Techno-economic Evaluation of Telecommunications Networks and Services

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Abstract—This doctoral thesis presents a methodological framework which integrates, in a uniform way, a number of important parameters that influence the prices of telecommunications products and services. Given the above methodological framework, significant problems of telecommunication market regarding price indexes, are faced. The approaches developed are based on an appropriate mathematical and statistical background and they are applied to specific case studies, providing highly accurate results. The objective of this thesis corresponds to an important part of the techno-economic design aiming to the construction of price indices in the telecommunications market. The design of networks together with the preferences of the customers, are important elements related to the development of the corresponding infrastructure. Due to the rapidly developing technologies and the growing demand for access, design of these networks should provide and support innovative network services and technologies. Determination of a number of parameters, such as the physical characteristics of the telecommunication products and services, the profile of users, the number of users, the socioeconomic factors that influence the telecommunication sector and the shaped market shares due to competition, should be the drivers for the pricing policy of network services and technologies and the development of the infrastructure to support the network operation.

Index Terms **—**Techno- economic Evaluation, Matched Models, Hedonic Price Indices, Leased Lines, ADSL connections, Physical and Socioeconomic characteristics

I. INTRODUCTION

While price indexing has been a common feature of many products, exactly what constitutes price indexing has been the subject of some disagreement. Price index of products is a research field facing a high level of interest and it is applied for all new and innovative products [1, 2], [4], [5], [6-8]. In case that, false price indices have been constructed, then the consequences for the product marketing will probably be dramatic, since they implicit lack of meeting the customers' preferences and the market's competition leading to oversupply and unneeded investments. The most appropriate case to be considered as an example is the telecommunication sector, since it is almost always connected to significant contemporary investments, regarding new technologies and services and critical business plans, targeting to meet the customers' needs and the market's competition.

As telecommunication services and products are being improved and developed at a fast pace especially during the last ten years, industrial plans rolled out in an attempt to attract and to retain customers. For this purpose, they must precisely know what influence or determines the products' prices, how prices for products that enter the market for the first time or have been modified can be estimated and finally the determination of a price index for these products in a specific period, m, giving the trend of products' prices over time.

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Although literature regarding price indices for established products and services is well developed, new opportunities have emerged due to the nature of high technology products' market. Therefore, further methodological work should be done, by identifying the gaps that have opened up in pricing policy, due to the rapid change of the products' and services' prices and the obvious markets' behavior to fulfill the customers' needs and preferences..

II. THEORETICAL BACKGROUND

One of the main central themes is the mathematical modeling of price indexing, for different types of products and under different assumptions. So far the established research has examined two possible price indexing schemes, under the umbrella of econometric methods. Econometric methods have been used for price index calculation for a long period of time: cars [2], refrigerators [5] and computers [4] are some examples. Furthermore indices about information technology can be found in [1] and [6]. In addition, statisticians use econometric methods in U.S.A but the root of hedonic approach, which is a part of economic research, goes back to [9-12].
There are two types of econometric methods:

- *hedonic methods* and
- *matched model methods,*

each of which have both advantages and disadvantages. One choice is to apply the 'hedonic methods', such as two-period method, single-period method, two-period method with an indicator for new models, or single-regression method. Such indices are commonly used for products, which undergo rapid technological changes.
Hedonic methods refer to regression models in which product prices are related to product characteristics and the observed price of a product (service) is considered to be a function of its characteristics. Generally hedonic methods are based on the idea that a service (product) is a bundle of characteristics and that consumers just buy bundles of product characteristics instead of the product itself. These methods can be used to construct a quality-adjusted price index of a service and researchers described an overview on hedonic price equations [7], [13]. Researcher states that from a large amount of product varieties, consumer chooses without influencing prices [24]. Therefore, consumers maximize utility and producers maximize profits. In hedonic studies it is possible to adjust the price of a service for its quality not quantity. All of them are based on some estimated coefficients that are inflicted on the characteristics of the products in both periods; m and m+1. Someone can estimate the coefficients for every year separately or can have observations of two or all years together and estimate a common set of coefficients. The advantage of this method is that calculations are easy and fast. Indeed hedonic methods are very fast to apply but the disadvantage is that index price can change even if no new products are existed, or all prices remain the same.

