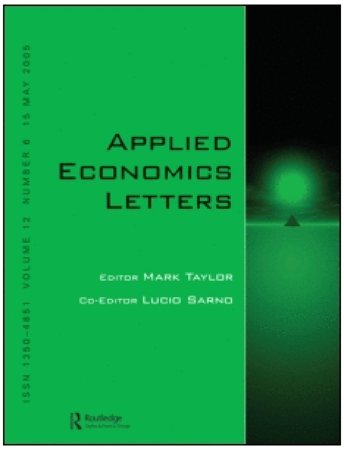

Applied Economics Letters
Publication details, including instructions for authors and subscription information:
http://www.informaworld.com/smpp/title~content=t713684190

A hedonic approach to estimate price evolution of telecommunication services: evidence from Greece

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To cite this Article Varoutas, D. , Deligiorgi, K. , Michalakelis, C. andSphicopoulos, T.(2008) 'A hedonic approach to estimate price evolution of telecommunication services: evidence from Greece', Applied Economics Letters, 15: 14, 1131 — 1134
To link to this Article: DOI: 10.1080/13504850600993648
URL: http://dx.doi.org/10.1080/13504850600993648

Applied Economics Letters, 2008, **15**, 1131–1134

Routledge
Taylor & Francis Group

A hedonic approach to estimate price evolution of telecommunication services: evidence from Greece

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Following a description of the leased lines telecommunication market, a single index (based on hedonic approach) for this market is introduced based on data across Europe. This article aims to provide a framework for analysing telecommunication prices over time and study how the prices will fluctuate during coming years, especially as new technologies are commercially provided. The behaviour of the Greek market is analysed from 1997 to 2002.

I. Introduction

Telecommunication services and products are being improved and developed at a fast pace especially during the last 10 years. The question arisen is generally about prices of products and what influences or determines them. 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? Econometric methods for calculation of a price index have been used for cars (Griliches, 1961; Naik and Tsai, 2001), for refrigerators (Triplett and McDonald, 1977), for cars and computers (Cole, 1986). Furthermore indices for information technology products can be found in (Cartwright and Smith, 1988; Moreau, 1991a; Triplett, 2000) (Table 1).

The article 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. In this study, data for national leased lines from 1997 until 2002 have been used. Three different distances are covered, namely 2 km (local circuits), 50 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 2 Mb/s. Structures for earlier years may be different, but special attention has been paid to ensure the compatibility of the data. All prices are presented in Euros (€) per year, excluding VAT. This overview about data prices and circuits is expressed in '*Report on Telecoms Price Developments from 1997 to 2000*' which is prepared for European Commission by Teligen Ltd (Teligen, 2000).

The rest of the article is organized as follows. Section II gives a description of the hedonic models and their implementation for the selection of a single-index model used as a price index. Section III concludes the results.

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Applied Economics Letters ISSN 1350–4851 print/ISSN 1466–4291 online © 2008 Taylor & Francis
http://www.informaworld.com
DOI: 10.1080/13504850600993648

Table 1. Classification of leased lines for different technical characteristics

	1: When tariff specifies local tail prices separately, in addition to main circuit		2: When tariff specifies a single price for the circuit, end to end	
	Local tail length	Main circuit length	Local tail length	Main circuit length
2 km circuit	1 km	0	0	2 km
50 km circuit	2 km	46 km	0	50 km
200 km circuit	2 km	196 km	0	200 km

Note: The local tail length is per tail, i.e. there will be two such tails with each circuit.

II. The Hedonic Price Index for Leased Lines

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

$$Y = g(\beta X) + u \quad (1)$$

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; Akaike, 1973), by minimizing the Kullback-Leibler distance (Naik and Tsai, 2001). This procedure results in simultaneously choosing the relevant regressors, and a smoothing parameter for the unknown hedonic function. These techniques are extensively described in (Naik and Tsai, 2001) 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 (Duan and Li, 1991) and (Li, 1991).
- The application of a Local Polynomial Regression (LPR), with a Gaussian kernel (Simonoff, 1996), in order to estimate the unknown hedonic function by $\hat{g}(t)$, where $t = X\hat{\beta}_{SIR}$.
- Finally, the application of the improved AIC which minimizes the expected Kullback-Leibler distance (Naik and Tsai, 2001), in order to select the appropriate model from a wider class of candidate models.

