S	87,4943	102,3504
a	-6,3152	-4,36423
b	0,6755	0,6079

Table 3: Adjusted estimation of parameters

	Central - Eastern Europe	Western Europe
S	91,2486	102,5588
a	-6,136296	-4,3642
b	0,6594	0,60797
	b21 = 0,00155	**b12 = 0,0000**

Table 4: Adjusted diffusion estimation after cross-national methodology application of mobile subscriptions in Eastern Europe

Estimations for Central - Eastern Europe

Year	Initial	Final	Difference
1999	14,86	16,44	**1,58**
2000	25,09	27,20	**2,11**
2001	38,62	41,15	**2,53**
2002	53,22	56,01	**2,80**
2003	65,89	68,89	**3,00**
2004	74,99	78,19	**3,20**
2005	80,65	84,06	**3,41**
2006	83,87	87,45	**3,58**
2007	85,61	89,32	**3,71**
2008	86,53	90,31	**3,79**
2009	87,00	90,84	**3,84**
2010	87,24	91,11	**3,87**

Before proceeding, it is worth explaining the meaning of both the initial and final estimations of the evaluated dataset, presented in Table 2 and Table 3, focusing mainly on the saturation levels of the diffusion process, denoted by parameter S. The initially saturation level was calculated at a value of approximately S=87,5. The physical meaning of this value is that given the already established market penetration the percentage of consumers is expected to reach, at maximum, the 87,5 percent of population. However and after the adjustment performed by the methodological approach, due to cross-national diffusion, the same parameter is calculated at a value of over 91 percent of the population. This difference derives due to the expected influence, as a result of the interaction between the two markets. The adjusted results are presented in Table 4, along with the calculated difference in penetration over time regarding with respect to the studied population.

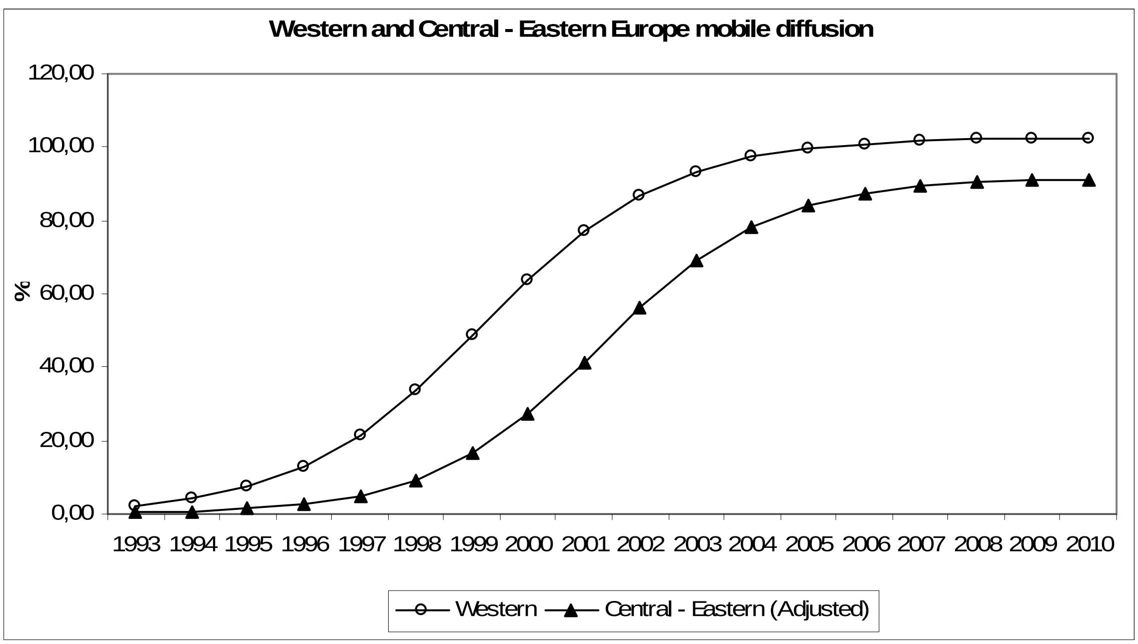

Figure 5: Mobile diffusion in Central - Eastern Europe under cross-national effects