Another choice is to apply a matched model method such as chained Laspeyres (LCPI), (LPI) or chained Paashe (PCPI), (PPI) or chained Fisher or chained Tornqvist or chained geometric – mean [25]. A classic LPI cannot deal with such complexity due to rapid technological changes or the introduction of new products (services). With LPI an index shows how much the product would cost in period m+1 relatively to what it cost in period m. Other price indices function in the same way with slight differences.

The hedonic price indices are commonly used as approximations to the true cost-of-living indices (COLI) which indicate how much money a consumer would need in period m+1 relatively to the amount of money he needed in period m so as to keep the same level of utility in period m+1 as in period m [3]. The solution is to determine consumer's profile so as to react to a varied and fast-changing supply of products. But how can this profile be determined when everyone has different needs and requirements? No matter what profile is decided, it will be a hypothesis and an assumption that will respond at a specific model. In addition to the above, someone can see that consumer's desire is not stable and this is not unreasonable because there is a great offer as the 'goods' of technology become more and more attractive. However according to this approach the price index is constructed only using the prices of products, which are available in two adjacent periods.

According to matched model method, Laspeyres in order to create a price index at a time, someone observes the number of units sold in a period m (for example a month) and the average unit price in the period m and m+1. These data are used in the following formula:

$$I_{m+1/m} = \frac{\sum_{i=1}^{n} p_{im+1} q_{im}}{\sum_{i=1}^{n} p_{im} q_{im}} \qquad \text{Eq. 1}$$

Price indices are measured, as it is mentioned above, by the matched model method of Laspeyres with chaining average unit prices, which are referred to a previous period, among units sold in the same period.

The term 'hedonic methods' refers to a 'hedonic function' $f(X)$, which is used in economic measurement, where

$$P_i = f(X_i) \qquad \text{Eq. 2}$$

where P_i is the price of a variety (or a model) i of a product and X_i is a vector of characteristics associated with the variety. The hedonic function is then used, for different characteristics among varieties of the product, in calculating the price index.

As soon as it is determined which characteristics have to be considered, then the equations (13) and (14) are estimated for N telecommunication products in period m and m+1:

$$\ln(p_{im}) = b_0 + b_1 \cdot X_{1i} + b_2 \cdot X_{2i} + u_{im}\ ,\ i=1,\dots,N \qquad \text{Eq. 3}$$

$$\ln(p_{im+1}) = b_0 + b_1 \cdot X_{1i} + b_2 \cdot X_{2i} + b_3 + u_{im+1} \qquad \text{Eq. 4}$$

where b_i are some coefficients that have to be estimated.

A problem which is posed is the selection of the best hedonic model. So, in order to estimate prices a Sliced Inverse Regression (SIR) is performed, without knowing the shape of the function [14]. Then a Local Polynomial Regression (LPR) is applied and a possible shape of the hedonic function is extracted. In order to find out which is the best model, from a variety of candidate models that describe a product with a set of characteristics, the following equations are used:

$$\hat{\sigma}^2 = \frac{\{\mathrm{Y} - \hat{f}(X\hat{b})\}'\{Y - \hat{f}(X\hat{b})\}}{n} \qquad \text{Eq. 5}$$

$$\mathrm{d}((\hat{f}, \hat{b}, \hat{\sigma}^2) = E_0\{-2\log f(Y)\} \qquad \text{Eq. 6}$$

where $f(Y)$ shows the possibility for the candidate model and E_0 shows expectation under the true model. Among several candidate hedonic models the best one is derived by applying the (AIC)Akaike Information Criterion (Naik and Tsai 2001) by the following equation:

$$AIC_c = \log \hat{\sigma}^2 + \frac{1 + tr(\hat{H}_p + \hat{H}_{np} - \hat{H}_p \hat{H}_{np})/n}{1 - \{tr(\hat{H}_p + \hat{H}_{np} - \hat{H}_p \hat{H}_{np}) + 2\}/n} \qquad \text{Eq. 7}$$

where $\hat{H}_p = \hat{V}(\hat{V}'\hat{V})^{-1}\hat{V}', \hat{V}$ is obtained by replacing $b*$ and $\tilde{f}.in\tilde{V}$ with estimators $\hat{b}and\hat{f}$, and $\hat{H}_{np} is H_{np}$ evaluated at $Xb = X\hat{b}$.

Across the candidate models in several shapes of link function, the one which gives the smallest AIC is the suitable.