As described above, the price of a telecommunications product is related to its characteristics, so as to show the quality of this product. It is assumed that telecommunication products (and especially leased lines) have two characteristics: Distance (Dist) and Transmission rate per second (MB). These two characteristics are widely used from telecom operators for valuating and selling leased lines across Europe.

The procedure described previously was applied, in order to conclude to the best fitting model, among the candidate ones. For the sake of robustness, the procedure had been tested over a dataset of the leased lines price evolution over *all* European countries, with data from year 1997 to 2003, which actually includes 42 combinations of capacity, distance and price, over time.

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. As a result, the estimates of the coefficients were derived, which were used to form a linear combination together with the variables under consideration, namely capacity and distance. The plot of Y against the SIR variates is depicted in Fig. 1. 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, using different bandwidths (i.e. 5, 10 and 100). Taking into account the shape of the above plot (Fig. 1), the following hedonic function will be evaluated by the improved AIC,

$$Y = \ln(P_i) = g_0(\beta_0 X_0) \quad (2)$$

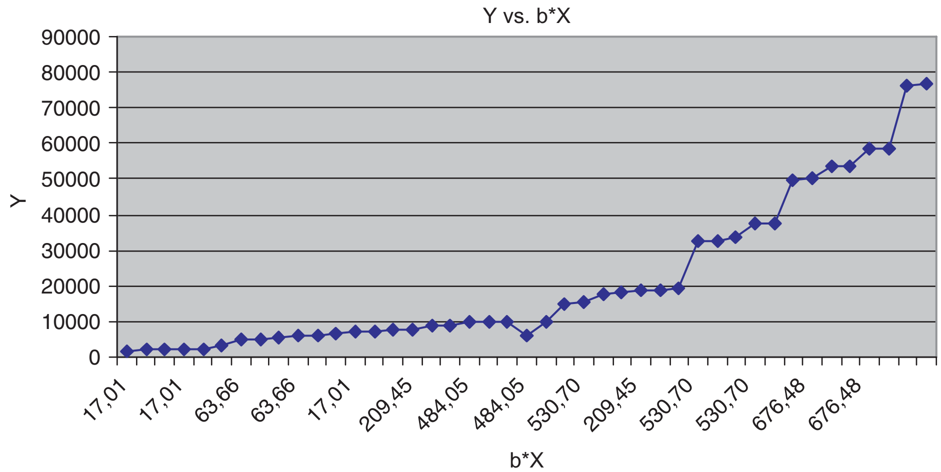

Fig. 1. Plot of Y (prices) against the SIR variates

Table 2. AIC results for the examined models

Model	$g(\beta_0 X_0) = \alpha + \beta_0 X_0$	$g(\beta_0 X_0) = \exp(\alpha + \beta_0 X_0)$	$g(\beta_0 X_0) = \alpha + \beta_0 X_0^2$	$g(\beta_0 X_0) = \alpha + \beta_0 \ln(X_0)$
AIC	0.1145957	0.132359	0.4372874	0.1649474

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

The corresponding results are provided in Table 2.

Thus, the first examined model turns out to be the most suitable among the two candidates. Fig. 2 shows the fitting results of the first and more suitable model against the actual prices.

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

$$\ln(P_i) = \beta_0 + \beta_1 \mathrm{Dist} + \beta_2 MB \tag{3}$$

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:

$$I_{m+1/m} = \hat{g}_{m+1}(\beta_0 + \beta_1 \mathrm{Dist} + \beta_2 MB) - \hat{g}_m(\beta_0 + \beta_1 \mathrm{Dist} + \beta_2 MB) \tag{4}$$

In Fig. 3, this index and its evolution for several years are presented for the case of the Greek market 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.

