Broadband hedonic price index: a firm-level study

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***Abstract*— Broadband price determinants in the European area are evaluated in the context of the present work, based on a hedonic approach. The hedonic price index is constructed over a dataset describing a number of countries, providing useful insights about the critical factors affecting broadband prices, which are presented and discussed.**

Index Terms— broadband prices, hedonic functions, broadband networks

I. Introduction

Broadband adoption has led to the transformation of a market niche into a commodity service. During the last decade the rudimentary internet access in Europe – mainly provided over the legacy copper network – has been transformed into broadband and cable services leading the way to faster connections. While the early offerings of the access market were primarily characterized by a lack of modularity and options for the end users, the current situation is quite different. In particular, buyers can choose from a wide range of bundled packages that match their usage patterns and minimize the overall cost of the service. The technical features of each bundle affect both the suppliers' production costs and the subscribers' utility functions resulting in a simultaneous effect on the final price of the product. Moreover the openness and competition established in modern European telecommunications' markets that operate under the Commission's regulatory umbrella allow for transparency, equal access to the unbundled local loop and quick substitutability between different operators.

In this study we propose the introduction of a hedonic Broadband Price Index in order to measure the monetary effect of each characteristic of the high-speed internet access offerings in Europe. In particular we will focus on the price of each feature of the bundles and its impact on the final price of the service. For this purpose each bundle is treated as an aggregation of several clearly defined characteristics that totally describe and constitute the end product. The importance of this monetary classification of the technological features will allow us to accurately determine the market value of the existing products and forecast the prices of similar bundles that might appear in the future. Policy makers, antitrust authorities and telecommunications' observatories will be aided to spot possible SMP misuse through offerings below the market level – *bargains* – and the publication of these results will inform consumers for unreasonably expensive bundles.

Making hedonic-based price adjustments has been primarily used on indexes for consumer electronics [1],[2] as well as for housing and automobiles [3],[4]. The analysis presented hereafter is built on past research in hedonics using Box-Cox regressions as an empirical criterion of functional form selection. In [5] and [6] a hedonic study primarily for narrowband internet access in Canada has been presented. They found that quality adjusted indexes declined at about 15% per year. In [7] a hedonic model for mixed Internet access in the USA (narrowband and broadband, business and residential) used and also showed that a hedonic price index declines much faster than non-quality adjustable indexes. In [8] – [10] a single year hedonic models for Taiwan, USA and UK DSL access respectively has been constructed. Using Box-Cox transformations and data from web search engines they concluded that the use of dynamic IP addresses is significant and that the download speed parameter in DSL connections is insignificant – a counterintuitive result. The most recent hedonic study for Internet access service with direct quality adjustments to prices comes from [11] using observations from year 2006. The article recommends price adjustments using the predicted-price method based on the Box-Cox model. The Box-Cox model produced more accurate results and the predicted-price method was preferred because it did not assume a fixed marginal price.

From the existing literature there is a clear gap in broadband hedonic models for European markets. In our study we assume that the existence of a high level of broadband penetration across all European countries provides a homogeneous environment in terms of level of infrastructure and ICT literacy that does not affect bundles launched in different places. We also consider the intangible parameters of the products as insignificant for this product class[1].

The paper is organised as follows: firstly the theoretical background behind the hedonic functions and hedonic price

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[1] Several studies for price indexes address these issues as important especially the environmental parameters for the price of homes and the goodwill effect on automobile purchases.

indexes is presented. In section 3, the methodology used to determine the appropriate functional forms is described. In section 4 the models used are presented. In section 5, the results are presented and discussed. In section 6 we analyze the findings and finally in section 7 we conclude.

II. THEORETICAL BACKGROUND

The hedonic price theory is used to estimate the implicit prices of the characteristics that differentiate products in a product class [12]. Modern hedonic models were was first applied by [13] for automobile prices in the United States nonetheless the earliest citation of a hedonic approach on farmland prices came from [14] and [15]. The term hedonic[2] was first used by Court (1939) to measure consumers' 'pleasure and comfort' from several automobile characteristics. This interpretation was used for some time especially for the CPI and for investment purposes. The debate on user value approach (demand side) versus resource cost approach (supply side) for productivity measurement between Jorgenson and Griliches [16] and Denison [17] was followed by Muellbauer's [18] and then by Rosen's [19] seminal work on hedonic functions. Rosen [19] introduced the concept of hedonic functions as envelopes rather than user value measures. That means that they do not trace out demand and supply functions but provide hedonic quality adjustments interpretations as approximations to both user value and resource cost for small, incremental changes [20].