Finally when there are *N* telecommunication products in period *m* and *m+1*, the proposed hedonic price index can be calculated by the following equation:

$$I_{m+1/m} = \widehat{f}_{m+1}(\widehat{b}_i * X_i) - \widehat{f}_m(\widehat{b}_i * X_i) \quad \text{Eq. 8}$$

III. PRICE INDEXES FOR LEASED LINES

Markets of high technology products and services, such as telecommunications, are described by fast technological changes and rapid generational substitutions. As a result, the question arisen is generally about prices of products and what influences or determines them. Particularly, how prices for products that enter the market for the first time or have been modified can be estimated, how can someone determine a price index for these products in a specific period m and what do these prices tend to become over time? For this purpose, the work presented in this section, deals with the construction of a price index for telecommunication services (leased lines) with a hedonic approach. A leased line is a permanent connection between two telecommunications sites. The prices usually depend on the distance and on the transmission rate and the operators guarantee better access to the network. The importance of such an approach is especially significant for markets characterized by rapid technological and generational changes[21].

A. Methodology

The hedonic approach is based on the fact that there is a set of consumers who have preferences over some characteristics of a service. The term 'hedonic methods' refers to a 'hedonic function' Y used in econometrics, where

$$Y = g\left(\beta X\right) + u \quad \text{Eq. 9}$$

with *Y* refers to data (e.g.. prices of products), X_i is a vector of regressor values (e.g. characteristics associated with the variety of the products) and *u* is distributed normally around zero.

In order to choose the hedonic function that associates the observed output with the vector of the variables, a number of mathematical techniques have been used, resulting in the selection of the model using an improved Akaike Information Criterion – AIC [15], by minimizing the Kullback - Leibler distance [8]. This procedure results in simultaneously choosing the relevant regressors, and a smoothing parameter for the unknown hedonic function. These techniques are extensively described in [8] and consist of the following steps:

- Firstly, the application of Sliced Inverse Regression, (SIR), in order to obtain a consistent estimate of the parameters of the model, $\hat{\beta}_{SIR}$, without requiring estimation of the hedonic function [16], [14] .
- The application of a Local Polynomial Regression, (LPR), with a Gaussian kernel, in order to estimate the unknown hedonic function by $\hat{g}\left(t\right)$, where $t = X\hat{\beta}_{SIR}$ [26].
- Finally, the application of the improved Akaike Information Criterion which minimizes the expected Kullback - Leibler distance, in order to select the appropriate model from a wider class of candidate models [8].

B. Evaluation

Evaluation of the proposed methodology was performed over **all** European countries, with data from year 1997 to year 2003, which actually includes 42 combinations of capacity, distance and price, over time, whereas a price index is constructed for the case of Greece. These two characteristics (capacity (DIST) and distance (MB)) are widely used from telecom operators for valuating and selling leased lines across Europe. Three different distances are covered, namely 2 km (local circuits), 50 km and 200 km as well as four types of leased lines circuits, namely 64 kb/s, 2 Mb/s, 34 Mb/s and 155 Mb/s but there are enough price data only for 64 Kb/s and 2Mb/s, ensuring the compatibility of the data. All prices are presented in Euros (€) per year, excluding VAT. This overview about data prices and circuits expressed in '*Report on Telecoms Price Developments from 1997 to 2000'* which is prepared for European Commission [17].

By dividing the dataset to slices and performing the SIR algorithm, the corresponding SIR directions were calculated, after conducting eigenvalue decomposition, with respect to the covariance matrices. The plot of Y against the SIR variates is depicted in Figure 1.

