Factors and characteristics affecting ADSL tariffs in Europe

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***Abstract*—During the last decade broadband services and applications achieved significant penetration into the mass market across Europe. As the operators will continue to improve network infrastructures, customers will 'enjoy' new services in more attractive prices. Telecommunications' pricing process is influenced by a number of factors, such as subscribers' profile, market competition as much as users' income. In this work an overview of tariffs for ADSL connections across Europe is presented and a hedonic model is applied in order to identify and estimate the characteristics which are of substantial influence of the prices' shape.**

***Index Terms*— ADSL connections, broadband communication, hedonic model, technological innovation, competition**

I. Introduction

During the last decade broadband access to the home and Small Office/Home Office (SOHO) users received a lot of attention across Europe. Among *wireline* broadband alternatives, telecom operators focused on providing Asymmetric Digital Subscriber Line (ADSL) access since they use the existing copper line or upgrade the network infrastructure with low cost. Despite of the economic turndown at the beginning of the new century, broadband penetration succeeded an important and substantial growth. Since broadband connections are 'always on', a variety of broadband services such as high speed Internet access, voice over IP (VoIP) and high definition television (HDTV) encourage customers to stay on line for longer, which in turn leads to development of e-commerce that "*…enable companies to lower costs such as…selling and distribution, which will lead to the development of new markets and services*."[8].

On the other hand, the interdependence between the appropriate broadband service basket and the price each customer can afford to pay becomes a key component in the evolution of broadband penetration. The main target which aims to the dominance of market share grows the competition among telecom operators. Thus, new technologies are developed in order to meet the market demand as soon as it appears, in terms of services and prices. In the near future, operators will be able to provide the same type of service, with the same quality in every place of country [5]. This technological development will give equal rights to information access to all customers. Several business plans have been developed, comprising technological infrastructure, tariffs and basket services, in order to keep the broadband market evolution combined with the offer of more services in attractive prices.

The above discussion raises several questions to the "broadband community", which can be summarized to the following:

a) Which are the factors that affect broadband expansion?
b) How are prices of ADSL fluctuated?
c) Which characteristics of ADSL influence more the shape of their prices?
d) How operators react to the market demand?
e) Which are the governments' regulations and policies?

The present work focuses on attempting to explain the aforementioned observations and answer the raised questions. The rest of the paper is organized as follows. In section 2 the factors that provisionally affect broadband expansion are analyzed. In section 3 a hedonic model is studied, in which only the market for ADSL connections is considered. In section 4 numerical results are presented and finally, in section 5 conclusions are presented.

II. Factors Affecting the Broadband Access Development

The most important factors that affect the expansion of broadband services include the investments in the telecom sector, the technological enhancements of existing network infrastructures, the Gross Domestic Product (GDP), the competition among operators expressed by the contracts they offer. In addition, the subscribers' profile is taken into account while the governmental policies and guidelines for the telecom market are also of considerable importance.

A. Investments and GDP

Generally, the expected investments during each year or a period of time depend on the required equipments and network infrastructure. However, a crucial role to these investments holds the fact that the equipment prices are decreasing over time due to the mass production [1]. Other significant parameters in the investment plans constitution are the expected costs that will probably appear at the studied period such as maintenance and repair costs of the existing

network infrastructure, licenses costs (software and hardware), marketing costs for promoting a product and customers' installation. Many investments plans have been proposed in order to estimate the above parameters. However, the most difficult part to estimate, are the running costs, since new services appear and in replacement of others.

In addition, it has been noticed that higher-income households are using Internet more often, for a longer period of time [4] and for a variety of services (e.g. goods purchase, banking services, services under credit-card, video, audio etc) while people who live in urban areas are more likely to use Internet than others who live in suburban or rural areas. Thus, there is a higher investment risk in the latter areas, with a long period of pay back, which in turn leads in a growing inequality of the Internet access capability among different geographical regions [7].