A hedonic function is a relationship between prices of varieties or models of heterogeneous goods – or services – and the quantities of characteristics contained in them. Let *Y* represent a product class. Any model of *Y* can be completely described by a vector of its characteristics. Let $Q = q_1,...,q_j,...,q_n$ represent the vector of characteristics of *Y*. Then any model of *Y*, can be described by its characteristics: $y_i = y_i\left(q_{i1},...,q_{ij},...,q_{in}\right)$ where q_{ij} is the quantity of the *j*th characteristic provided by model *i* of good *Y*. The hedonic price function for *Y* gives the price of any model as a function of its characteristics. For y_i: $p_y = p_y\left(q_{i1},...,q_{ij},...,q_{in}\right)$

Under hedonic hypothesis every 'transaction is a tied sale of a bundle of characteristics' which implies an aggregation of lower-order prices and quantities [21]. Therefore it is a theory of prices and quantities of characteristics rather than prices and quantities of the products themselves.

III. METHODOLOGY

A hedonic price index is any price index that makes use of a hedonic function. Arbitrary functional forms have often been used in the literature without explanation for the goodness of fit or the origin of the relationship. While Cropper *et al* [22] found that a linear Box-Cox function performs better than linear, semilog, double-log, quadratic, and quadratic Box-Cox functions, Triplett [20] supports that it is better to chose among alternative functional forms based on statistical tests, thus suggesting that functional forms rely entirely on the empirical study of interest. Nevertheless, Box-Cox regression (after Box and Cox, [24]) has been a particularly popular method of finding an appropriate functional form based on goodness of fit. The test involves adding nonlinear parameters on both sides of the hedonic function equation, so that, depending on these estimated parameters the function collapses to either logarithmic or linear.

Diewert [23] argues that for single period hedonic regressions it is more appropriate to use natural logarithms for the price and the characteristics variables instead of simple linear regression on the basis of homoskedastic error terms for the former and larger error terms for the latter. Triplett [20] argues against logarithmic hedonic functions despite the reduction in heteroskedasticity of the error terms because this will not affect the estimated coefficients of the characteristics but their standard errors. He also suggests that the logarithms may be an inappropriate functional form for every hedonic regression and this has to be found through statistical tests.

A basic Box-Cox transformation $Y^{(\lambda)}$ on a single variable is defined as:

$$Y^{(\lambda)} = \frac{Y^{\lambda} - 1}{\lambda} \text{ for } \lambda \neq 0 \text{ or}$$

$$Y^{(\lambda)} = \ln Y \text{ for } \lambda = 0$$

A more complex version transforms both sides of the equation with different parameters. Here λ denotes the Box-Cox transformation parameter on the dependent variable while θ denotes the Box-Cox transformation parameter on independent variables. Such a transformation for nonzero values, with logarithms providing the transformation when λ is zero, can be represented as:

$$\frac{Y^{\lambda} - 1}{\lambda} = \alpha + \sum_{i=1}^{K} \beta_i \frac{X_i^{\theta} - 1}{\theta} + \sum_{s=1}^{J} \gamma_s D_s + \varepsilon$$

for $\lambda \neq 0$ and $\theta \neq 0$

(Unrestricted Box-Cox Model, ubc)

For $\lambda=\theta$ we get the restricted Box-Cox Model

$$\frac{Y^{\lambda} - 1}{\lambda} = \alpha + \sum_{i=1}^{K} \beta_i \frac{X_i^{\lambda} - 1}{\lambda} + \sum_{s=1}^{J} \gamma_s D_s + \varepsilon \text{ for } \lambda \neq 0$$

$$\ln Y = \alpha + \sum_{i=1}^{K} \beta_i \ln X_i + \sum_{s=1}^{J} \gamma_s D_S + \varepsilon \text{ for } \lambda = 0$$

(Restricted Box-Cox, rbc)

A left-hand-side Box-Cox transforms only the dependent variable

$$\frac{Y^{\lambda} - 1}{\lambda} = \alpha + \sum_{i=1}^{K} \beta_i X_i^{\lambda} + \sum_{s=1}^{J} \gamma_s D_s + \varepsilon \text{ for } \lambda \neq 0$$

$$\ln Y = \alpha + \sum_{i=1}^{K} \beta_i X_i + \sum_{s=1}^{J} \gamma_s D_S + \varepsilon \text{ for } \lambda = 0$$

(Left-hand-side Box-Cox,lhbc)

and a right-hand-side Box-Cox the independent variable respectively.