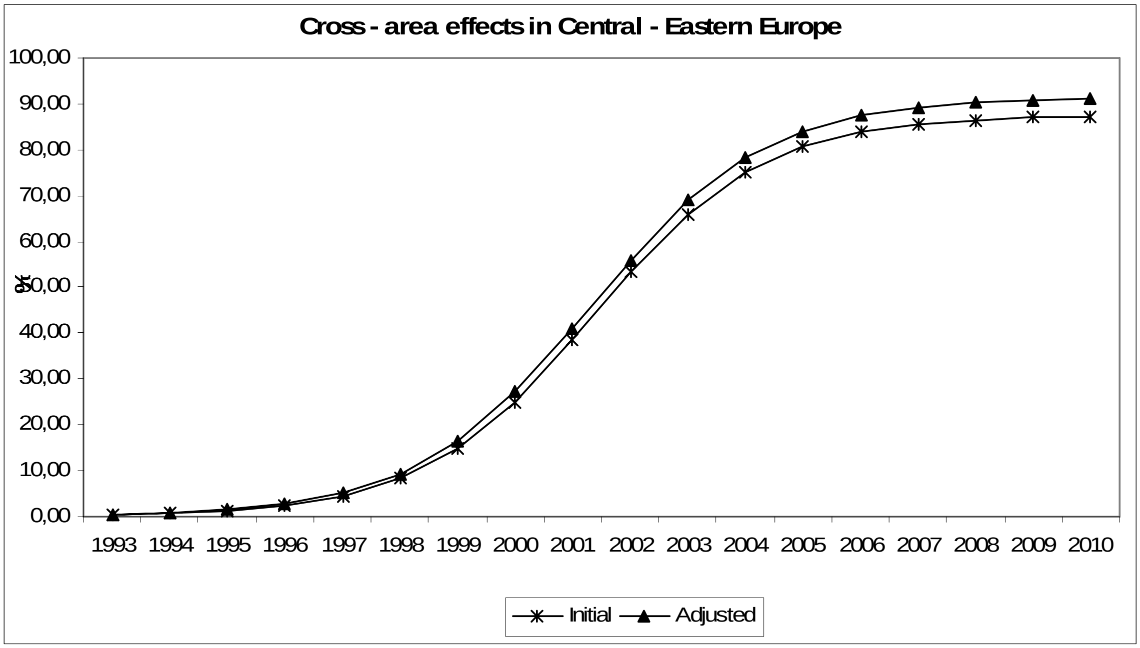

Figure 6 Initial estimation and (cross-national) adjusted mobile penetration in Central - Eastern Europe

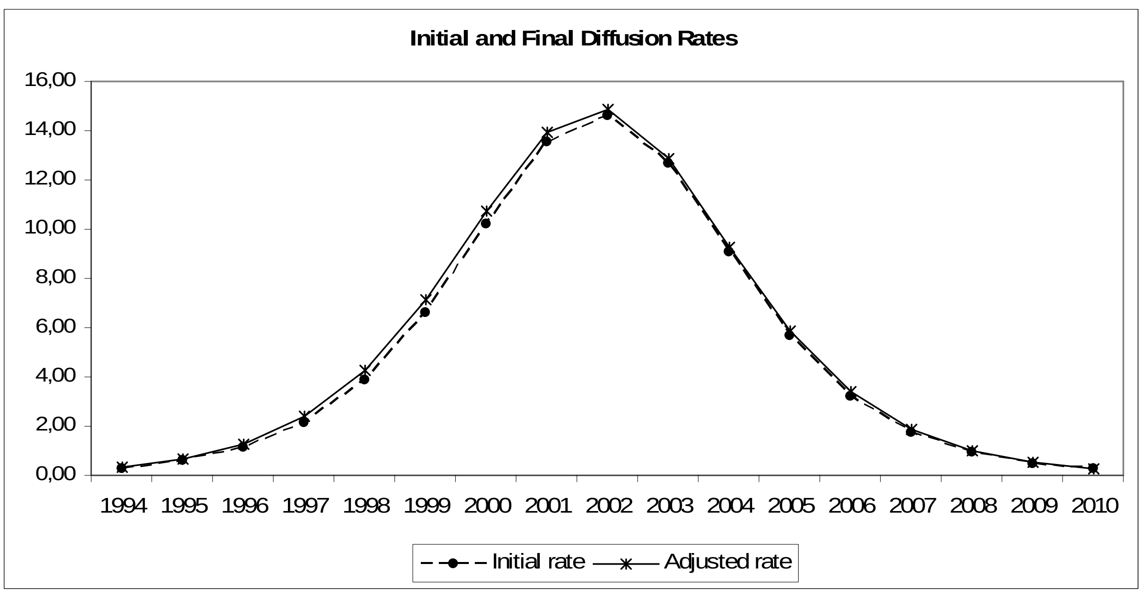

Figure 7 Initial and adjusted estimations of diffusion rates in Central - Eastern European countries