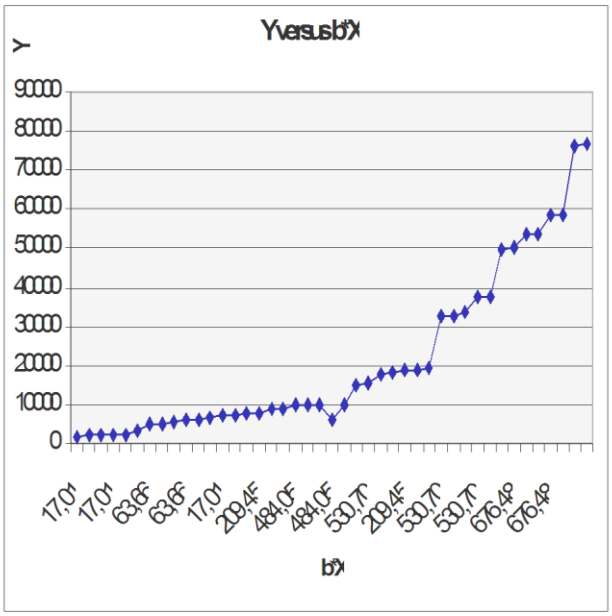

Figure 1: Plot of Y (prices) against the SIR variates

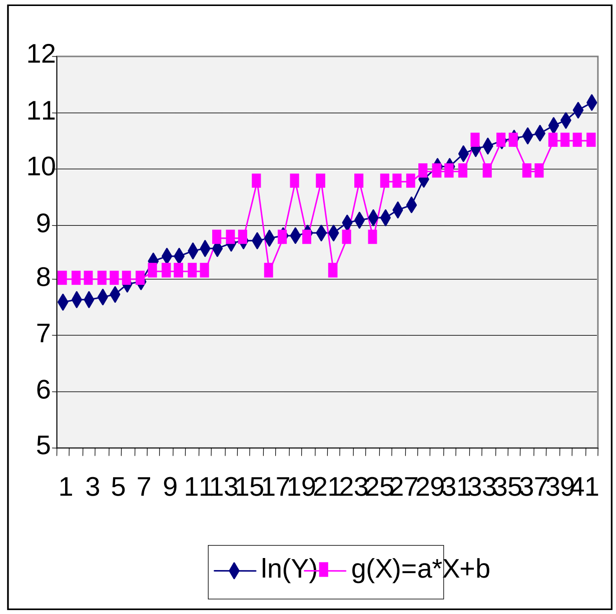

Figure 2: Selected model fitting results

This plot provides a graphical summary, useful for revealing the regression structure, thus giving an insight of the form of the underlying model. As a next step, the LPR algorithm is applied (Figure 2), using different bandwidths (i.e. 5, 10 and 100). Taking into account the shape of the above plot the following hedonic function will be evaluated by the AIC,

$$Y = \ln(P_i) = g_0(\beta_0 X_0) \quad \text{Eq. 10}$$

where P_i is the price of a product variety and $g(\beta_0 X_0)$ could be:

i) $g(\beta_0 X_0) = \alpha + \beta_0 X_0$

ii) $g(\beta_0 X_0) = \exp(\alpha + \beta_0 X_0)$

iii) $g(\beta_0 X_0) = \alpha + \beta_0 X_0^2$

iv) $g(\beta_0 X_0) = \alpha + \beta_0 \ln(X_0)$

Concluding, the considered equation relating the product's price and its characteristics is the following:

$$\ln(P_i) = \beta_0 + \beta_1 Dist + \beta_2 MB \quad \text{Eq. 11}$$

where β_i are the coefficients estimated in the above described procedure.

Therefore, the proposed hedonic price index can be calculated by the following equation:

$$I_{m+1/m} = \hat{g}_{m+1}(\beta_0 + \beta_1 Dist + \beta_2 MB) - \hat{g}_m(\beta_0 + \beta_1 Dist + \beta_2 MB) \quad \text{Eq. 12}$$

This index and its evolution for several years are presented for the case of the Greek market (Figure 3) for the telecommunications leased lines, showing the decrease of the prices in 1998 as a part of market liberalization and the stability of this market in the next years.

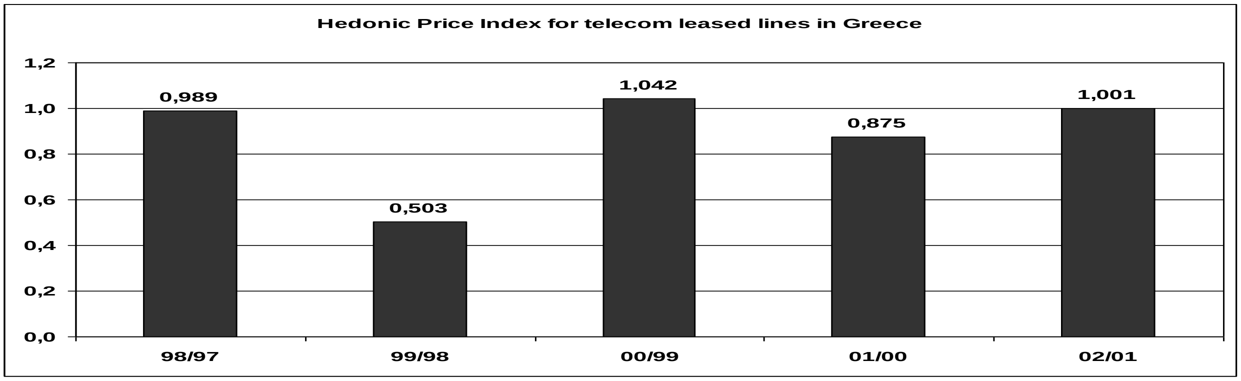

Figure 3: Hedonic price index evolution for the case of leased lines market in Greece