[2] The term *'hedonic'* originated from the Greek word *'hedone'* meaning pleasure. The term was kept for the hedonic methodology although there is little semantic relationship with the current use of the term.

TABLE 1
Summary Statistics of the Sample

	Observations	Mean	Max	Min
Price (Euro)	172	79.557	680	6.9
Download Speed (kbps)	183	8859.813	100,000	128
E-mail accounts	184	11.959	200	1
Data allowance (GB)	185	58.956	2592	1
Web space (MB)	185	29.707	250	0
Fixed Telephony	185	0.286	1	0
TV	185	0.117	1	0
Installation Cost (Euro)	185	85.152	499	0
Equipment Cost (Euro)	185	14.749	199	0

$$\frac{Y^{\lambda}-1}{\lambda}=\alpha+\sum_{i=1}^{K}\beta_i\frac{X_i^{\lambda}-1}{\lambda}+\sum_{s=1}^{J}\gamma_s D_s+\varepsilon \text{ for } \lambda\neq 0$$

$$\ln Y=\alpha+\sum_{i=1}^{K}\beta_i \ln X_i+\sum_{s=1}^{J}\gamma_s D_S+\varepsilon \text{ for } \lambda=0$$

(Right-hand-side Box-Cox,rhbc)

Using statistical software for all these models through an iterative process we select the maximum likelihood Box-Cox parameter values that fit best. The Box-Cox form accommodates data in multiple functional forms, and certain Box-Cox parameter values are associated with basic functional forms, including the linear, loglog, and semilog forms. For λ =1 an rBC model represents a linear model and for $\lambda = 0$ a log-log model. An lhBC model is equivalent to a left-side semilog model when $\lambda = 0$ and for $\lambda = 1$ it is equivalent to a linear functional form. An rhBC model represents a linear form when $\theta = 1$ and for $\theta = 0$ the model is equivalent to a right-side semilog. An rhBC represents a reciprocal functional form when $\theta = -1$. A uBC model, the most general Box-Cox form used here, can represent any model represented by a rBC, an lhBC, or an rhBC model. As mentioned earlier, a uBC model is an rBC model when it has the restriction that λ must be equal to θ. A uBC model represents an lhBC model when $\theta = 1$; a uBC model represents an rhBC model when $\lambda = 1$.

Box-Cox regression can be used both as a test of functional form and as a form in itself. Because the Box-Cox regression can represent the standard functional forms, it can find whether any of these forms are appropriate and, if so, the one that works the best. For instance, if the Box-Cox regression returns values of 0 for both λ and θ, then a log-log model is indicated. Triplett (2004) offers further discussion of the Box-Cox regression as a test of functional form in hedonic models.

IV. DATA

The dataset comes from firm level observations for residential and business broadband offerings. It covers twenty-five companies across four European countries (Germany, Austria, France and Iceland) for the year 2007. The variables of interest are primarily related to the service itself (price, download speed, e-mail accounts, data download allowance, etc) but they also describe the characteristics or the marketing strategy employed by the companies (type of medium, bundled offers with fixed telephony or TV, etc). In Table 1, the variables used in the dataset and their characteristics are presented.

Most Internet Service Providers offer their broadband products in bundles including various combinations of fixed telephony, web space, on-demand and regular television programs and other peripheral services. These characteristics have been described in the dataset either with the use of quantified measures, i.e the exact value of the web space offered in the bundle or with a binary dummy variable to signal the existence of fixed telephony or TV features. The quality adjustment for the type of TV or voice telephony services was not included in the details gathered from the dataset[3]. One other important parameter was the medium used for the provision of the service (Cable, Fiber, Copper). This has been specified for each bundle as well as the provision of a symmetric or asymmetric (SDSL versus ADSL) connection.

