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**Conference Paper**

## Dynamics of broadband demand: Substitution or complementarity between fixed and mobile technologies? An application to the Portuguese case

24th European Regional Conference of the International Telecommunications Society (ITS): "Technology, Investment and Uncertainty", Florence, Italy, 20th-23rd October, 2013

**Provided in Cooperation with:**

International Telecommunications Society (ITS)

*Suggested Citation:* Silva, Rita Filipe; Proença, Isabel; Vareda, João (2013) : Dynamics of broadband demand: Substitution or complementarity between fixed and mobile technologies? An application to the Portuguese case, 24th European Regional Conference of the International Telecommunications Society (ITS): "Technology, Investment and Uncertainty", Florence, Italy, 20th-23rd October, 2013, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/88541>

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# DYNAMICS OF BROADBAND DEMAND: SUBSTITUTION OR COMPLEMENTARITY BETWEEN FIXED AND MOBILE TECHNOLOGIES? AN APPLICATION TO THE PORTUGUESE CASE\*

WORKING VERSION

RITA FILIPE SILVA †, ISABEL PROENÇA‡, JOÃO VAREDA±

## ABSTRACT

The development of the broadband market is a key aspect of the economic and social growth of a country. However, despite the importance and the development of broadband market in Portugal in recent years, especially with the explosion of the number of mobile broadband accesses, the studies for the Portuguese case are rare.

The present paper seeks to contribute to the discussion about the definition of the broadband market in Portugal, specifically studying the demand for broadband Internet and measuring the determinants that explain the use of each of the technologies available to provide broadband access, with emphasis on the differences between fixed and mobile accesses. Demand broadband functions were estimated using nested logit and multinomial discrete choice model. The primary source of information was ANACOM's Electronic Communications Services Consumption Survey, complemented with price information regarding the offers available in the market.

The estimations obtained for the elasticities point out the probable existence of substitution between ADSL and cable and between these fixed broadband technologies and the mobile broadband. However, the inverse relation is not statistically significant, the demand for mobile broadband isn't constrained by the price of ADSL or of cable, which may reveal the existence of asymmetric substitution between fixed and mobile broadband accesses. These results have implications in the definition of the broadband market in Portugal which will be discussed.

**Keywords** Broadband, Market Definition, Demand, Regulation, Fixed-Mobile Substitution.

**JEL Classifications** L51 L96

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\* The opinions expressed in this article reflect only the authors' views and do not bind the institutions to which they are affiliated.

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## **1. INTRODUCTION**

Broadband (BB) is a critical element of economic progress: drives growth, stimulates innovation and creates new fields of economic activity. In developed economies Internet represents about 10% of GDP. The BB market is enormous and its impact on social welfare is revolutionary: the amount of information available is massive, BB accelerates the diffusion of information and reduces transaction costs through electronic commerce, reducing delivery costs and thus making available a wide variety of services from entertainment services to e-learning and e-health.

The relevance of BB for the economic and social development is one of the motivations of this paper, thus it is important to study the characteristics that influence demand and Internet access in Portugal.

In the European Union (EU) electronic communications regulatory framework, BB market definition has been warmly discussed, namely if shall include cable and, in a more recent debate, mobile broadband (MBB). This last discuss was initiated by the Austrian regulator (RTR), which concluded that fixed broadband (FBB) and MBB access services shall constitute the same market. This conclusion was made through an empirical analysis of the market and by conducting a “small but significant non-transitory increase in price” (SSNIP) test that using elasticities based on a survey, indicated the existence of substitutability between MBB and FBB services. In line with this approach is other goal of this paper: contribute to the discussion about BB market definition and substitutability between fixed and mobile accesses in Portugal, using a similar methodology to calculate the SSNIP test and assess about BB market definition. With this aim we will use discrete demand models and analyze the individual characteristics of consumers that explain the access to different BB technologies, identifying usage patterns. Then, we will analyze the competitive pressure which MBB exerts on FBB, to assess whether MBB shall be included in the same market. With this objective we will estimate own and cross elasticities for MBB and FBB technologies for the Portuguese market.

The Portuguese market is particularly interesting to study this question as the MBB penetration rate more than tripled in the past five years and is higher than the FBB rate of penetration (32.9 accesses per 100 inhabitants compared with 22.6 for MBB).

Finally, this paper aims to contribute to the debate about the substitution between fixed and mobile access technologies, as there are few specific studies about BB demand, particularly in Portugal.

## **2. BROADBAND MARKET IN PORTUGAL**

The analysis of the number of accesses using different technologies shows that all types of access continue to show an upward trend in 2012, with the exception of ADSL. The higher increase is in MBB penetration rate, but FBB accesses continue to grow, which may indicate complementary. Portugal is in a good position in the EU penetration rate ranking in what matters MBB accesses through cards (11<sup>th</sup> position in the EU in 2012, above the EU average). This tendency was significantly influenced by the dissemination and development of the

program “e-initiatives”<sup>2</sup>, which allowed, under certain conditions of eligibility of the users, the provision of computers with Internet MBB connection under favourable terms.

Table 1 – BB penetration rates (%)

	2008	2009	2010	2011	2012	var. (p.p) 2012/2011
<b>Fixed Broadband Accesses</b>	15,9	18,0	20,0	21,2	22,6	1,4
ADSL Accesses	9,4	10,3	10,5	10,4	10,2	-0,2
Cable modem Accesses	6,3	7,2	8,1	8,5	9,0	0,5
Optical Fibre and other types of access	0,2	0,5	1,4	2,2	3,4	1,2
<b>Mobile Broadband Accesses</b>	10,9	20,4	24,1	27,7	32,9	5,2
MBB using cards/active modems	8,3	11,3	12,0	10,7	9,3	-1,4

Source: ANACOM, Situation of Communications.

Another important aspect of BB market in Portugal is the expansion of offers in bundles, including triple-play or quadruple play: in 2012, 44.3% of the households have a triple or quadruple-play offer. Specifically regarding triple-play, Portugal occupied in 2012 the fourth position in the EU ranking.

From the point of view of the consumer there is a need: access and use BB Internet services. Therefore, in principle is indifferent the technology or network in which these services will be provided. More than the specific technology, for the end user is important the features that each type of access allows (e.g. speed, quality, coverage, mobility).

In what matters FBB, cable and ADSL exhibit very similar features from the point of view of end users (permanent access, speed and equivalent quality), so these technologies satisfy similar needs. Based on these similarities and considering other factors which indicated the existence of substitutability between ADSL and cable access, ANACOM, in the last BB market access analysis (i2009) maintained the position that, from the point of view of demand and supply, ADSL and cable access services are substitutes and belong to the same retail market.

On the other hand, as shown in the table 2, the differences in terms of cost and access speeds between the FBB and MBB have been strengthening.

Table 2 – Difference of average prices and download speeds between FBB and MBB

	Average Price (€)			Average Download speed (Mbps)			Price/Mbps		
	2010	2011	2012	2010	2011	2012	2010	2011	2012
<b>ADSL (stand-alone)</b>	26.6	25.8	25.2	9.5	9.0	9.2	2.8	2.9	2.7
<b>FBB</b>									
Fiber (includ. fixed telephone)	40.0	*	*	76.7	*	*	0.5	*	*
Cabo (stand-alone)	34.3	35.9	*	17.6	25.0	*	1.9	1.4	*
<b>MBB</b>									
Cards/Modem	27.8	26.0	23.0	7.8	8.8	30.0	3.6	3.0	0.8
Mobile Phone Internet	10.3	10.3	11.6	4.1	4.1	18.0	2.5	2.5	0.6

\* No existing stand-alone offer

Source: Situation of Communications ANACOM 2010, 2011, 2012

<sup>2</sup> Program active from end 2007 until 2010.

Additionally it turns out that the majority of FBB offers supports triple-play offers that include (in addition to fixed telephone) television and access to streaming, which MBB does not allow. The main advantage of MBB is its inherent mobility, which permits the use of the service anywhere with a unique contract.

We resumed some qualitative arguments that seem to support the existence of substitutability between MBB and FBB. Thus, it is clearly relevant to continue this discussion in empirical terms by estimating discrete choice models for the BB demand in Portugal.