IV. NON PARAMETRIC APPROACH FOR ADSL CONNECTIONS

It is evidence that the demand for Asymmetric Digital Subscriber Line (ADSL) connections increases day by day in all European countries as much as worldwide and it is well known that Internet's penetration is considerably amazing. At the same time, due to the fierce competition among ADSL connections providers, several packages are offered in attractive tariffs. As a product consists of various characteristics that consumers prefer, the questions that arise are how should consumers' choices and preferences for ADSL connections affect tariffs and what are the more significant and powerful characteristics that shape tariffs of ADSL connections? This work in this section provides a hedonic price analysis of ADSL connections for the European market. The problem which is posed is the selection of the best hedonic model. So, in order to estimate prices a sliced inverse regression (SIR) is performed, without knowing the shape of the function. Then by applying Local Polynomial Regression (LPR) a possible shape of the hedonic function is given. Among several candidate hedonic models and by applying AIC criterion, the best one is derived [22].

A. *ADSL High-speed Internet connections*

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.

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 4. 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 includes 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.

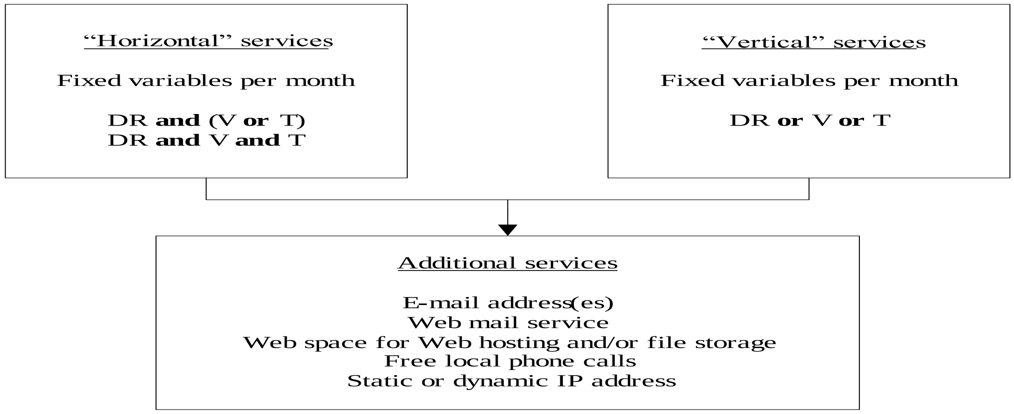

Figure 4: Typical ADSL service basket

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.

B. Evaluation of the model

Evaluation of the methodology was performed over 15 European countries and more specifically, tariffs' data have been collected over the period from 2003 to 2005. Apart from tariffs, data that specify ADSL connections, such as supported data rate DR (up and down), maximum consumed data volume (V) and maximum allowed minutes on line (T) have also been collected and analyzed.

Considering that the hedonic function is given by the following equation:

$$P_i=f(X_i) \qquad \text{Eq. 13}$$

with P_i is the price of a variety (or a model) i of a product and X_i is a vector of characteristics associated with the variety.

First of all, the SIR algorithm is applied, where the data are sorted by P_i and then are divided into three slices. Without specifying the unknown link function we derive:

$$\widehat{b}_{SIR} = (0.581899, -0.78326, -0.00011, -0.21886)$$

The above results imply that the price is strongly related only with the downlink DR [18].

By having four characteristics we take under consideration 4^2-1 nested candidate models. For each of the nested models SIR estimates are obtained (Figure 5) and then by applying the LPR (Figure 6) the link function $\widehat{f}_k\,(k=1,2,3,..15)$. Figure 5,6 also shows that some individual tariffs are existing which decline significantly from the main cluster.