The selection of variables in the dataset is refined by statistical justification. The further screening of variables is necessitated

TABLE 2
Pair-wise correlation of the sample

	DSL Speed	Mail	Data	Web Space	Fixed	TV	Install	Equipment
DSL Speed	1.000							
Mail	-0.087	1.000						
Data	0.381	-0.256	1.000					
Web Space	0.149	0.208	-0.130	1.000				
Fixed	0.290	-0.227	0.322	-0.202	1.000			
TV	0.416	-0.154	0.226	0.093	0.197	1.000		
Install	-0.176	0.261	-0.324	0.323	-0.310	-0.217	1.000	
Equip	0.600	-0.145	0.224	0.235	0.198	0.234	-0.117	1.000

[3] Many double of triple play services across Europe offer unlimited fixed line calls and TV content usage. However this information was not specified in the data mining process.

by the desire to eliminate potential collinearity. Pearson's correlation method is used to perform the first step of screening. Pair-wise correlations revealed one strong correlation between the variables Equipment and DSL Speed. For this we drop equipment from the transformations (Table 2). Subsequent screening involved regressing five remaining independent variables[4] on the price of each bundle. All variables had significant t-statistics and were retained for the final model (Table 3).

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V. Results and Discussions

The proposed models for the hedonic regression include the price of the service as the left hand side variable and all the characteristics that make up the price as right hand side variables. The common regressors in all five models are the following: Downloading speed (DLSpeed), number of E-mail accounts (Mail), Internet access capacity/usage (Data) Web space (Web) and Installation charges (Install). Two additional regressors, the existence of fixed telephony (FxTel) in the bundle and the TV offering (TV), have been used in models 2-5. In terms of fixed effects we used two different kinds: medium effects (type of access medium, i.e. ADSL, SDLS, Cable and FTTH) and country effects (Germany, Austria, France and Iceland). Models 1 and 2 were estimated using random effects, Model 3 using only medium fixed effects, Model 4 using only country fixed effects and Model 5 using both country and medium fixed effects. All models are presented below[6]:

Random effects

$$Price = a_1 DlSpeed + a_2 Mail + a_3 Data + b_1 Web + b_2 Install + b_3 Eq + \varepsilon \quad (1)$$

Random effects with TV and fixed telephony

$$Price = a_1 DlSpeed + a_2 Mail + a_3 Data + b_1 Web + b_2 Install + b_3 Eq + b_4 FxTel + b_5 TV + \varepsilon \quad (2)$$

Medium fixed effects with TV and fixed telephony

$$Price = a_1 DlSpeed + a_2 Mail + a_3 Data + b_1 Web + b_2 Install + b_3 Eq + b_4 FxTel + b_5 TV + \varepsilon \quad (3)$$

Country fixed effects with TV and fixed telephony

$$Price = a_1 DlSpeed + a_2 Mail + a_3 Data + b_1 Web + b_2 Install + b_3 Eq + b_4 FxTel + b_5 TV + \varepsilon \quad (4)$$

Medium and country fixed effects with TV and fixed telephony

$$Price = a_1 DlSpeed + a_2 Mail + a_3 Data + b_1 Web + b_2 Install + b_3 Eq + b_4 FxTel + b_5 TV + \varepsilon \quad (5)$$

TABLE 3
Statistical significance of regressors

Price	Coefficient	t-stat
DSL Speed	0.499[3]	18.24
Mail	0.199[1]	1.80
Data	-0.076[3]	-3.26
Web Space	-0.110[1]	-1.89
Install	0.003[3]	3.81

Number of Obs =170
R-squared = 0.9652
Root MSE = 0.7662

Superscripts ([1,2,3]) denote statistical significance
[1] 1% level significance
[2] 5% level significance
[3] 10% level significance

For the above models' variables we used four different forms of the Box-Cox transformations. In particular we used a transformation on the left hand side variable only (lhBC), a transformation on the independent variables alone (rhBC), transformations with the same value on both sides of the equation (rBC – restricted) and lastly transformations using different values on both sides of the equation (uBC). As mentioned in the *methodology* section these transformations are based on different hypotheses for λ and θ. The results for the subsequent hypotheses of each transformation are presented below (Table 4).