The information provided by the arithmetic examples are graphically depicted in the corresponding figures, which reveal that as probably expected CEE countries will be significantly influenced by Western Europe while vice-versa direction is not very likely to happen. Figure 5 shows the forecasting results for both areas and Figure 6 depicts the influence of Western over CEE, which drives the corresponding change in the diffusion process. It is clear that saturation level in CEE's diffusion process is about to reach a higher value than initially estimated. Following the above, information in Figure 7 reveals that Western Europe's influence speeds up CEE's diffusion rate (the graph is constructed by considering the first derivatives of cumulative diffusion). This generates the expectation that the saturation level of penetration will be met earlier in time than initially expected. Summarizing, it is concluded that both initially estimated saturation level and diffusion speed are increased, due to inter-market influence.

More specifically, in Table 3 where the final estimators are presented, the influence of Western over Central and Eastern Europe is quantified as a factor of b21=0,00155. The physical meaning of this factor is that CEE's diffusion will be adjusted by b21 times the value of the corresponding Western Europe's penetration, for each year of study. This refers to the quantification of the reason for the speeding up in CEE's adoption rate.

4.2 ADSL penetration

Table 5 presents ADSL subscribers per 100 inhabitants in corresponding areas. Data refer to average values in Eastern and Central Europe and it can be observed that there is a time lag between the introduction of ADSL technology in these areas of consideration.

Table 5 Broadband subscribers per 100 inhabitants *(Source: OECD)*

Year	Central - Eastern	Western
1999		0,63
2000		1,33
2001	0,07	2,44
2002	0,17	4,95
2003	1,50	7,91
2004	3,43	12,42
2005	4,50	14,81

Table 6 Initial estimation of parameters

Central – Eastern		Western	
S	4,728416	**S**	23,55622
a	-6,42475	**A**	-4,30993
b	1,86184	**B**	0,733282

Table 7 Adjusted estimation of parameters

Central - Eastern		Western	
S	6,307165	**S**	23,55622
a	-5,72528	**A**	-4,30993
b	1,504595	**B**	0,733282
b21	0,00967	**b12**	0,00000