In order to examine the relationship between the price of an ADSL connection and their main characteristics, such as the supported data rate and the maximum consumed data, several candidate link functions are applied. Across the candidate models in several shapes of link function, the one which gives the smallest AICc (0,2125746 vs 7,846617) value from equation 13, is described by the equation:

$$\ln(p) = b_0 + b_1 \cdot DR(down) + b_2 \cdot DR(up) + b_3 \cdot (V) + b_4 \cdot (T) \qquad \text{Eq. 14}$$

Even link functions such as hyperbolic sine or hyperbolic cosine give almost the same results with the non linear functions. Although linear model on logged price is not comparable with all the other models, because of the AICc value, linear model on logged scale has an advantage.

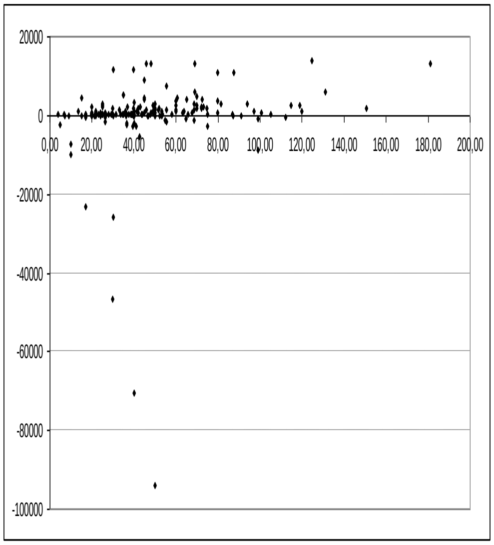

Figure 5: Plot of P_i against SIR directions

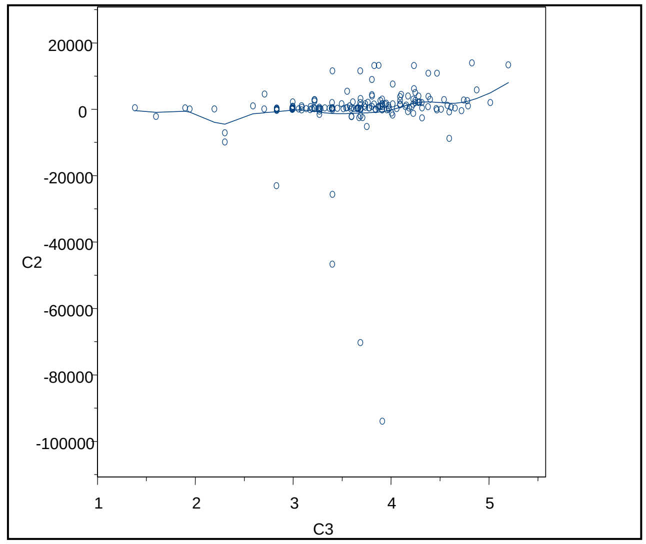

Figure 6: Local Polynomial Regression with Kernel Smoothing

Working in the logarithmic scale using a linear model results shows a better fit than all the other models because first of all the residuals from the log-linear model are all around zero (Figure 7) [18] and less standard error (0,5845 vs 26,58).

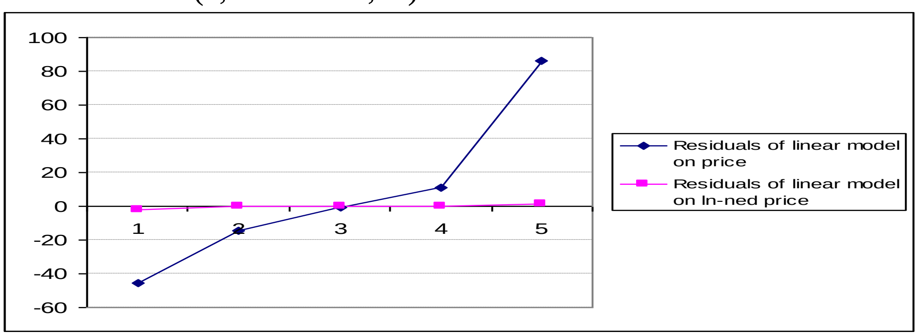

Figure 7: Residuals

Using data such from all European countries, it can been observed that it is not easy to compare prices for different data rate and consumed volume and allowed time on line, but there are similarities and patterns that must be evaluated. It is obvious that the more a consumer demands for a product with upper services, the more the prices of this product are increased. Because of this consumers' 'behavior' there is no implicit prices for all characteristics.