The results from the above-presented hypotheses can act as tests for the suitability of the functional forms. For example the parameter value of 1 represents a linear model for the unrestricted and restricted Box-Cox transformations. Moreover a parameter value of 0 represents a log-log (double log) transformation. Both linear and log-log models are rejected for all models. Consequently we turn to the right and left hand side transformations. For θ=0 in the right hand side and λ=0 in the left hand side the semi-log models are rejected. Across all models in the right hand BC for $\theta = -1$ the hypothesis is not rejected. Also the values estimated for the parameter are significant, indicating a reciprocal functional form transformation. However the estimated thetas are nowhere close to -1, turning us to think of further analysing the regressions. While Box-Cox regressions are the tests of functional forms they are also functional forms themselves [11]. As a next step of selecting the appropriate transformation from the four different Box-Cox variants we will incorporate the statistical information criteria (Akaike and Bayesian). We are looking for the *minimum* results of the tests to show the best-fit models. Table 5 presents the results of the information

[4] Dummy transformable variables (TV and fixed) are not included in this significance test

[5] Dummy transformable variables (TV and fixed) are not included in this significance test

[6] Nonzero continuous variable are only transformed with Box Cox. Dummy variables (Fixed and TV) and the ones containing zeros (Web Space and Install) cannot be transformed. The transformable variables are presented with a_i symbols in the models. Non-transformable variables are presented with b_j symbols.

criteria for the five above models.

Across all specifications the restricted model reports the lowest Bayesian information criteria. For the Akaike criterion only the third model results suggested that the unrestricted model is preferable. Combining the results of tables 4 and 5 we find that the most appropriate transformations are the restricted and one case of the unrestricted BC. All estimates in the rhBC of λ and θ in table 4 are sufficiently close to 0 and statistically significant. Cross model test comparisons are not always appropriate because of the sensitivity of information criteria on different functional forms. For multi-year datasets the restricted and unrestricted quadratic Box-Cox, translog and generic flexible functional form transformations can be used as well. However the information criteria usually penalize these transformations because of the inclusion of second order terms [5].

Table 6 presents the results of the unrestricted Box-Cox regression. Table 7 presents the results of the restricted Box-Cox regression. We also include the hypotheses and the λ and θ values. The AIC and BIC are also included in the tables. The results of the regressions are discussed below.

From the tables 6 and 7 we find that across all specifications download speed and mail accounts are the key variables that shape the broadband bundle price. We will primarily look at the results from table 7 since the information criteria suggest that the restricted transformation fits our data best. Downloading speed is the only variable always to appear positive and significant at the 1% level. E-mail accounts bundled in each package seem to have an important impact in the price. The mail variable is always positive and significant at the 1% level for models 2,3,4 and 5. In terms of the data allowance variable the results show an important statistical significance change across models. In particular the first three models show that data allowance is negatively and significantly related to price – a counterintuitive finding. However once we controlled for country fixed effects (models 4 and 5) this unexpected relationship disappeared. The rest of the non-transformed variables are discussed only for models 4 and 5 where they appear and the statistical controls are more rigid than the first. The key finding here is the importance of

TABLE 4
Box-Cox Transformation results

	Transformation	λ	θ	Hypothesis	Chi² Statistic for hypothesis X=		
					1	0	-1
Model 1	Left hand BC	-0.110	-	λ=X	137.09[1]	2.45	265.59[1]
	Right hand BC	-	1.349[1]	θ=X	18.25[1]	11.14[1]	0.64
	Restricted BC	-0.162[1]	-0.162[1]	λ=θ=X	140.77[1]	5.74[2]	279.72[1]
	Unrestricted BC	-0.411[3]	-0.146[2]	λ=θ=X	141.87[1]	6.84[1]	280.83[1]
Model 2	Left hand BC	-0.121[3]	-	λ=X	133.36[1]	2.94[3]	267.94[1]
	Right hand BC	-	1.275[1]	θ=X	18.46[1]	11.02[1]	0.44
	Restricted BC	-0.181[1]	-0.181[1]	λ=θ=X	133.57[1]	6.92[1]	282.70[1]
	Unrestricted BC	-0.45[3]	-0.163[2]	λ=θ=X	134.98[1]	8.33[1]	284.11[1]
Model 3	Left hand BC	-0.016	-	λ=X	172.47[1]	0.06	277.73[1]
	Right hand BC	-	0.964[2]	θ=X	15.61[1]	4.48[2]	0.01
	Restricted BC	-0.085	-0.085	λ=θ=X	185.60[1]	2.06	310.31[1]
	Unrestricted BC	-0.356[2]	-0.049	λ=θ=X	189.22[1]	5.68[2]	313.93[1]
Model 4	Left hand BC	-0.135[3]	-	λ=X	137.16[1]	3.83[2]	279.25[1]
	Right hand BC	-	0.889[1]	θ=X	19.88[1]	10.04[1]	0.11
	Restricted BC	-0.176[1]	-0.176[1]	λ=θ=X	142.02[1]	6.82[1]	292.20[1]
	Unrestricted BC	-0.281	-0.171[2]	λ=θ=X	142.20[1]	7.00[1]	292.38[1]
Model 5	Left hand BC	-0.05	-	λ=X	180.00[1]	0.67	303.82[1]
	Right hand BC	-	0.607[2]	θ=X	21.91[1]	6.44[2]	1.79
	Restricted BC	-0.104[3]	-0.104[3]	λ=θ=X	20.893[1]	3.57[3]	341.19[1]
	Unrestricted BC	-29.197	-0.734	λ=θ=X	166.48[1]	-35.38	302.24[1]