### **3. LITERATURE REVIEW**

#### **3.1. REGULATORY FRAMEWORK FOR ELECTRONIC COMMUNICATIONS IN THE EU**

According to the EU regulatory framework for electronic communications, the national regulatory authorities of each Member State must review periodically the markets that are subject to *ex ante* regulation. In the 2007 Recommendation, the European Commission (COM) defined the relevant markets candidates to the imposition of *ex ante* regulation, which includes the wholesale market of network infrastructure access (market 4) and broadband access (market 5). These are the wholesale markets that are more directly related to the BB service available at the retail level and, therefore, the obligations imposed on these markets seek to eliminate existing competition problems in the BB retail market.

If a company has significant market power (SMP) in a market, regulators must apply *ex ante* remedies to prevent anti-competitive practices and abuse of dominant position and promote competition. Before analyzing the potential existence of SMP it shall be define the relevant market. The COM has created guidelines for the SMP assessment, which follow EU competition law, defining the relevant markets as the intersection of the size of the product and geographic markets.

For the product relevant market the aim is to identify all products and services sufficiently substitutable or interchangeable. Products or services with a limited substitutability are not part of the same market. Products are part of the same relevant market if the behaviour of producers and suppliers is subject to the same kind of competitive pressures, particularly in terms of prices.

The methods used for assessing the existence of substitutability on the demand side include the application of the hypothetical monopolist (HM) test. There are several versions of this test, but the COM defined it as examining whether a non-transitory increase of 5-10% will be profitable for the HM in the relevant market. The smallest set of services to which this price increase can be sustained is the relevant market.

The COM indicates that the responses of consumers and businesses to the hypothetical price increase will help determine if there are substitute products and, if applicable, the limits of the relevant market. That is, if the cross elasticity between two products is high, we can in principle conclude that consumers perceive these products as close substitutes.

One of the objectives of this thesis is precisely to look at the demand-side substitutability BB retail access, estimating the price elasticities for the various BB types of access.

Market definition of BB retail and wholesale broadband markets has generated attention and even controversy in the regulatory environment. It is noteworthy the notification to the COM of BB wholesale access market by OFCOM, ANACOM and other regulators. These regulators concluded that accesses using cable networks and using copper networks (xDSL) constitute the same market when there wasn't wholesale broadband access offer supported in cable networks. There wasn't, therefore, a direct and effective substitutability at the wholesale level between these networks.

In this context it shall be considered the existence of significant indirect constraints, which was exactly the argument used by the regulators: the HM of ADSL access could not raise the prices of wholesale bitstream profitably by 5-10%, since, on certain conditions, this would increase the retail prices of the ADSL offer, which would make customer switching from ADSL other technologies which maintained the prices. If the retail substitution is strong enough, the increase in the wholesale price will not be profitable since the accesses given through another retail network cease to be supplied also at the wholesale level. The retail elasticity of demand is thus crucial not only for the definition of retail markets but also for the definition of BB wholesale market. The COM, which considers that the indirect constraints should only be considered when assessing SMP and not on market definition, ask the regulators to demonstrate the retail elasticities of demand to validate the existence of indirect constraints.

BB market analysis obtained even more controversy in 2009 with the notification of this market by RTR. By examining the BB retail access market, RTR concluded that FBB and MBB constitute the same market, taking into account, *inter alia*, that MBB accesses represent a significant share of the total market and observed a massive growth; that about 25 % of MBB accesses were used in a complementary way with fixed networks accesses; data revealed that there was a growing number of end users who have switched FBB access by MBB; the SSNIP test, made through the use of questionnaire carried out to end users, indicated the existence of substitutability between MBB and FBB.

In Portugal, ANACOM concluded in the last market analysis that there was no demand-side substitutability for most users and that supply-side substitutability was not relevant, concluding that MBB and FBB do not constitute the same relevant market. The defined BB product retail access market in Portugal includes BB access services through xDSL, cable modem and fiber optic provided to residential and non-residential clients.

### **3.2. BROADBAND DEMAND STUDIES**

One of the motivations of this paper is to contribute to the discussion on the demand for BB, since there are few specific studies on this subject and, above all, there are is lack of studies on the substitution between the MBB and FBB.

Within the studies that estimate the magnitude of the elasticities of demand for various types of Internet access, the majority conclude that the price of DSL is restricted by the cable and that the two services have a high probability of being part of the same relevant market.

Some limitations can be found in these studies. Firstly, they are static, so they do not allow analyzing switching costs. On the other hand, generally these studies do not analyze if the FBB is restricted by MBB, question which

has becoming increasingly important with the increase of MBB penetration rate, which is one of the aims of this paper. A third set of problems is related to the available data. The majority of the databases used in these papers are not representative of the markets, don't consider all the offers available in the market or use aggregated data.

A summary of the literature review can be found in the appendix (Table 12). It follows a review of the most relevant studies for the analysis of the problems of this paper.

The main reference of this paper is the study of Cardona *et al* (2009) about the demand for residential Internet access in Austria. Mobile connections are included and were estimated various nested logit models in order to derive conclusions about the BB market analysis. The data used is a RTR questionnaire of 2006, made solely for this purpose. This survey covers 4029 households and has information about the type of Internet connection, monthly expenses, age, education and household size. The database was divided into two sub-samples: one for areas where there are 4 types of technology (DSL, cable, mobile and narrowband) and one for areas where only narrowband and DSL are available. The results indicate that Internet demand in Austria is elastic for DSL, cable and mobile in areas where there are several types of BB access and that the different BB access technologies are close substitutes and restrict each other. Applying a SSNIP test for defining the market, an increase of 5-10% of the competitive price is not profitable for the hypothetical monopolist with regard to DSL, so the cable should be included in the relevant market. The authors also conclude that the magnitude of substitution between retail DSL and cable is sufficiently large so (by considering the existence of indirect constraints) both products are part of the same wholesale market. As the MBB penetration rate was very low in 2006, it was not specifically investigated whether DSL and cable together are restricted by the MBB.

Ida and Kuroda (2006), in an application for Japan, use conditional logit model and nested logit model to calculate the own price elasticities and conclude that the market for ADSL is independent of the others, since the demand for ADSL is inelastic and lower than the elasticity of demand for cable and fibre. As the BB Japanese market is dominated by the ADSL, the authors divide the market into three categories: high, medium and low speed. It appears that the ADSL of high and low speeds is highly elastic (9.1 and 10.6), so there is direct competition between high-speed ADSL and fibre (FTTH) and between low-speed ADSL and narrowband.

Pereira and Ribeiro (2006) provide an econometric analysis for the Portuguese market. This article aimed to measure the impact on BB access and in terms of welfare of the structural separation between the cable and copper networks, as on that time, Portugal Telecom (PT) owned PT Communications (copper network - xDSL) and PT Multimedia (cable network). These authors estimate several discrete choice models to obtain the elasticities of BB demand in Portugal. They concluded that households are very sensitive to price changes in the access to Internet services. More specifically, the BB demand is more elastic than the demand for narrowband. They also conclude that both are substitutes by calculating cross elasticities.

The report from Hauge *et al* (2009) commissioned by ANACOM and ANATEL, aims to examine the adoption, use and impact of MBB in Portugal and Brazil, comparing the factors which determined the adoption of the FBB. The conclusion is that the use is similar among users of MBB and FBB, suggesting that these services are substitutes from the point of view of consumers. Using as a basis only the analysis of the individual

characteristics of the respondents (the authors do not analyze price or elasticities), they conclude that the MBB and FBB are reasonable substitutes for consumers.

Demand for access Internet residential customers in the United States is estimated by Crandall *et al* (2002) using nested logit discrete choice models. They conclude that DSL and cable demand is elastic and that the cross-elasticity of the cable relative to the price of ADSL is 0.591. The authors consider this as evidence that DSL and cable belong to the same market, without, however, undergone a SSNIP test.

Rappoport *et al* (2003) conducted a similar analysis, which differs only in the Internet choices available for households. The outcome was that DSL demand is elastic and cable demand inelastic. The demand cross-elasticity for cable with respect to the DSL price is 0.618, so they conclude that DSL and cable belong to the same market.

#### 4. ECONOMETRIC AND THEORETICAL MODEL

An innovation in demand analysis literature is the use of discrete choice models to analyze the access demand under the assumption that consumer choice is qualitative. Perl (1978) was the first to apply discrete choice models for analyzing telecommunications access demand, followed by the use of logit and probit discrete choice models. The emergence of nested logit models, which make partially flexible the hypothesis of independence of irrelevant alternatives (IIA) of the conditional logit models, was particularly important.