V. INCLUDING SOCIO-ECONOMIC VARIABLES IN HEDONIC MODEL

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 are expected to "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. Finally, a price index for ADSL connections is constructed [23].

A. Socio-economic variables

According to the economic theory described above regarding hedonic models, there are several characteristics that influence tariffs. Data by the meaning of attributes of a given product can be divided in three categories: spatial, physical and socio-economic [19].

The spatial division can be handled separate by location. Attributes or exogenous variables are made up of physical quality characteristics and socio-economic attributes. Measures and differences that compare geographical areas have implications for regional cost of living. This has a substantial effect not only to consumers' choices and preferences, but also to the governments' policies and market relocation as well. This is an index for decision-making affecting all involved parties.

The physical quality characteristics are the attributes which are unique and specify the product. For instance, a bundle of physical characteristics can be: the offered data rate, the maximum consumed data volume etc.

The socio-economic variables are characteristics that are not easily calculated, but it is assumed that influence the ADSL market expansion and penetration. Such characteristics are: the educational level, the age, the income and the personalization of the subscribers, the technological infrastructure improvement, the year of telecommunications' liberalization etc. As to the customers' interests, they can be identified from the web pages they visit and the amount of time they spend on them. But it is extremely difficult to gather data, in order to understand customers' profile and characteristics, because on one hand the veracity of them is doubtful and on the other customers are not interested in providing information for privacy concerns. By including in the model the socio-economic variables implicit market's prices may arise for quality characteristics.

B. Evaluation of the model

Following the theoretical presentation of the preceding sections, a hedonic (econometric) model was applied, in order to study a typical ADSL basket across the European countries. The evaluation was based on data for ADSL connections, which were collected from year 2003 to 2005 for both residential and business connections. Of course there is a large variation of values of the participating variables, as well as in price levels between the participating countries, for the same service considered. Evaluation data were collected from Austria, Belgium, Denmark, Finland, France, Germany, Iceland, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, UK, and Greece. In addition, they correspond to all operators, no matter the number of subscribers they have. By applying a multiple regression model to the ADSL connections data, the best fitting function for every year (2003, 2004 and 2005), turned out to be:

$$P_{im} = b_0 + b_1 \cdot D(\text{Mbps})_i + b_2 \cdot U(\text{Mbps})_i + b_3 \cdot \ln V(\text{Gbps})_i + b_4 \cdot \ln(GDP(€)^2)_i + b_5 \cdot \ln((OP)^2)_i + b_6 \cdot DUR_{\text{i}} \qquad \text{Eq. 15}$$

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 and m is the year. Finally, coefficients b_0 to b_6 are constants and they are the corresponding weighting factors. Table 1 shows the results of fitting by a multiple linear regression model, in order to describe the relationship between the 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 of the independent variables is 0.2258 belonging to $\ln(GDP^2)$ [20].

The P-value that appears in the results' table is related to the probability for the corresponding parameter to be equal to zero. So, this parameter can be considered as less significant for the model, the evolution of broadband tariffs in the presented case. Finally, since the coefficient determination (R-squared) is in excess of 94% the validity of the above model is even more strengthened.

Using data such, for the case of Europe, it can be observed that it is not easy to compare prices for different characteristics such as data rate, consumed volume, allowed time on line, since on the same time, the subscription price for year 2004 is 50% less than this of 2003, but for the period 2004 – 2005 it is approximately the same.

Table 1: Regression analysis

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

However, in countries such as Belgium and The Netherlands, prices were reduced during 2003 – 2004 but in 2004 – 2005 remained almost the same, whereas in other such as Spain there is a continuous reduction across years.