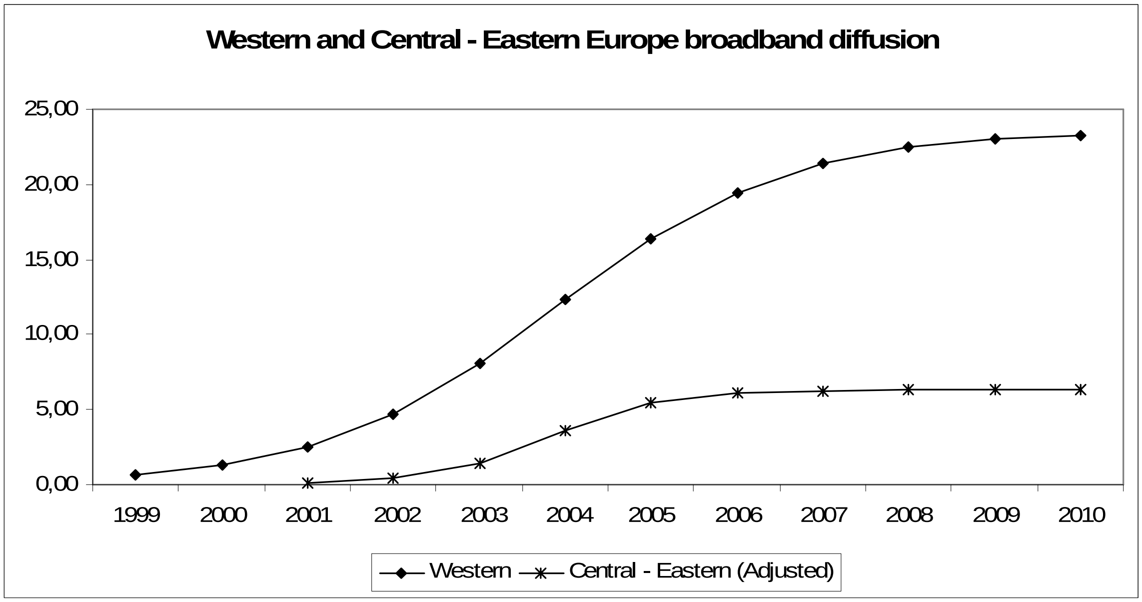

Figure 8 Broadband diffusion, Western and Central – Eastern Europe

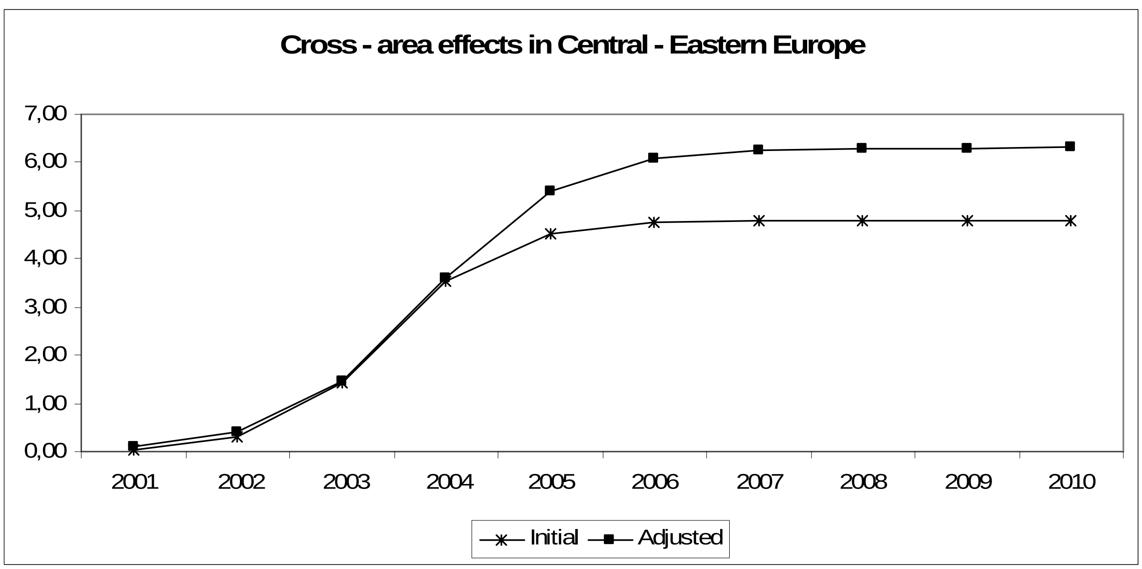

Figure 9 Initial and adjusted ADSL diffusion in Central - Eastern Europe under cross-national effects