##### 4.1. MULTINOMIAL REGRESSION MODELS

The multinomial regression models are models where the dependent variable defines several mutually exclusive categories. The probability that the outcome for individual  $i$  is the alternative  $j$ , conditional on regressors  $x_i$  is:

$$(1) P_{ij} = Pr(y_i = j) = F_j(x_i\beta_j), \text{ sendo } j = 1, \dots, J \text{ para cada decisor } i = 1, \dots, I.$$

In discrete choice models the consumer behaviour is based on the theory of Random Utility. Econometrically these models can be interpreted in terms of random utility maximization (RUM models). In these models is attributed a utility  $U_{ij}$  to each alternative  $j = 1, \dots, J$  for each  $i = 1, \dots, I$  decision-maker. The decision-maker will choose the alternative with higher utility, *i.e.*, will choose alternative  $j$  if and only if  $U_{ij} > U_{ik}, \forall j \neq k$ .

The utility, which is only known by the decision-maker, is determined by a large number of features and alternatives. As we have information only about some of the factors determining the utility of choosing a type of access, the utility has a deterministic part  $V_{ij}$  and a stochastic part  $\varepsilon_{ij}$  (not observed):

$$(2) U_{ij} = V_{ij} + \varepsilon_{ij}$$

The likelihood  $P_{ij}$  of a consumer  $i$  choosing alternative  $j$  is equal to the probability of  $U_{ij}$  being not inferior to all  $U_{ik}$ , with  $k \neq j$ . Being  $y_i \in \{1 \dots J\}$  the alternative that the decision maker  $i$  chooses, its probability of choice is:

$$(3) P_{ij} = Pr(y_i = j) = Pr(\varepsilon_{ik} - \varepsilon_{ij} \leq V_{ij} - V_{ik}, \forall k = 1, \dots, J; k \neq j)$$



Given the specification of the deterministic part of the utility function  $(V_{i1}, \dots, V_{ij})$ , this probability depends on the assumptions about the distribution of the stochastic error terms  $\varepsilon_{i1}, \dots, \varepsilon_{ij}$ , which lead to several discrete choice models with different  $F_j(\cdot)$  specifications in equation (1), being the most prominent examples for the case study logit, multinomial logit, conditional and nested logit.

In the event that  $\varepsilon_{ij}$  follows a distribution of Type I extreme value, the probability  $P_{ij}$  has the following general specification:

$$(4) P_{ij} = \frac{e^{V_{ij}}}{\sum_{k=1}^J e^{V_{ik}}}$$

Where, for the multinomial logit models we have:

$$(5) V_{ij} = x_i \beta_j$$

And for the conditional logit (CL):

$$(6) V_{ij} = z_{ij} \gamma$$

Representing  $z_{ij}$  the regressors specific to alternative  $j$  and  $x_i$  the regressors specific to individual  $i$ .

#### 4.2. NESTED LOGIT MODELS

The nested logit models allow relaxing the IIA assumption and are ideal to use when a decision can be made in stages and according to a clear hierarchical tree structure. In this case, it is found that there is independence between the different alternative nests of a tree, when the alternatives of the same nest can be correlated. Another advantage is that, in general, these models are consistent with utility maximization.

The set of choices is partitioned into  $M$  subsets (nests)  $B_m, m = 1, \dots, M$ , where each nest may have several alternatives. The individual chooses the nest first and then the alternative  $j$  of that nest.

In this context, it is relevant to know the probability of an individual choosing the nest  $m$  and the alternative  $j$ ,

$$(7) P_{i,mj} = P_{im} * P_{ij|m}$$

For each nest  $m=1, \dots, M$  the joint distribution of the error term has an additional parameter  $\tau_m$  which represents the measure of mutual correlation of the error term between all alternatives of that nest. The model will be compatible with RUM models if  $\tau_m$  is positive and less or equal to 1.

Note that  $\tau_m = \sqrt{1 - \rho_m}$ , with  $\rho_m$  representing the correlation coefficient. Thus, it is an inverse measure of correlation, thus is called in the literature as dissimilarity parameter. The nested logit specification results of the hypothesis of the joint distribution of the errors being of generalized extreme value. When  $\tau_m = 1, \forall m = 1, \dots, M$ , we obtained the special case of the model defined in (6).

The estimation of the parameters of these models is made resorting to maximizing its likelihood function.

## 5. DATA AND DESCRIPTIVE STATISTICS

A major problem of estimating Internet demand is the rapid technological change of the market. Given the short life cycle of these services, time series for estimating the BB demand are unavailable. This is one of the reasons for choosing a cross-section model instead of a time series model. On the other hand, the micro-databases have the advantage of having a greater quality of information which allows analyzing how the individual characteristics affect BB access.

Another limitation faced by the Internet demand researchers is the lack of data, especially about prices, speed and volume. This is a common problem in the applications for the Portuguese case<sup>3</sup>. As a consequence, researches have to use imperfect estimation approaches to determine marginal effects and BB price-demand elasticities.

The more recent cross-section databases about residential Internet in Portugal are the Survey on the use of information technology by the families of the Institute of National Statistics (INE), the ANACOM's Electronic Communications Services Consumption Survey (ICSCE)<sup>4</sup>, the National Index of Customer Satisfaction of the Portuguese Institute of Quality and the Markttest Communications Barometer. None of these databases has information on BB expenditures and download speed, with the exception of the Markttest Barometer. As the access to the individual data of the latter data base was not granted<sup>5</sup>, it was chosen the more recent and rich database, the ICSCE 2009<sup>6</sup>, which has information regarding the specific characteristics of the respondents and of their Internet access choice.

For the prices we defined a proxy that corresponds to the price of the offer which is closer to the characteristics of the type of Internet access chosen by the household (identified in the questionnaire). Thus, the primary source of our paper was completed with the information from providers pricing plans<sup>7</sup>. For each of the individuals of the ICSCE 2009 database was imputed a price corresponding to the household choice of access, analyzing which was the offer in 2009 (moment of inquiry) which fits the characteristics of the technology chosen<sup>8</sup>. This approach required an enormous workload and took a long time but allowed a good approximation of the relevant price data, enabling to have econometric estimations with an explanatory variable essential to the demand, the price.

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<sup>3</sup> As identified in the studies of Pereira and Ribeiro (2006) and Hauge *et al* (2009).

<sup>4</sup> The last edition of this annual survey was 2009.

<sup>5</sup> It was given access only to aggregate data of previous years. Moreover, the rate of non-response to the questions about expenditures and speed is particularly high, with a non-response rate on the mobile Internet expenditure in June 2010 of about 16.8% for mobile and 34.9% for fixed Internet. The rate of non-response to the question about download speed is even higher: 50.2% in December 2010. Thus, even if we had access to the Barometer data, we still have the problem of the quality of information.

<sup>6</sup> ICSCE 2009 has 3106 observations obtained through personal interviews conducted to individuals with 15 years or older, selected by the quota method of NUTS II region, gender, age, education and occupation.

<sup>7</sup> Public information from the providers, collected by ANACOM.

<sup>8</sup> For FBB we have the following variables: type of technology (ADSL, cable, fibre and others), operator, type of tariff, region, date of contract and type of bundle. For MBB: download speed, operator, type of technology, type of tariff, contract date and use of MBB "e-initiatives" program. Therefore, we have quite a realistic approximation of the real price and a significant variability of prices. For individuals who indicated that they had adhered to "e-initiatives" program, it was considered the price of the respective initiative, which is known. These prices are significantly lower than the market prices. For example, for the adherents of "e-opportunities" the price is €15 and for the "e-school" the price varies in 3 levels, where, for example, for a student with a low income the monthly price was €5.

Given the substantial differences between the MBB access via mobile phones and cards/modems and the low penetration of the use of MBB using smartphones in 2009, it was not considered that, in that period, MBB via mobile phones is a FBB substitute. Therefore, in the estimations we only considered the MBB access through cards and as such we removed from the database the 25 observations of MBB through mobile phones.

A caveat shall be made regarding the imputation of the price when the service is provided in a bundle. The methodology followed was to consider, for each type of bundle, the percentage of the price that is related to FBB, considering the stand-alone offer of that specific provider.

Based on this approach it was possible to have large price variability, which is relatively close to average expenditures values obtained in the Marktest Barometer<sup>9</sup>. Table 3 presents the price and speed of download of our database.