Superscripts ([1,2,3]) denote statistical significance
[1] 1% level significance
[2] 5% level significance
[3] 10% level significance

fixed telephony in the bundles. It is always positively and significantly associated with the price of the bundles. The TV offering does not seem to affect the prices critically.

TABLE 5
Akaike and Bayesian Information Criteria

		Left hand BC	Right hand BC	Restricted BC	Unrestricted BC
Model 1	AIC	1718.793	1983.746	**1704.663**	1705.557
	BIC	1721.935	1986.887	**1707.805**	1711.841
Model 2	AIC	1715.257	1982.752	**1700.492**	1701.081
	BIC	1718.398	1985.893	**1703.633**	1707.365
Model 3	AIC	1650.226	1927.945	1617.644	**1616.02**
	BIC	1653.368	1931.087	**1620.786**	1622.303
Model 4	AIC	1683.485	1962.63	**1670.533**	1672.353
	BIC	1686.627	1965.772	**1673.675**	1678.637
Model 5	AIC	1608.889	1910.918	**1571.521**	1612.469
	BIC	1612.031	1914.059	**1574.663**	1618.752

VI. ANALYSIS AND IMPLICATIONS

The hedonic methodology has helped us disentangle the broadband bundles offered by operators across Europe in 2007. We found that broadband price is mainly determined by downloading speed. In monetary terms each additional Mbps (1024 kbps) of downloading capacity is estimated at €13.09 (all monetary estimates derive from Model 5 from the rbc estimate in Table 7). It is essential to understand that this is only an estimate since decreasing returns to scale and combinations with other characteristics might seriously affect this figure. It is nevertheless an intuitive result given the downloading speeds in the sample range from 128 kbps to 100 Mbps. E-mail accounts are important in monetary terms – 5 accounts cost €1.27 in each bundle. Data capacity gave a mixed picture without any statistically significant result. Fixed telephony comes into the estimates as a dummy variable hence

TABLE 6
Unrestricted Box-Cox Regressions

	(1)	(2)	(3)	(4)	(5)[1]
Transformed variables					
DLspeed	2.74[3]	3.136[3]	2.957[3]	0.851[3]	-
Mail	0.142[3]	0.149[3]	0.239[3]	0.149[3]	-
Data	-0.112[2]	-0.127[3]	-0.175[3]	-0.004	-
Non-transformed variables					
Install	0.0016[3]	0.0017[3]	0.000	0.002[3]	-
Wspace	-0.007	-0.001	-0.001	-0.001	-
Fixed	-	0.121[1]	0.272[3]	0.214[3]	-
TV	-	0.091	0.076	0.035	-
SDSL	-	-	1.275[3]	-	-
FTTH	-	-	-0.083	-	-
Cable	-	-	0.228[2]	-	-
χ^2	68.07	72.54	157.61	101.27	-
λ	-0.411[1]	-0.450[1]	-0.356[2]	-0.281	-
θ	-0.146[2]	-0.163[2]	-0.048	-0.171[2]	-
AIC	1705.557	1701.081	1616.020	1672.353	-
BIC	1711.841	1707.365	1622.303	1678.637	-