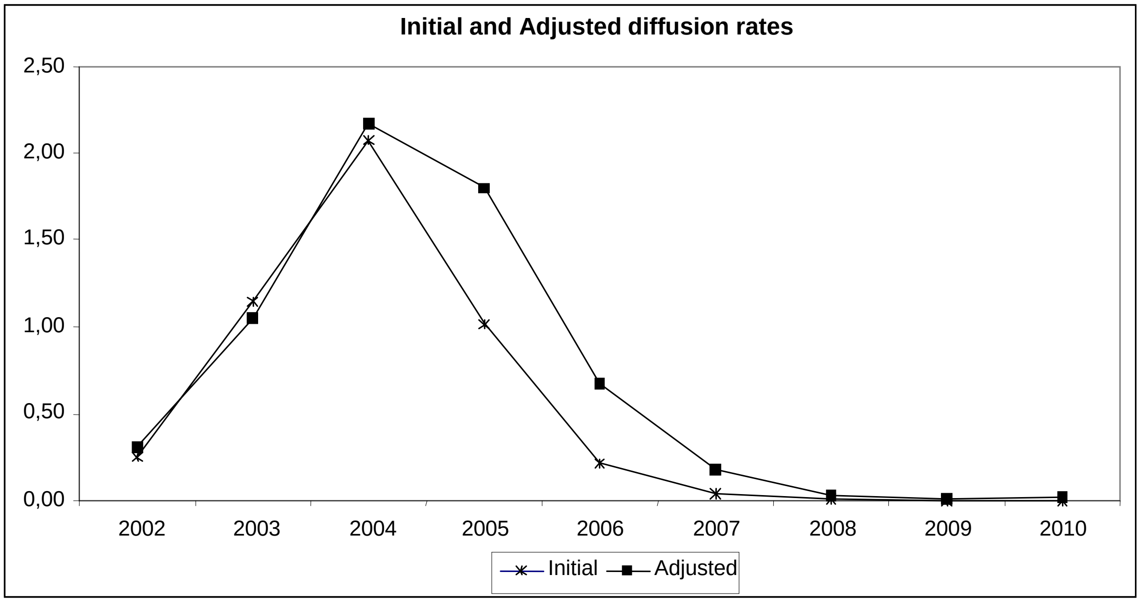

Figure 10 Initial and adjusted diffusion rates, Central - Eastern Europe

Results in this case of broadband connections are in agreement with previous findings, related to mobile subscriptions. Broadband penetration in Western Europe influences diffusion in CEE countries, even more than mobile, as Figure 9 shows. As before, results indicate the expected outcome, that Western Europe' s influence causes adjustments not only to the maximum expected saturation level but also to the speed of the adoption rate. It is worth mentioning that the case of broadband services is of important current interest as it is widespread across countries.

4.3 Discussion of results

Commenting further on the results presented above, it is clear that they are coherent with what someone would expect, as Western Europe is more developed and technologically advanced than CEE. For example, Germany which is a representative country of Central Europe is developed and industrialized in such an extent that German market adopts easily every new technology. Furthermore, there is no doubt that

Sweden, even though is less developed than Germany, adopts new technological trends in high rates. These are two representative examples of Western Europe presenting a high adoption rate in technology products' markets.

In addition, Western Europe influences CEE not only due to technological advance but also because of the great mobility of the people that it is observed in this area. In fact, mobility increases communication and culture exchange, which in turn provides an increase in CEE's influence. Western Europe's countries have a higher mean GDP and GDP per capita, than the corresponding values recorded for CEE. It is quite acceptable that prices of products and people's income are always an important factor for the adoption process of the product. Another important aspect related to the above is that, due to Central and Eastern Europe's countries entrance into the European Union, mobility and communication will increase further and GDP per capita will probably move towards convergence with the rest of European Union. These facts, which were not taken into account during the evaluation of the methodology, will raise even more penetration of new technology in the wider area of CEE.

In both cases considered, mobile and broadband services, diffusion will be accelerated, due to crossnational influence. Figure 7 Figure 10 depict these changes in the diffusion rates of corresponding datasets in Central and Eastern Europe, before and after the application of the methodology. As observed, there is a substantial change in the estimated penetration rate, which leads to the expectation that CEE's market will meet a faster penetration. This is also supported by the fact that advertising processes, which already take place in Central and Eastern European countries, make people eager to adopt new products. This is consistent with literature findings considering lag - time between introductions of products to different markets. This becomes clearer after studying the results of broadband diffusion, where the coefficient of influence, b_{21}, reaches a higher value. This value derives mainly for two reasons: The existent time lag, and the fact that broadband services are still immature in the countries of CEE, especially compared to mobile communications. Thus, it is quite expectable that as soon as they become more available and affordable enough penetration will take off.

5 Conclusions

The preceding analysis was based on the current levels of economical and social indicators in the area of Central and Eastern Europe. Although the methodology is quite robust, demand can be expected to rise even more, depending on the convergence of some major economical and social indicators between the countries of these two groups. The most representative of these indicators are the GDP per capita, the industrialization level of the country, unemployment level, the potential user's perceived risk of choice, the time of the product's introduction, the education level of population and the competition level of telecommunications market. These factors, among others, are major drivers for defining the demand function of the product. As already recorded within Western Europe area, wherever these indicators reach a high diffusion, technology products meets higher penetration rates. In that sense, if appropriate investments will be made so as to increase the values of these indicators, then a desirable economical and social convergence will be achieved. In this direction, specific measures towards faster adoption of these services must be taken in national and international level.

The above approach brings to the argument that the study of the future trends of the demand evolution of telecommunication services will be of major interest. Thinking in terms of convergence, as the Central and Eastern European countries moving towards the levels of Western Europe's development indicators, the evaluation of the methodology will probably produce results depicting an increased demand. This will happen because the historical data that will be used will accommodate the inter-countries influence by that time.

The work presented in the preceding sections focused on introducing a methodology for estimating cross-area diffusion process and evaluating it over a real – world case of major interest, European countries, where telecom markets with different characteristics are aggregated. As the definition of cross-national, is not limited to country segmentation, but can be extended to include all kinds of market segmentations, the segmentation adopted here considered the groups of countries, Western and Central - Eastern European ones.