Table 3 – Descriptive statistics of the price and download speed of the database

	Average	Standard deviation	Minimum	Maximum
<b>Prices in euros (month)</b>				
ADSL	26,5	12,1	8,1	52,5
Cable	22,1	10,6	9,2	65
Optic Fiber	27,5	9,7	16,4	44,9
MBB (Cards)	27,5	11,4	4,2	49,9
<b>Download speeds (Mbps)</b>				
ADSL	15,5	5,0	3,6	27,3
Cable	7,0	6,9	3,5	24,0
Optic Fiber	14,3	7,3	6,8	30,0
MBB (Cards)	4,0	2,0	1,0	12,0

The estimation of nested logit models imply that each individual has a price for all internet options, even those not chosen, which raises the question of how to determine the price of these alternatives. We applied a methodology similar to the used by Cardona *et al* (2009), using the prices of the offers in 2009.

The price of not having Internet is zero<sup>10</sup>. For individuals who have ADSL it was used information available for the offers in December 2009. We defined 3 average prices<sup>11</sup> that correspond to a low, medium and high level of use. Individuals who do not have Internet or that have narrowband are assigned to the low usage profile. Individuals who have cable, fibre and MBB are allocated to the offer which has the closest price to the chosen option (ADSL).

For cable and fibre we also defined 3 average prices corresponding to a low, medium and high level of use, considering, as for ADSL, the closest price to the chosen option (cable or fibre).

For MBB the methodology is similar, but we defined 5 levels of use, corresponding to the 5 different offers in terms of download speeds offered by all MBB operators in 2009. Table 13 in Appendix shows the prices obtained using this methodology.

<sup>9</sup> In June 2010 the average expenditure was €20.58 for mobile internet and €22.88 for fixed Internet.

<sup>10</sup> Was also set a price for narrowband, but since the information available about this type of access is scarce and there are no differences between user profiles, was considered the average price in 2009 (€18.94 for 56 kbps/s).

<sup>11</sup> The average prices for each technology are obtained by weighting the price of each operator by its market share.

The following table presents the descriptive statistics of the database used in the estimations and in Table 14 in the appendix it can be found the definition of the variables used.

Table 4 – Descriptive statistics of the individual variables

	No BB (1743)	ADSL (391)	Cable (514)	Optic Fiber (49)	Other FBB (66)	MBB Cards (257)	MBB and FBB (61)
Age (average)	52,6	36,5	37	31,7	43,4	31,4	32,6
Gender: Female	55%	52%	52%	51%	48%	54%	51%
Dimension of the household	2,6	3,5	3,3	3,5	3,7	3,2	3,5
Desktops (average number)	0,2	0,8	0,8	0,5	0,7	0,4	0,9
Laptops (average number)	0,2	0,9	0,9	1,2	0,9	1,1	1,6
PDA's/Palmtops (average number)	0,0	0,0	0,0	0,1	0,0	0,1	0,1
Televisions (average number)	1,9	2,7	2,8	2,5	2,2	2,5	3,1
Game consoles (average number)	0,0	0,2	0,2	0,4	0,1	0,2	0,4
Income level A	0,4%	1%	3%	2%	0%	2%	0%
Income level B	4,4%	23%	24%	29%	15%	24%	36%
Income level C	11,5%	29%	25%	24%	20%	17%	26%
Income level D	64,4%	35%	35%	27%	52%	39%	31%
Income level E	19,2%	12%	12%	18%	14%	17%	7%
Employed	43%	68%	65%	57%	68%	64%	72%
Student	3%	14%	15%	27%	6%	22%	21%
Unemployed	8%	7%	6%	6%	3%	9%	5%
Retired	33%	6%	7%	4%	15%	2%	0%
Other types of inactivity	14%	5%	7%	6%	8%	2%	2%
Education: Cannot read	6,0%	1%	0%	2%	0%	0%	0%
Education: Can read without education	11,0%	1%	1%	0%	5%	0%	0%
Education: 9 years of education	73,0%	55%	56%	53%	74%	53%	38%
Education: 12 years education (high school)	7,0%	29%	27%	22%	17%	29%	34%
Education: university degree	3,0%	14%	16%	22%	5%	18%	28%
Region: North	27,0%	20%	17%	29%	24%	28%	11%
Region: Center	16,0%	18%	13%	14%	5%	11%	23%
Region: Lisbon	15,0%	16%	28%	29%	20%	16%	30%
Region: Alentejo	11,0%	17%	4%	0%	9%	18%	10%
Region: Algarve	11,0%	11%	5%	10%	6%	15%	8%
Region: Azores Islands	9,0%	12%	12%	8%	27%	5%	11%
Region: Madeira Islands	10,0%	7%	20%	10%	9%	7%	7%
Nr Inhabitants: Below 2 000	52%	45%	29%	29%	50%	51%	38%
Nr Inhabitants: Between 2 000 and 4 999	9%	11%	10%	16%	12%	13%	21%
Nr Inhabitants: Between 5 000 and 9 999	7%	13%	8%	6%	14%	9%	2%
Nr Inhabitants: Between 10 000 and 99 999	20%	20%	29%	20%	9%	20%	28%
Nr Inhabitants: More than 100 000	11%	12%	24%	29%	15%	7%	11%

## 6. ESTIMATION RESULTS

The deterministic part of the utility of consumer  $i$  to choose alternative  $j$  ( $V_{ij}$ ), is a linear function of the characteristics of consumer<sup>12</sup> ( $x_i$ ) and of the product ( $z_{ij}$ )<sup>13</sup>:

$$(8) V_{ij} = x_i\beta_j + z_{ij}\gamma$$

In order to explain the probability of an individual choosing a particular BB alternative access<sup>14</sup> several binary, multinomial and nested logit models were estimated<sup>15</sup>. The output of the estimated models is presented in Tables 15 to 22 in Appendix. The restricted models were obtained by testing the joint nullity of the parameters, considering a 10% level of significance.

The multinomial models presented the more interesting results, which will be discussed in the following section. We will also present some conclusions about the nested logit.

### 6.1. MULTINOMIAL REGRESSION MODELS

Multinomial models are an extension of the models used to represent the binary choice between more than two mutually exclusive options. The dependent variable is a dummy variable representing the alternatives for choosing Internet. The explanatory variables are the variables with individual features identified in Table 13 and the prices of each type of BB access<sup>16</sup>. The dependent variable of the multinomial Model A is a discrete variable that assumes the values 1, 2, 3 and 4 representing the access options No BB (1), FBB (2) MBB (3) , FBB and MBB (4). The goodness of fit of the model is high (adjusted  $R^2$  of about 48.1%) and the base variable (omitted) the MBB access. Tables 5 and 6 show the average marginal effects<sup>17</sup> on the probability of choosing FBB and MBB, respectively.

The average marginal effect on the probability of having FBB (Table 5<sup>18</sup>) indicate that, on average, when the price of FBB increases one euro, the probability of having FBB reduces by 2.0 percentage points (p.p.), whereas when the MBB price increases one euro, this probability increases by 2.5 p.p.

In terms of individual features, marginal effects also have the expected sign of variation. On the other hand, individuals living in places with more than 5000 inhabitants have a higher probability of having FBB than those living in smaller places. As expected, having desktops and laptops increases the likelihood of having FBB. Having one more desktop increases in 20.5 p.p. the probability of having FBB and having one laptop has an impact of 9.2 p.p.

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<sup>12</sup> Within the consumer characteristics is included the age, education, gender, household size, presence of children and elderly in the household, employment situation, income level, region, size of the local, use of Internet outside the home of the household and existence of desktops, laptops, pdas, TVs and game devices.

<sup>13</sup> Price of the Internet access.

<sup>14</sup> Thus, the dependent variables in these models indicate the presence/absence of a particular type of access and not a given quantity. For this reason, the results indicate the likelihood of having a type of access, not the variation in quantity. This feature of the models has implications in the interpretation of the marginal effects and elasticities.

<sup>15</sup> All estimations were obtained using STATA-11.

<sup>16</sup> Prices attributed to each type of access, according to the methodology defined in Chapter 5.

<sup>17</sup> Which show the likelihood of the household, on average, choosing an option of access related to the base alternative, depending on the variation of one unit of a given variable.

<sup>18</sup> All marginal effects were statistically significant at 5% except Madeira Islands (10%).