B. Technological innovations

Telecom operators are expected to provide broadband communication services in all geographical areas, due to subscribers' preferences and the growing political interest (e.g. e-Europe 2005 guideline), necessitating the technological upgrading as inevitable. As a result, network operators are enforced to increase the available bandwidth, in order to give more services to customers. This is achieved by replacing parts of existing networks network with fiber infrastructure, especially in areas with specific characteristics, such as high density of potential subscribers. In addition, they have to identify these characteristics and make corresponding plans, in order to ensure a secure profit after upgrading their network. More specifically, they have to examine the existence of these characteristics in urban, suburban and rural areas. These include the necessary cable length for the expected connections, the number of subscribers per square km, the number of buildings in each specific area, as well as the number of potential subscribers per building [7]. As a consequence, a detailed study and identification of the necessary network infrastructure in order to satisfy Internet services and traffic characteristics is extracted. It is worth mentioning that in North Europe, the differences between rural and urban areas concerning the use of Internet are quite small, while the differences in south Europe are observable [8]. Rural areas of Northern Europe have low population density to present which leads to very high costs of network infrastructures. On the contrary, in South Europe the situation is quite different. In rural areas, with high population density, which is an advantage for the network infrastructure and equipment cost, the demand for broadband services is low, as a result of social and economic differences between them and the urban areas.

C. Subscribers' profile

People across all Europe are accessing Internet in growing numbers. Internet penetration has a great difference across European countries according to several characteristics such as the age, the educational level, the level of the income and the type of the family [4]. It is well known that different needs are satisfied in different ages. For example a kid is interested in Internet for playing games, listening to radio or educational services. On the contrary an adult has other needs like e-mail access, health and tourism information, electronic banking and purchase of goods. Moreover, the educational level of the subscriber is an important factor, since higher-educated people are more familiar and interested in new technologies [10] being more willing to use Internet for their needs. In addition, there is a strong relationship between income and Internet use [11]. Households with higher income have a strong effect on technology adoption, as they are expected to have already used some kind of such access technology in the past, obtaining the necessary familiarity. It is obvious that in developing countries possible customers have higher income, which means greater payment ability, and they can afford higher prices for technology equipment and services. A last characteristic of the subscribers' profile is the type of family. The use of Internet seems to be higher in families with children, instead of families with no children, or one person household. This is because all members of a family are accessing Internet for different reasons and preferences.

D. Competition among operators

Telecom operators, in order to ensure high quality and reliability of Internet services offer a number of choices, according to the customer demands and paying abilities. As a result, there is a fierce competition among them so as to attract more subscribers [3]. Some of them offer contracts with free of charge extra time of Internet connection, the duration of which depends on the offered bandwidth. There is also a great difference between residential and business packages offered. Currently, operators offer ADSL packages with various and data rates. There are low prices Internet connections that are designed to attract residential customers, while the most expensive ones, providing higher speed connections are designed for business customers. On the other hand, some operators offer free unlimited access to Internet, provided that telephone companies accept to pay these providers [2]. It is obvious that as the competition among firms is growing up, customers will experience low prices with better services.

E. Governments' policy and instructions

Governments are trying to promote broadband communications since the information being traded through Internet includes health, tourism, entertainment and commerce oriented subjects [8]. In general, the promotion of broadband services has a positive effect to economic activity and speeds up the economic development [9] while such policies will improve the quality of life and modernize the less developed areas by offering these services. Consequently, as the governments recognize the need for special attention, treatment and confront in rural areas, they are taking active measures by creating network infrastructures, which lead to high speed Internet access, so as all citizens can participate in an information society.

III. ADSL High-Speed Internet Connections

TABLE I
REQUIRED BANDWIDTH FOR TYPICAL BROADBAND SERVICES

Service	Bandwidth (Mbps)
High Definition TV (HDTV)	16 – 20
Telemedicine	6
Video on Demand (VoD)	6 – 18
Internet access	1,5
Video conferencing	1,5
Telecommuting	3
Multiple digital TV	6 – 24

Broadband services and applications are classified according to the offered data rate. The domination of ADSL technology for broadband access across Europe during the last years demonstrated the high-speed Internet access and IP-telephone as the most common broadband services. However, a wide range of new services are now becoming present in the mass market with an increased penetration of new

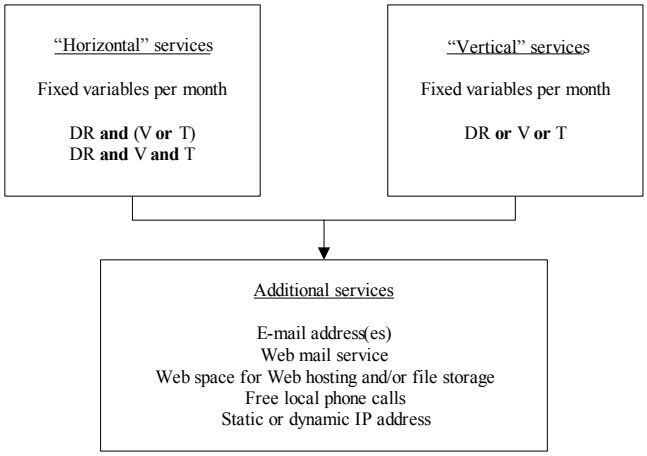

Fig. 1. Typical ADSL service basket

technologies (e.g. FTTx, ADSL2++, WiMAX) [6]. Table I summarizes typical broadband services that are expected to dominate in the near future.