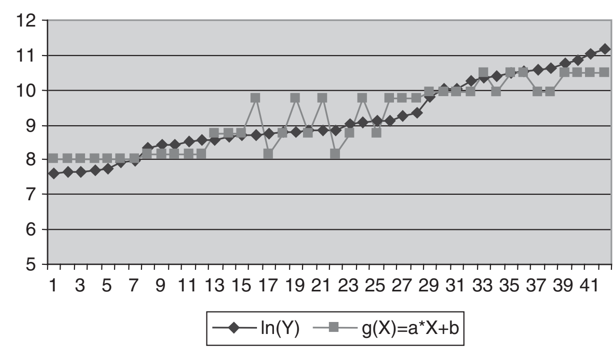

Fig. 2. Selected model fitting results

III. Conclusions

The trends of national leased lines as a typical telecommunication service has been introduced and presented, by applying a hedonic method. As telecommunication leased lines have important and specific characteristics and their prices vary over time, the relationship between market prices and product's attributes is of great importance in the telecommunications sector for technical, marketing and regulatory reasons. The approach introduced, analysed and presented in this article, aims to provide a framework for analysing telecommunication prices over time and study how the prices will fluctuate during next years, especially as new technologies such as

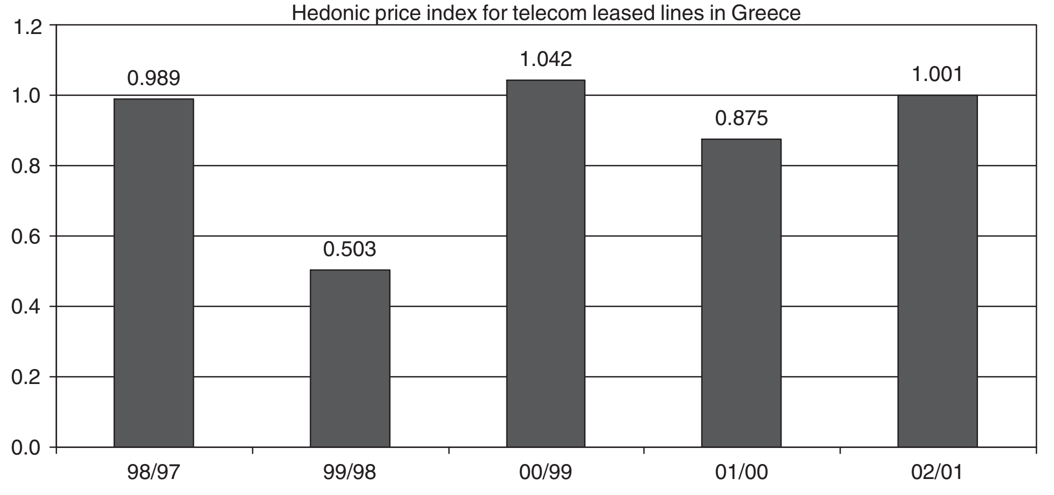

Fig. 3. Hedonic price index evolution for the case of leased lines market in Greece

DSL (Digital Subscriber Line) and FTTH/O (Fiber to the Home/Office) are commercially provided in the mass market and compete with mature technologies such as leased lines.

As the relationship between prices and product's characteristics in the telecom market is subject to rapid technology developments and market competition, extensive research has been undertaken worldwide towards this direction. The introduced single-index model aims to contribute to this direction using as an accurate method to estimate prices both for existing and emerging telecommunications products over next years. The validity of the model and the appropriate selection of its hedonic form chosen to relate price and characteristics must be verified over the next years and through extensive observations over different market and technology situations.

Acknowledgement

This work is partially supported by the Greek Ministry of Education and Religious Affairs under a Pythagoras Grant.

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