Table 9 – Multinomial Model A – Average marginal effects on the probability of choosing FBB

Average marginal effects		Number of obs = 3081				
Model VCE : OIM						
Expression : Pr(chosen50==BLF), predict(outcome(BLF))						
		Delta-method			[95% Conf. Interval]	
	dy/dx	Std. Err.	z	P> z		
preoblf	-.0195731	.0013381	-14.63	0.000	-.0221958	-.0169504
preoblm	.0251091	.0015654	16.04	0.000	.022041	.0281772
idade2	-.0000118	5.40e-06	-2.19	0.029	-.0000224	-1.23e-06
rendb	.054148	.0211904	2.56	0.011	.0126155	.0956804
rendc	.0453199	.0169326	2.68	0.007	.0121325	.0785072
crian_agreg	-.0425418	.0146177	-2.91	0.004	-.0711919	-.0138917
agreg	.0246741	.0066725	3.70	0.000	.0115963	.0377519
desktops	.2047373	.0101119	20.25	0.000	.1849184	.2245563
laptops	.0917069	.0091684	10.00	0.000	.0737372	.1096766
tvvs	.0133374	.0060755	2.20	0.028	.0014297	.0252451
ensinosecund	.035925	.0180735	1.99	0.047	.0005015	.0713485
5000-9999	.0790677	.0243547	3.25	0.001	.0313333	.1268021
10000-99999	.0580506	.0161474	3.60	0.000	.0264023	.0896988
mais_100000	.0858588	.0206682	4.15	0.000	.0453498	.1263678
norte	-.0807441	.0169807	-4.76	0.000	-.1140257	-.0474626
alentejo	-.0951681	.0224813	-4.23	0.000	-.1392306	-.0511057
algarve	-.0524076	.0221775	-2.36	0.018	-.0958748	-.0089405
ramadeira	.0398885	.0238638	1.67	0.095	-.0068838	.0866607
internetfora	-.0578509	.0159555	-3.63	0.000	-.0891231	-.0265787

If the base option is MBB access (Table 6), on average, when the weighted FBB price increases in one euro, the probability of having MBB increases by 1.4 p.p., while when the MBB price increases one euro this probability decreases by 1 p.p. These results already indicate that the own elasticity of MBB related to other options in terms of access is negative and that the cross-elasticity is positive. On the other hand, individuals who have higher levels of education are more likely to have MBB.

Table 6 - Multinomial Model A – Average marginal effects on the probability of choosing MBB

Average marginal effects		Number of obs = 3081				
Model VCE : OIM						
Expression : Pr(chosen50==BLM), predict(outcome(BLM))						
		Delta-method			[95% Conf. Interval]	
	dy/dx	Std. Err.	z	P> z		
preoblf	.0142844	.0008676	16.47	0.000	.012584	.0159847
preoblm	-.0101039	.0007836	-12.89	0.000	-.0116398	-.008568
idade2	-.0000286	4.49e-06	-6.38	0.000	-.0000374	-.0000198
rendc	-.0245032	.0119743	-2.05	0.041	-.0479724	-.0010339
agreg	-.014712	.004592	-3.20	0.001	-.0237121	-.0057119
desktops	-.0132022	.0075393	-1.75	0.080	-.0279789	.0015745
laptops	.0489952	.0054471	8.99	0.000	.0383191	.0596713
ensinosecund	.0283824	.0111324	2.55	0.011	.0065632	.0502015
ens_superior	.0294913	.0142458	2.07	0.038	.0015701	.0574125
mais_100000	-.0518348	.016954	-3.06	0.002	-.085064	-.0186056
norte	.0184099	.0107438	1.71	0.087	-.0026475	.0394673
alentejo	.0356332	.0130264	2.74	0.006	.0101019	.0611644
algarve	.0434331	.0131542	3.30	0.001	.0176514	.0692148
raaores	-.037046	.0193073	-1.92	0.055	-.0748875	.0007955
ramadeira	-.0564304	.0184963	-3.05	0.002	-.0926825	-.0201782
internetfora	-.0456438	.0105624	-4.32	0.000	-.0663458	-.0249418

Model A allows to conclude that, on average, the demand for FBB and MBB (compared to the alternatives) is elastic (elasticities between -2.55 and -4.14) and cross-elasticities are positive, which indicates substitutability between the MBB and FBB - Table 7.

Table 7 – Own and Cross- Elasticities of FBB and MBB (Multinomial Model A)

$\epsilon_{ij}$	Model A	
	FBB	MBB
FBB Price	-2.55	5.97
MBB Price	3.36	-4.14

In order to analyze how each of the FBB technologies restricts the MBB demand and infer about the substitutability among FBB technologies, we estimated multinomial regression models with the FBB disaggregated by technology (ADSL, Cable and fiber<sup>19</sup>) – Model B.

In Model B the dependent variable is the dummy: No BB (1) ADSL (2) Cable (3) MBB (4), MBB and FBB (5)<sup>20</sup>. The results of this model for MBB as a base option are shown in table 16. We conclude that the probability of choosing ADSL alternative compared with the other options increases on average 1.5 and 0.2 p.p. when the price, of respectively, the cable and MBB increases in one euro – Table 8<sup>21</sup>. When the ADSL price increases in 1 euro, *ceteris paribus*, the probability of choosing the ADSL alternative compared to the others decreases 0.8 p.p. on average. The probability of having ADSL (compared to the other technologies) is reduced in 23 p.p. if the individual is from Madeira Islands and in 4.2 p.p if is from the North. However, an individual from Azores Islands is 7.2 p.p. more likely to choose ADSL than the other technologies.

Table 8 – Model B: Average Marginal Effects in the probability of choosing ADSL

```

Average marginal effects                                Number of obs =      2965
Model VCE      : OIM
Expression     : Pr(chosen9==ADSL), predict(outcome(ADSL))
-----
              |               Delta-method
              |      dy/dx   Std. Err.      z    P>|z|    [95% Conf. Interval]
-----+-----
  preoadsl | -.0079146   .0011714   -6.76  0.000   -0.0102105   -0.0056186
  preocabo |  .0146737   .0010621   13.82  0.000    .012592    .0167554
  preoblm  |  .002386    .0011881    2.01  0.045    .0000572    .0047147
  rendb   |  .0425577   .0196115    2.17  0.030    .0041198    .0809956
  rendc   |  .0585935   .0173655    3.37  0.001    .0245578    .0926293
  crian_agreg | -.037247   .0117532   -3.17  0.002   -0.0602828   -0.0142112
  agreg   |  .0235969   .0055898    4.22  0.000    .012641    .0345527
  desktops |  .1211272   .0087612   13.83  0.000   .1039556    .1382988
  laptops |  .0268826   .0067512    3.98  0.000    .0136505    .0401147
  pdas    |  .0759932   .0282159    2.69  0.007    .020691    .1312953
  ensinosecund | .0325044   .0138467    2.35  0.019    .0053655    .0596434
  5000_9999 | .0428427   .0179959    2.38  0.017    .0075715    .0781139
  norte   | -.0420006   .0130904   -3.21  0.001   -0.0676573   -0.0163439
  raaores |  .0715462   .0183711    3.89  0.000    .0355395    .1075528
  ramadeira | -.2285629   .0246848   -9.26  0.000   -0.2769442   -0.1801815
  internetfora | -.0359137   .0129144   -2.78  0.005   -0.0612256   -0.0106019
-----

```

<sup>19</sup> In these estimations were removed the observations corresponding to the respondents who indicated other FBB access or which don't know the FBB technology chosen. Therefore, in these estimates the number of observations is smaller than for the model A. In model A the FBB options were aggregated, so it was important to include all households with FBB, which is not the case in Model B.

<sup>20</sup> We also estimated models including optic fiber, but the results for this technology were not statistically significant, therefore these 49 observations were excluded.

<sup>21</sup> All marginal effects are significant at 5%.

In Table 9<sup>22</sup>, the probability of respondents choosing the cable alternative increases on average 2.0 p.p. when the ADSL price increases in one euro and 0.2 p.p. with an equal variation of the MBB price. When the cable price increases 1 euro, as expected, the probability of choosing the alternative cable compared to the other alternatives decreases by 2.8 p.p.