In order to specify the basic basket of broadband services an extended survey of providers across European countries took place, focused on the services offered, the pricing policy as well as the development in broadband market. As a result, the typical ADSL service basket was determined as a combination of main and additional services according to Figure 1. Main services are distinguished into "horizontal" and "vertical" according to the number of fixed variables among supported data rate (DR), maximum consumed data volume (V) and maximum allowed minutes on line (T). Additional services include a number of email addresses, web space for web hosting and/or file storage and optional free local phone calls and static IP address. The choice of the appropriate combination for each operator is depending on the specific business plan as well as the techno-economic model parameters and assumptions.

The evolution of broadband technology offers new and challenging options. The EU Commission's "Broadband for all" policy is expected to grow the interest for broadband in the next years and to enforce the infrastructure competition among providers. As a result of this competitive environment the provision of enhanced broadband services with reduced tariffs is expected to increase significantly the number of broadband subscribers.

IV. Evaluation of ADSL Services

A. Hedonic method

In order to study a typical ADSL basket in European countries, a hedonic (econometric) model has been applied. A hedonic function is a relation between the prices of different varieties of a product, such as the various tariffs of ADSL connections and the characteristics of them. As a result the hedonic function is used for different characteristics among varieties of the product. In general, a hedonic model is described by the following equation:

$$P_i = g(Xi \cdot b_i) \quad (1)$$

where P_i is the price of a variety (or a model) i of a product and X_i is a vector of variables. In the economics literature, the variable of a 'hedonic function' are called characteristics.

After determining which characteristics have to be considered, the following equation [12] is estimated for N telecommunication products in period m:

$$\ln (P_{im}) = b_0 + b_1 \cdot \ln X_{1i} + b_2 \cdot \ln X_{2i} + u_{im}, \quad i = 1,..,N \quad (2)$$

where b_i are some coefficients that have to be estimated. The u_{im} is a regression residual, which indicates if the price of the particular product i, is close to the regression line at time m.

B. ADSL hedonic model

Many functional forms have been used in hedonic research, including research on various products such as computers, house bargain, wines' preference etc.

TABLE II
PRICES AND CAPACITIES FROM 2003 TO 2005

Year	min	mean	max
	Subscription price (€)		
2003	12,95	80,45	339
2004	6,73	44,81	170
2005	3,99	46,79	181
	Downstream Bandwidth (kbps)		
2003	250	872,22	3.000
2004	250	2.152,77	24.000
2005	256	4.284,93	26.000
	Upstream Bandwidth (kbps)		
2003	128	186,67	432
2004	128	660,89	24.000
2005	128	878,01	26.000

Regarding the ADSL connections data, which are collected from year 2003 to 2005 for both residential and business

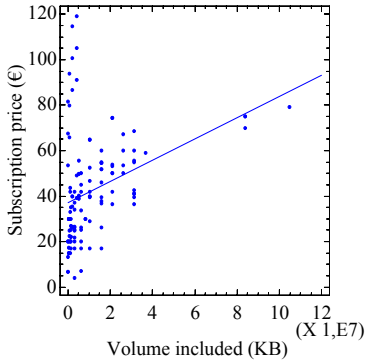

Fig. 2. Volume vs Subscription price

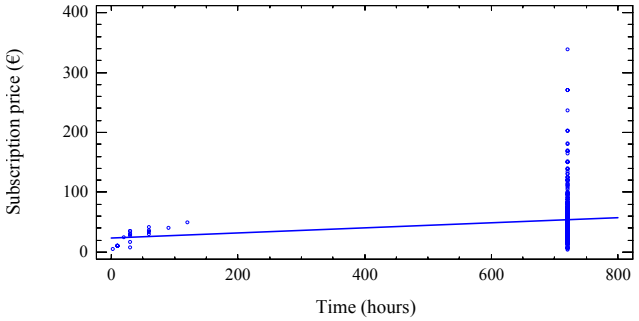

Fig. 3. Time vs Subscription price

connections, it is clear that there is a large variation of values in the variables and even more the price level is also varying from country to country, for the same service considered. As it can be seen in Table II from 2003 to 2004 there was a significant reduction in subscription prices on one hand and on the other hand an evolution on capacities' values which is about 30%.