[1] Iterations do not converge
Superscripts ([1,2,3]) denote statistical significance
[1] 1% level significance
[2] 5% level significance
[3] 10% level significance

we can only comment on its importance rather than its actual monetary value. Unlike TV offerings, fixed telephony is always positively and significantly related to price. While from the buyers' perspective this looks inexplicable the suppliers' costs might shed some light into this coefficient. Operators pay the termination charges (for fixed or mobile calls) of each call (usually in a per second predetermined price) for the usage of their customer base each month. The inclusion of fixed telephony allowance is often based on estimates for usage patterns of their target group and the costs are indirectly transferred to the subscriber through the monthly fee (hence the positive and significant effect). Contrary to this, TV costs are primarily fixed costs for the operators. The use of TV might create higher data transfers over their proprietary data networks but does never incur additional costs to third parties. Therefore it is an additional in-house service based on the capacity of the network of each operator. Web space and installation charges are unimportant ones partly because these expenses do not appear in many packages and also they do not necessarily conform under a certain rule. Of all available access media, only SDSL is found to be a key parameter for price increases because of the symmetric quality of the service - a result totally expected.

The key finding here is the importance of fixed telephony in the bundles. It is always positively and significantly associated with the price of the bundles. It is striking that TV offering do not affect the prices critically. While from the buyers' perspective this looks inexplicable the suppliers' costs might shed some light into this coefficient. Operators have to pay the termination charges of each call (usually in a per-second predetermined price) for the usage of their customer base each month. The inclusion of fixed telephony allowance is often based on estimates for usage patterns of their target group and the costs are indirectly transferred to the subscriber through the monthly fee (hence the positive and significant effect). Contrary to this, TV costs are primarily fixed costs for the operators. The use of TV might create higher data transfers over their proprietary data networks but does never incur additional costs to third parties. Therefore, it is an additional in-house service based on the capacity of the network of each operator. This service is found not to have an impact on the price because it acts as a product sweetener to persuade potential customers. Web space and installation charges are unimportant ones partly because these expenses do not appear in many packages and also they do not necessarily conform under a certain rule. Lastly SDSL is found to be a key parameter for price increases because of the symmetric quality of the service - a result totally expected.

VII. Conclusions

The broadband price index for a sample of 4 European countries in 2007 led to some very interesting results. Broadband subscribers paid on average €13.09 for each Mbps and €1.27 for 5 e-mail accounts in their ADSL bundles. The offerings of VoIP service and symmetric connections were significantly more expensive than their cable and FTTH/C

TABLE 7
Restricted Box-Cox regressions

	(1)	(2)	(3)	(4)	(5)
Transformed variables					
DLspeed	0.363[3]	0.349[3]	0.306[3]	0.358[3]	0.371[3]
Mail	0.094[2]	0.096[3]	0.130[3]	0.127[3]	0.153[3]
Data	-0.072[2]	-0.078[3]	-0.094[3]	-0.003	-0.029
Non-transformed variables					
Install	0.002[3]	0.002[3]	0.000	0.002[3]	0.000
Wspace	-0.001	-0.001	-0.001	-0.001	-0.001
Fixed	-	0.111[1]	0.233[3]	0.208[3]	0.345[3]
TV	-	0.083	0.074	0.0374	0.047
SDSL	-	-	1.088[3]	-	1.036[3]
FTTH	-	-	-0.176	-	0.053
Cable	-	-	0.193[2]	-	0.143
χ^2	66.96	71.13	153.98	101.09	200.10
λ	-0.162[2]	-0.181[3]	-0.085	-0.176[3]	-0.104[1]
θ	-0.162[2]	-0.181[3]	-0.085	-0.176[3]	-0.104[1]
AIC	1704.663	1700.492	1617.644	1670.533	1571.521
BIC	1707.805	1703.633	1620.786	1673.675	1574.663

Superscripts ([1,2,3]) denote statistical significance
[1] 1% level significance
[2] 5% level significance
[3] 10% level significance

counterparts targeting primarily the business access audience. TV bundles – often marketed as triple play services – were not found to increase the end price critically perhaps because of their pay per view nature whereas fixed telephony bundles always increased the price tag of the product as we analysed earlier. Other things being equal, data downloading volume did not affect the price significantly contrary to the early results of our analysis.

These useful insights act as a promising start in this under-researched part of the telecommunications industry literature. In the future richer datasets and wider country analysis may lead to better understanding of the market and help operators, regulators and user groups. In the short term, the analysis of broadband bundles and their evolution across Europe is a step in support of the i2010 initiative. It should therefore be a continuous exercise in order to promote the development of broadband infrastructure investments and services as well as the identification of potential technology risks.

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