Table 9 - Model G: Average Marginal Effects compared to the cable choice

Average marginal effects		Number of obs = 2965				
Model VCE : OIM						
Expression : Pr(chosen9==cabo), predict(outcome(cabo))						
	dy/dx	Delta-method Std. Err.	z	P> z	[95% Conf. Interval]	
preoadsl	.0207	.0011463	18.06	0.000	.0184534	.0229466
preocabo	-.0284617	.0010141	-28.07	0.000	-.0304493	-.0264741
preoblm	.0024017	.0010514	2.28	0.022	.0003411	.004624
rendd	-.0275654	.0129709	-2.13	0.034	-.0529879	-.0021429
desktops	.0449245	.0078132	5.75	0.000	.029611	.060238
laptops	.0187262	.0060658	3.09	0.002	.0068375	.0306149
pdas	-.174092	.0537923	-3.24	0.001	-.2795229	-.0686611
tv	.0130684	.0041205	3.17	0.002	.0049925	.0211444
10000-99999	.0524456	.011349	4.62	0.000	.030202	.0746892
mais_100000	.0485978	.0144009	3.37	0.001	.0203726	.0768231
raaores	-.1029624	.0149667	-6.88	0.000	-.1322966	-.0736283
ramadeira	.2801097	.0193706	14.46	0.000	.2421441	.3180754

In what matters the marginal effects on the probability of choosing MBB (Table 10<sup>23</sup>), if the price of ADSL or cable increases in one euro, the likelihood of having MBB compared with the alternatives increases 0.7 p.p. on average. If the MBB price increases in the same amount, the likelihood of choosing that option reduces 0.7 p.p. on average. Moreover, individuals who have higher levels of education are more likely to have MBB (compared to the alternatives).

Table 10 – Model B: Average Marginal Effects compared to the MBB choice

Average marginal effects		Number of obs = 2965				
Model VCE : OIM						
Expression : Pr(chosen9==BLM), predict(outcome(BLM))						
	dy/dx	Delta-method Std. Err.	z	P> z	[95% Conf. Interval]	
preoadsl	.0077205	.000911	8.48	0.000	.005935	.009506
preocabo	.0065177	.0007355	8.86	0.000	.0050761	.0079593
preoblm	-.007203	.0007623	-9.45	0.000	-.0086971	-.005709
idade2	-.0000293	4.82e-06	-6.08	0.000	-.0000387	-.0000198
rendc	-.030272	.0150122	-2.02	0.044	-.0596954	-.0008486
agreg	-.0137482	.0048945	-2.81	0.005	-.0233413	-.0041551
desktops	-.0223758	.0076203	-2.94	0.003	-.0373113	-.0074403
laptops	.0427444	.0056925	7.51	0.000	.0315873	.0539014
pdas	.0606512	.0193705	3.13	0.002	.0226858	.0986166
ensinosecond	.0263594	.0118509	2.22	0.026	.0031322	.0495867
ens_superior	.0308219	.015129	2.04	0.042	.0011697	.0604741
mais_100000	-.04859	.0170442	-2.85	0.004	-.0819961	-.0151839
ramadeira	-.0567345	.0181135	-3.13	0.002	-.0922364	-.0212326
internetfora	-.0490398	.0111377	-4.40	0.000	-.0708692	-.0272103

<sup>22</sup> All marginal effects are significant at 5%.

<sup>23</sup> All marginal effects are significant at 5%.



The analysis of the own elasticities (Table 11) demonstrates that the probability demand for ADSL and cable BLM is elastic. Moreover, the demand of the latter technology is highly elastic: a variation of 1% of the price of the cable causes a reduction of 11.62% of the probability of its demand. On the other hand, the ADSL demand is restricted by the cost of the cable and cable demand is also constrained by the cost of ADSL, but at a higher intensity. There is thus evidence of substitutability between the two technologies, which confirms the results obtained from the analysis of the BB retail market in Portugal. MBB demand is restricted by the price of ADSL and cable, but we couldn't verify if the ADSL and cable are constrained by the MBB price, since the estimated elasticities are not statistically significant. There is, however, evidence of substitutability, because the marginal effects analysis showed that when the MBB price increases in of 1 euro the demand for ADSL and cable increases by about 0.2 p.p.<sup>24</sup>.

Table 11 – Average own and cross elasticities of ADSL, cable and MBB (Model G)

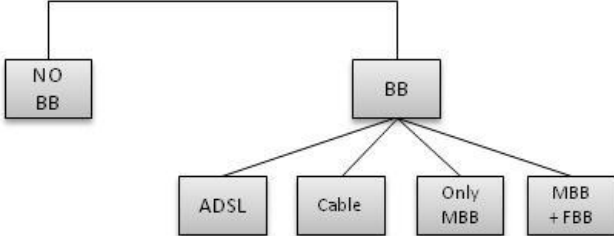
$\epsilon_{ij}$	ADSL	Cable	MBB
ADSL price	-1.09	7.68	3.78
Cable price	4.34	-11.62	3.15
MBB price	0.01*	0.42*	-3.45

All elasticities are significative at 1% except:  
 \* Elasticity non significative at 10%

These estimations results are particularly interesting. Firstly, there is evidence of symmetrical substitution between ADSL services and cable. By other side, when the price of cable or of ADSL increases, the MBB demand increases, but when the MBB price increases it is not necessary true that the cable and ADSL demand increases. And this takes us to a second conclusion: there is asymmetric substitutability of demand between MBB and the fixed technologies ADSL and cable, *i.e.*, the substitution between fixed and mobile technologies occurs only in the sense of fixed to mobile. In this regard, it will be important to consider that users who value mobility can hardly accept that a FBB offer is a substitute of the MBB.

**6.2. NESTED LOGIT MODELS**

Several nested logit models were estimated (Models C, D and E), which relax the hypothesis IIA of the conditional models. The nested Model C has the following decision tree:



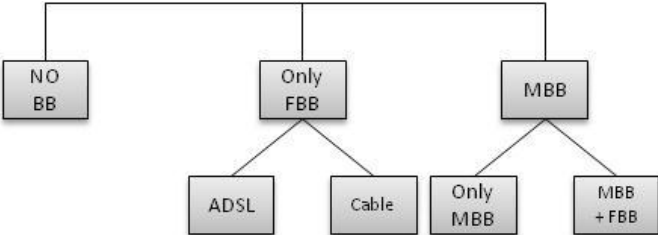
The omitted variable (base) of the model C is BB. The estimation results are shown in Table 17 in the Annex. For this model the price variable is statistically significant, but has no economic reading, since the coefficient sign is

<sup>24</sup> Although this effect is very small is statistically significant at 5%.

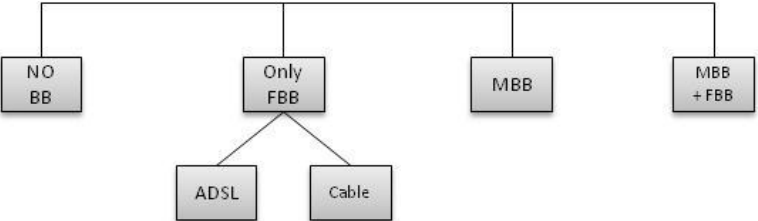
positive, that is, a price increase causes an increase in conditional probability of access alternatives demand, for each of these alternatives. Through the LR test for  $\tau_m$ , calculated for the hypothesis of all  $\tau_m$  being equal to one, it was concluded that using a CL model was not suitable. The model C is not compatible with a maximizing utility model, as the BB parameter of dissimilarity does not meet the compatibility conditions.

Marginal effects for the price of each access alternative were calculated using the method of calculating the average marginal effects for the nested logit models proposed by Cameron, A. C. & P. Trivedi K. (2010). None of the marginal effects is significant (Tables 18-20 in the appendix) and therefore we couldn't calculate the elasticities.

We also estimated model nested logit D, which has the following tree:



The estimation results (Only FBB base) are presented in Table 21 in the Appendix. For this model the variable price is not statistically significant, although this model is consistent with RUM. Finally, we estimated model E with the following decision tree:



The estimation results are shown in Table 22. In this model the sign of the coefficient of the price variable is consistent with the economic theory (negative), but this variable is not significant, so the marginal effects and elasticities are not significant. Model E is compatible with the assumptions of RUM models.

Through the analysis of nested logit models, we concluded that the price variable doesn't explain the demand based on the three decision trees used. There is evidence that, for the decision trees defined, other explanatory variables are more important than the price to discriminate the choice among the alternatives within each nest. It should be stressed that the variables which characterize the household have the expected sign and confirm the conclusions already obtained for the models previously estimated.

The nested models do not allow drawing the same conclusions regarding the price as the multinomial models. One reason which may explain this is that the price information is not good enough to discriminate between alternatives within each nest, but good enough for more flexible models, such as the multinomial models.