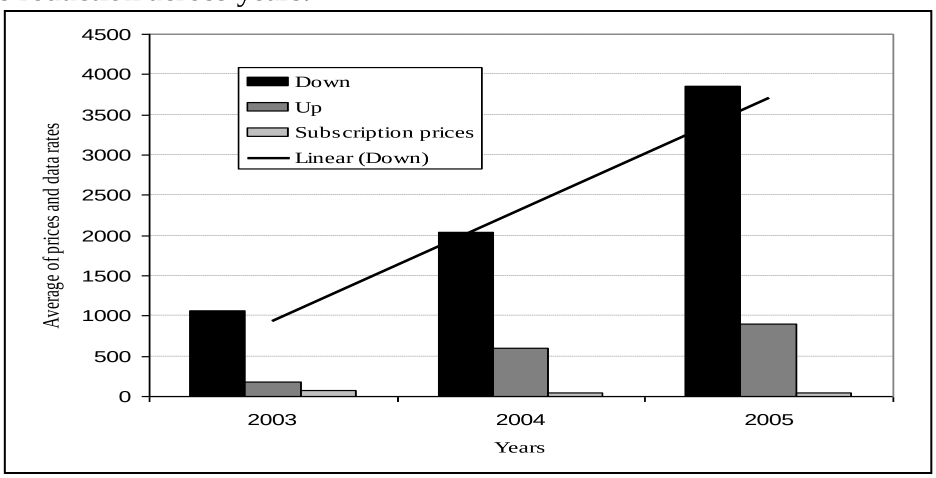

Figure 8: Evolution data rate (down) in Europe

Therefore, the average value of prices of ADSL connections and their characteristics (downstream and upstream) was computed for all countries (Figure 8), in order to provide an estimation for prices and physical characteristics (downstream and upstream) of a typical European ADSL connection. Once more, it can be observed that downstream and upstream data rates seem to follow a linear path over years (solid line in Figure 8).

Finally, in the case that there are N telecommunication products in the period between m and $m+1$, by considering Equation 4 which describes the relationship between prices and characteristics, in a variety of ADSL products, the proposed hedonic price index is calculated by Equation 8.

This behavior fits to the hedonic approach and it can be observed by calculating the hedonic price index from equation 16. In addition, In Figure 9, the calculated index and its evolution are presented for the case of European countries broadband market. It is observed that for the period 2003 – 2004 there is a trend of 50% reduction in prices.

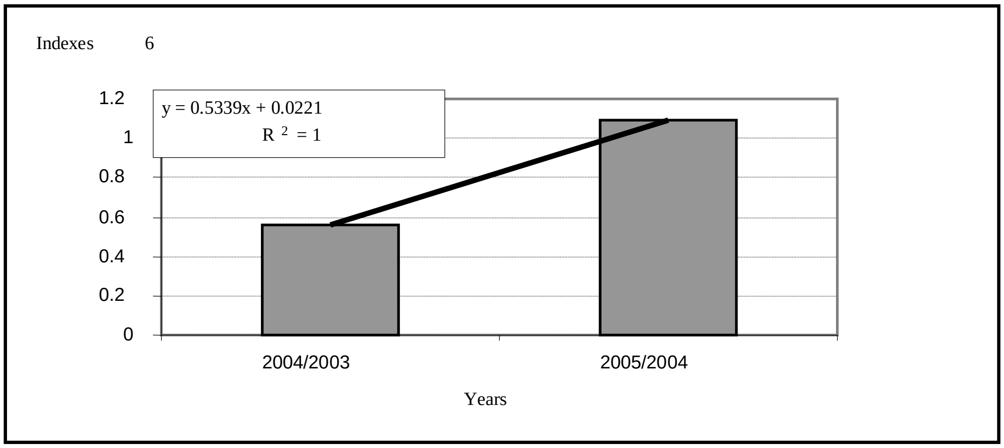

Figure 9: Hedonic price index evolution for the case of ADSL market in Europe

However, this does not apply for the period 2004 – 2005, even if the price index has approximately the value 1, which means that prices for ADSL services are the same. Taking into account that there is a significant trend in downstream and upstream bandwidth, it can be extracted that there is an implicit reduction of prices, since operators offer better services at more or less the same price.

VI. Conclusions

The main conclusions drawn by this doctoral thesis, which also constitute its contribution, lie in the following points:

- Overview of the physical, social, economic and spatial parameters that influence the prices of products-services and networks of the telecommunications market.
- Development of a methodology for the definition of characteristics, of telecoms products-services and networks that affect their prices.
- Categorization and grouping of characteristics of access technologies.
- Quantification of telecoms' networks and products data related to characteristics and the emergence of influence of them on the telecoms products-services pricing.
- Construction of price indices and clarification of the trend of prices and indices of the telecoms products and services.
- Implementation of methodological approach on different telecoms products-services and networks.
- Integration of price indices into the demand models and assessment of their influence on the diffusion process of telecoms products and services.

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