By applying a multiple regression model to the ADSL connections data, the best fitting function turned out to be:

$$P_{im} = b_0 + b_1 \cdot D(\text{Mbps}) + b_2 \cdot U(\text{Mbps}) + b_3 \cdot \ln V(\text{Gbps}) + b_4 \cdot \ln(GDP(€)^2) + b_5 \cdot \ln((OP)^2) + b_6 \cdot DUR \quad (3)$$

where D and U is the downstream and upstream data rate in Mbps, respectively, V is the maximum consumed data volume in Gbps, GDP is the Gross Domestic Product of each country in €, OP is the number of operators in each country and DUR is the downstream to upstream ratio. Table III shows the results of fitting a multiple linear regression model to describe the relationship between subscription price and the six aforementioned identified variables. The standard error of the estimation shows the standard deviation of the residuals, where the Mean Absolute Error (MAE) is their average value. It is noticeable that the highest P-value [13] of the independent variables is 0,2258 belonging to $\ln(GDP^2)$. It is worth mentioning that when the P-value of a parameter deviates significantly from 0,10 it becomes statistically less meaningful. So, this parameter is the less significant for the evolution of broadband tariffs. Finally, since the coefficient determination (R-squared) is in excess of 94% the validity of the above model is even more strengthened.

TABLE III
REGRESSION ANALYSIS

Dependent variable: Subscription Price (€)			
Parameter	Estimated Coefficients	Standard Error	P-Value
Downstream (Mbps)	-26,01	8,38	0,0210
Upstream (Mbps)	300,30	58,54	0,0022
ln(Operators^2)	9,26	3,68	0,0456
ln(GDP^2) (€)	-15,16	11,23	0,2258
Downstream to Upstream ratio	6,178	2,34	0,0388
ln(Volume) (Gbps)	15,28	4,46	0,0141
R-squared: 94,84 %			
Standard Error of Estimation: 7,55			
Mean absolute error: 3,49			

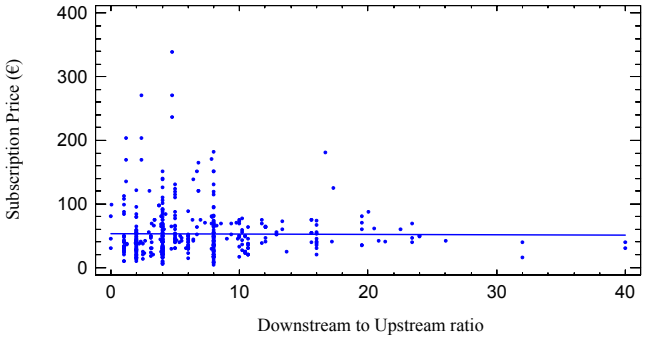

Fig. 4. Downstream to Upstream ratio vs Subscription price

Figures 2 and 3 present the shape of the subscription prices in connection with the maximum allowed volume data and maximum allowed time respectively, which are offered in every package. It can be observed that there is a growing trend in subscription price as both allowed volume data and time are increased.

Figure 4 shows the shape of the subscription prices in connection with the downstream to upstream ratio. It is clear that there is a remarkable trend for keeping the subscription price constant, as the downstream to upstream ratio increases on the same time.

Table III shows the results of fitting a multiple linear regression model to describe the relationship between subscription price and the six aforementioned identified variables. The standard error of the estimation shows the standard deviation of the residuals, where the Mean Absolute Error (MAE) is their average value. It is noticeable that the highest P-value [13] of the independent variables is 0,2258 belonging to $\ln(GDP^2)$. It is worth mentioning that when the P-value of a parameter deviates significantly from 0,10 it becomes statistically less meaningful. So, this parameter is the less significant for the evolution of broadband tariffs.

V. CONCLUSION

In this paper, a study of the dominant characteristics that

affect the tariff policy of ADSL services is presented. It has been shown that the general trend is the decrease of subscription prices, as probably expected. It is evidenced that customers are taking advantage from operators' competition. This is extracted from the fact that they are interested in the offered downstream and upstream rates, since these parameters designate the quality of the subscribed services.

However, as the factors affecting broadband tariffs can be numerous, a more detailed study that takes into account additional parameters is needed. In addition, the construction of unified price indexes for broadband connections is mandatory for an insight to real market conditions.

ACKNOWLEDGMENT

This work is financially supported from the Greek Ministry of Education and Religious Affairs and EU Operational Funds, under a *Pythagoras* Grant.

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