## 7. SSNIP TEST AND IMPLICATIONS FOR MARKET ANALYSIS

For market analysis, market definition serves to identify all sources of relevant competition that influence the conditions under which a good is supplied by the companies. The standard test for defining the relevant market is the HM test. In practice, the HM test is implemented using a set of quantitative and qualitative considerations or data about the demand behaviour. Empirically, the substitution behaviour of the retail demand can be determined with the help of the elasticity of retail demand, which indicates the percentage of change in the quantity demanded in response to a percentage change in the price.

To determine to what extent the existence of substitution is sufficient to limit the HM in its policy of setting prices, the elasticity of demand should be compared with the critical elasticity, the elasticity from which a given increase in the price is no longer profitable for the HM. The critical elasticity can be calculated as follows (for a linear demand):

$$\varepsilon_k = \frac{1}{m + t}$$

Where  $m$  is the initial margin, *i.e.*:

$$m = \frac{P_0 - c}{P_0}$$

And  $t$  is the percentage increase in the price (usually 5 or 10%), *i.e.*:

$$t = \frac{P_1 - P_0}{P_0}$$

If the actual elasticity is below the critical value the relevant market shall include the next best substitute. If it is above the critical value, the product (or product set) represents the relevant market.

In Portugal, in the last market analysis conducted by ANACOM was concluded that the BB access retail market consists of BB access services via xDSL, cable and optic fiber provided to residential and non-residential clients. The BB market defined by ANACOM is our starting point, so, if the HM test reveals that the HM cannot impose a non-transitory increase of 5-10% in a profitable way, to this relevant market must be added the closest substitute (MBB).

There isn't publicly available information about the  $m$  in Portugal, therefore we considered the percentage calculated by RTR for the Austrian market, *i.e.*,  $m$  is estimated to be about 60%-80%<sup>25</sup>. Consequently, the critical elasticity is between 1.1 and 1.5. As the estimated elasticities of our models are above this critical value, we can conclude that according to estimations, the current BB retail product market access should be extended to include the next best substitute, MBB.

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<sup>25</sup> The Austrian regulator considered that variable costs are an adequate approximation of marginal costs.

It is important to note, however, that the role of regulators in BB market is primarily at the level of the wholesale markets and aims to eliminate the problems identified in the retail market. The definition of the wholesale market does not differ conceptually from the definition at the retail level (HM test is used in both cases) and the definition of the retail market should even be the starting point for the definition of related wholesale markets. However, the definition at the wholesale level involves other issues that are mostly related to the possibility of direct substitution at the wholesale level, which are outside the scope of this paper. Nevertheless, there is also a need to consider sources of direct substitution at the wholesale level which are related to the substitution at the retail market.

Thus, at the wholesale level in addition to the potential direct substitution of the current wholesale services supported in copper networks by other wholesale services in cable or mobile networks, it must be also considered the indirect constraints in the wholesale market caused by the existence of substitutability at the retail level<sup>26</sup>. It is precisely in the study of indirect constraints that the estimations of substitution obtained might be relevant since they are important references in the impact of the retail market in the definition of the wholesale market.

In this regard and assuming that there is no direct substitution at the wholesale level, it can be considered the approach of Schwarz (2007), considering the assumptions that one unit of wholesale input is used to produce one unit of the good in retail and that the retail market is competitive. Therefore the relationship between the elasticity of demand in the retail and wholesale market is:

$$\varepsilon_W = \frac{w}{p} \varepsilon_R$$

Where  $\varepsilon_W$  is elasticity at the wholesale level and  $\varepsilon_R$  the elasticity at the retail level,  $w$  the wholesale price and  $p$  the retail price.

As we estimated the retail elasticity and there is information available on the percentage of the wholesale costs in the price of retail<sup>27</sup>, is possible to estimate the wholesale elasticity caused indirectly by the existing substitution in the retail market<sup>28</sup>, which assumes values between 3.5 and 4.3.

Thus, as the estimated elasticities for retail and the retail market are above the critical value calculated, the relevant market might include the next best substitute. Accordingly, it seems appropriate to incorporate in the same access market FBB and MBB services.

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<sup>26</sup> This because a price increase at the wholesale level also results, under certain conditions, in an increase of the price at the retail level, motivating consumers to switch to other products that are not made with the same inputs and whose prices were not increased.

<sup>27</sup> According to the analysis of BB market performed by ANACOM in 2009, the percentage of wholesale costs with the bitstream offer varies between 60% and 70% of the retail price.

<sup>28</sup> Assuming that there are no sources of direct substitution at the wholesale level.

## 8. CONCLUSIONS AND FURTHER RESEARCH STEPS

Aiming to study the demand for Internet, we estimated several multinomial and nested logit models, using information of the ICSC questionnaire, complemented with information of the price offers in the market.

These estimations identify the individual variables that influence the decision of consumers in terms of choice of access to Internet service and capture the demographic and socio-economic characteristics of BB demand.

It was confirmed an expected economic result: an increase of the price of a BB technology results in the decrease, in probabilistic terms, of the demand of such technologies. The estimated own price elasticities are all negative, so all BB access services BL are normal goods.

The empirical results also show that when the size of the household increases, its propensity to have MBB decreases. Furthermore, when the age of the respondent increases, the propensity to have BB reduces. The gender and the variables related to the condition towards work are not statistically significant, revealing to have little influence on the choice of internet access.

The estimated models permit calculating MBB and FBB own price elasticities, revealing that the demand for all technologies is elastic. By technology, the less elastic demand is for ADSL, a result already found by Ida & Kuroda (2006).

In the model that aggregates all FBB technologies, the demand for MBB is restricted by the FBB weighted price (elasticity of 5.97). But when analyzing the demand for each type of FBB technology the conclusions are slightly different.

Through the estimation of a multinomial discrete choice model for each FBB technology (ADSL and cable) and MBB was possible to reach conclusions particularly relevant for the substitution between fixed and mobile accesses. Firstly, there is evidence of symmetrical substitution between ADSL services and cable, with cross elasticities of, respectively, 4.34 and 7.68. These results support the BB market analysis in Portugal (ADSL and cable are in the same BB retail market), since both have the same features, identical speed, coverage and prices. By other side, when the price of ADSL or cable increases, the MBB demand increases (elasticities, respectively, of 3.78 and 3.15), but when the MBB price increases is not certain that the demand for cable and ADSL increases, as the estimation of these cross-elasticities is not statistically significant. That is, the substitution between fixed and mobile technologies occurs only in one direction, which leads us to a second conclusion: there is asymmetric substitutability of demand between the MBB and ADSL and cable fixed technologies. Users of ADSL and cable can replace Internet services by MBB in response to an increase in the price of ADSL or cable, but it is not necessarily true that users of the MBB service replace ADSL or cable in the case of a MBB price increase.

Economic theory tells us that the asymmetry in demand substitution can occur for many reasons, from the existence of potential price discrimination to the existence of asymmetric preferences in consumption. And as already stated, the distinctive MBB characteristics can lead to asymmetric preferences, due to its inherent mobility.

The next step was to carry out a SSNIP test based on estimated elasticities considering as the starting point the market that integrates ADSL and cable services. The test used is a simple test that follows the methodology established by RTR to analyse BB market in 2009, by calculating a critical value. It was found that the estimated

elasticities for the retail market are above the critical value calculated. This test reveals that the HM cannot impose a profitable non-transitory increase in price. Therefore, the current BB relevant market should be extended to include the next best substitute, MBB.

It should however be mentioned that the inclusion of one technology in the BB market results not only from SSNIP test analysis and from the calculation of elasticity. To draw robust conclusions for market definition we must also conclude that the features of the different technologies allow satisfying the pattern of use of the majority of the end users. It is evident that the fixed and mobile accesses have differences, namely the mobility provided by the MBB and the better quality of FBB, so it is always necessary to complement this analysis. If it is true that the differences between MBB and FBB have been narrowing, it is also relevant to consider that it is increasingly common to have Internet offered in a bundle, including television, which makes the substitution between MBB and FBB less intense (due to the reduced capacity of mobile networks to provide TV service).

It should also be mentioned that the results might be less robust due to lack of databases with information about the price. The constraint of having limited information about the characteristics of price plans, speed and volume is a common characteristic of all the studies about this topic. Thus, a next step in research, if possible, would be to repeat this exercise with a database which has the richness of the survey used (ICSCE) but with more information about the type of access, including prices and download speeds.