The methodology presented is quite interesting for studying the case of CEE in capturing the "lead-lag" effect, as shown above. The effects of the lead country over the lag one are expected to influence the adoption rate of the product within the lag country, as previous research has revealed that the later the product is introduced in the lag market, the greater the influence over the diffusion process would be. In fact, this time-lag between introductions is a subject of research by itself, as it can be crucial driver for the market's behavior. This consideration is the case for CEE, as new telecommunication technologies and services will shortly be introduced, which have already been introduced in Western Europe. This is expected to boost the estimated demand even more, as the market of reference is mature enough to adopt innovative telecommunication services, or next generations of already introduced ones.

6 References

Baliamoune Mina N.. The New Economy and Developing Countries. UNU/WIDER, 10-11 May 2002, Helsinki.

Bass Frank M., 1969. A new product growth for model consumer durables. Management Science, Vol. 15, No. 5, January 1969, pp. 215-227.

Ben-Akiva, M., Gershenfeld, S. (1989). Analysis of Business Establishment Choice of Telephone Systems. Cambridge Systematics, Cambridge, MA.

Bewley, R. & Fiebig, D. (1998). A flexible logistic growth model with applications in telecommunications. International Journal of forecasting, 4, 177-192.

Fisher, J. C. & Pry, R. H. (1971). A simple substitution model of technological change. Technology Forecasting and Social change, 3(1), 75-88

Gatignon Hubert; Eliashberg Jehoshua; Robertson (Thomas S.). Modeling Multinational Diffusion Patterns: An Efficient Methodology. Marketing Science, Vol. 8, No. 3 (summer, 1989), 231-247.

Gruber, H., (2005). The Economics of Mobile Telecommunications. Cambridge University Press

Gruber, H., (2001). Competition and innovation: The diffusion of mobile telecommunications in Central and Eastern Europe. Information Economics and Policy 13, 19–34

Helsen, K., K. Jedidi, W.S. DeSarbo. 1993. A new approach to country segmentation utilizing multinational diffusion patterns. J. Marketing 57 (Oct.) 60–71.

Jun, D. B. and Park, Y. S. A Choice-Based Diffusion Model for Multiple Generations of Products Technological Forecasting and Social Change 61, 45–58 (1999)

Jun, D.B., Kim, S.K., Park, M.H.,Park, Y.S., Juhn J.H., Lee, C. K., Joo, Y.J., (1997). Classification, Relationships and Forecasting Models for Telecommunication Services. Computers ind. Engng Vol. 33, Nos 3-4, pp. 829-832

Kauffman Robert J., Techatassanasoontorn Angsana A. International diffusion of digital mobile technology: A coupled-hazard approach. Forthcoming in Information Technology and Management. Last revised: June 2003.

Kumar V., New Product Forecasting. ISF 2002, Dublin, Ireland, June 27-30, 2002.

Kumar V., Krishnan Trichy V.. Research Note. Multinational Diffusion Models: An Alternative Framework. Marketing Science, Vol. 21, No. 3, Summer 2002, pp. 318-330.

Kumar V., Ganesh Jaishankar, and Echambadi Raj. Cross-National Diffusion Research: what Do We Know and How Certain Are We? J PROD INOV MANAG, 1998; 15:255-268.

Mahajan, V., Muller, E. & Bass F.M. (1990). New product diffusion models in marketing: A review and directions for research. Journal of Marketing. 54(1), 1-26.

Mahajan, V., Muller, E., Srivastava, R.K., (1990). Determination of adopter categories by using innovation diffusion-models. Journal of Marketing Research, 27 (1): 37-50

Michalakelis, Ch., G. Dede, D. Varoutas and Th. Sphicopoulos (2005), Impact of cross-national diffusion process in telecommunications demand forecasting Proc. Networking and E-Commerce Conference, Lake Garda, Italy, Oct. 2005

Rai, L.P. (1999) Appropriate models for technology substitution, Journal of Scientific & Industrial Research, 58 (1): 14-18

Rodriguez – Poo, J.M. (2003). Computer-Aided Introduction to Econometrics. Berlin: Springer Verlag

Stremersch, S., Tellis Gerard J. (2004) Understanding and managing international growth of new products. International Journal of Research in Marketing 21, 421-438.

Takada, H., D. Jain. (1991). Cross-national analysis of diffusion of consumer durable goods in pacific rim countries. J. Marketing 55 (April) 48–54.

Taylor, L. D. (1994). Telecommunications Demand Modeling: Theory and Applications. Kluwer.

Train Kenneth E. (2003). Discrete Choice Methods with Simulation, Cambridge University Press

Venkatesan, R. and Kumar, V. (2002). A genetic algorithms approach to growth phase forecasting of wireless subscribers, Int. J. Forecasting, vol. 18, pp. 625-646.