Other research step it will be to apply this method to a more recent database, in order to analyse the use of more recent technologies and tendencies, as the widespread of Internet in smartphones and of optic fibre. The estimation results can also be more robust if there are more observations with BB access, particularly with multiple types of access, which would allow the analysis of consumption patterns. Additionally, having more BB observations will permit to obtain statistically significant results with nested logit models, allowing to use more powerful econometric models and compatible with utility maximization.

We also estimated the wholesale elasticity caused by the indirect substitution in the existing retail market. A next step of research will be to examine in more detail this substitutability.

In summary, this paper presents some new aspects that contribute to the discussion of the dynamics of Internet demand in Portugal. Firstly, we built a database for the Internet access with information about prices. Despite the limitations of the assumptions inherent in the imputation of prices, is the first known application for the Portuguese market that analyzes the demand for Internet access through a micro-database representative of the Portuguese population. Secondly, it was possible to conclude about the marginal effects of individual explanatory variables and calculate demand price elasticities. The third innovation was conducting a HM test by using the estimated values of the elasticities, concluding that there is empirical evidence that the relevant BB market in Portugal might include MBB in the coming years or, at least, that effective substitutability between MBB and FBB services should continue to be analyzed in detail.

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APPENDIX

Table 12 – Resume of Literature Review

Study (Country)	Method and Data	Own Demand Elasticities	Cross Elasticities	Conclusions
<b>Cardona et al (2009)</b> <b>(Austria)</b>	- <i>Nested logit</i> - Consumers Survey RTR (2825 observations)	4 technologies: Demand of DSL, cable and mobile elastic (between -2.61 and -2.48) Two technologies: DSL (-0.97) and narrowband (-0.77) inelastic	4 technologies: Between 0,183 and 0,402	The different technologies are close BB substitutes
<b>Pereira &amp; Ribeiro (2006)</b> <b>(Portugal)</b>	- <i>Mixed logit</i> - Panel Markttest (1200 households)	BB elastic (-2,836) Narrowband lelastic (-1,156) DSL: -3,196 Cable: -3,130	BB Demand /narrowband price: 0,503 Demand narrowband /BB price: 0,876	BB and narrowband are substitutes
<b>Ida &amp; Kuroda (2006)</b> <b>(Japão)</b>	- Conditional and <i>nested logit</i> - Surveys Web (< 800 observations)	ADSL inelastic (-0,846) Cable (-3,150) and fiber (-2,5) elastic	Not estimated	ADSL market is independent from cable and fiber
<b>Hauge et al (2009)</b> <b>(Portugal)</b>	- Multinomial Model - ICSCCE 2008 and BB Survey 2006	Not estimated	Not estimated	Substitution between MBB and FBB (analysis of the individual features)
<b>Crandall et al (2002)</b> <b>(USA)</b>	- <i>Nested logit</i> - Survey: 3 500 observations	DSL elastic (-1,184) Cable: -1,220	Demand cable/ price DSL: 0,591 Demand DSL/ price cable: 0,415	DSL and cable in the same market (without conducting a SSNIP test)
<b>Rappoport et al (2003)</b> <b>(USA)</b>	- <i>Nested logit</i> - 20 000 random households	DSL elastica (-1,462) Cable inelastic (-0,587)	Demand cable/price DSL: 0,618	DSL and cable substitutes and in the same market (without conducting a SSNIP test)
<b>Goel et al (2007)</b> <b>(OECD Countries)</b>	- <i>log-linear</i> - Data from OECD and World Bank	Internet: between -0.6 and -0.7	Not estimated	Demand Internet inelastic



Table 13 – Usage patterns

		Price (€)	Speed (Mbps)	Household with access
	<b>Low Usage</b>	21,37	3,47	Without Internet and narrowband; Cable, MBB and optic fiber: offer closer to price
<b>ADSL</b>	<b>Average Usage</b>	26,88	8,28	Cable, MBB and optic fiber: offer closer to the price
	<b>High Usage</b>	38,69	24	Cable, MBB and optic fiber: offer closer to the price
	<b>Low Usage</b>	Mainland: 26,73 Azores: 16,57 Madeira: 35,18	Mainland: 8,39 Azores: 5,19 Madeira: 6,8	Without access and narrowband; ADSL, MBB and optic fiber: offer closer to the price
<b>Cable</b>	<b>Average Usage</b>	Mainland: 37,12 Azores: 22,47 Madeira: 43,49	Mainland: 18,38 Azores: 10,39 Madeira: 13,59	ADSL, MBB and optic fiber: offer closer to the price
	<b>High Usage</b>	Mainland: 59,24 Azores: 33,12 Madeira: 153,98	Mainland: 29,97 Azores: 20,39 Madeira: 20,39	ADSL, MBB and optic fiber: offer closer to the price
	<b>Low Usage</b>	20,54 Madeira: 19,81	28,84 Madeira: 23,46	Without Internet and narrowband; ADSL, Cable and MBB: offer closer to the price
<b>Optic Fiber</b>	<b>Average Usage</b>	24,21 Madeira: 33,28	63,46 Madeira: 50	ADSL, cable and MBB: offer closer to the price
	<b>High Usage</b>	37,13 Madeira: 36,72	126,91 Madeira: 100	ADSL, cable and MBB: offer closer to the price
	<b>Very Low Usage</b>	22,80	2	Without Internet (and doesn't pretend to have in the next 12 months) and narrowband; ADSL, Cable and optic fiber: offer
	<b>Low Usage</b>	30,33	3,6	Without Internet (but pretend to have in the next 12 months) and narrowband; ADSL, Cable and optic fiber: offer closer to the
<b>MBB (Cards)</b>	<b>Average Usage</b>	36,67	5	ADSL, cable and optic fiber: offer closer to the price
	<b>High Usage</b>	45,53	7,2	ADSL, cable and optic fiber: offer closer to the price
	<b>Very High Usage</b>	49,90	21,6	ADSL, cable and optic fiber: offer closer to the price

Table 14 – Description of the variables of the models

	Variável	Description
<b>Type of access</b>	BLM	MBB Access = 1, otherwise = 0
	BLF	FBB Access = 1, Otherwise = 0
	Chosen50	No Internet = 1, FBB = 2, MBB = 3, MBB and FBB = 4
	Chosen9	No Internet = 1, ADSL = 2, Cable = 3, MBB = 4, MBB and FBB = 5
<b>Price</b>	preobl m	Price of MBB Access
	preobl f	Price of FBB Access
	preoadsl	Price of ADSL Access
	preocabo	Price of Cable Access
<b>Region</b>	norte	North Region = 1, Any other region = 0
	centro	Center Region = 1, Any other region = 0
	alentejo	Alentejo Region = 1, Any other region = 0
	algarve	Algarve Region = 1, Any other region = 0
	raaores	Azores Islands = 1, Any other region = 0
	ramadeira	Madeira Islands = 1, Any other region = 0
<b>Size of the place of living</b>	2000-4999	Place with 2 000 - 4 999 inhabitants = 1, Otherwise = 0
	5000-9999	Place with 5 000 - 9 999 inhabitants = 1, Otherwise = 0
	10000-99999	Place with 10 000 - 99 999 inhabitants = 1, Otherwise = 0
	mais_100000	Place with more than 100 000 inhabitants = 1, Otherwise = 0
<b>School level</b>	ensinosecund	High school completed = 1, otherwise = 0
	ens__superior	Graduation completed = 1, otherwise = 0
<b>Gender</b>	mulher	Female = 1, Male = 0
<b>Bundle</b>	cabaz	Internet included in a bundle = 1, otherwise = 0
<b>Household</b>	agreg	Household dimension (number)
	crian_agreg	Children in the household = 1, otherwise = 0
	idosos_agreg	Elderly in the household = 1, otherwise = 0
<b>Existence of devices in the household</b>	desktops	Number of desktops in the household
	laptops	Number of laptops in the household
	pdas	Number of pdas and palmtops in the household
	tvs	Number of televisions in the household
	consolas	Number of game consoles in the household
<b>Employment</b>	trabalhador	Employed = 1, otherwise = 0
	desempregados	Unemployed = 1, otherwise = 0
	reformados	Retired = 1, otherwise = 0
	outros_inact	Other type of inactivity = 1, otherwise = 0
<b>Age</b>	idade	Number of years of the respondent
	idade2	Square of the number of years of the respondent
<b>Income</b>	renda	Income level A (higher) = 1 , other levels = 0
	rendb	Income level B = 1 , other levels = 0
	rendc	Income level C = 1 , other levels = 0
	rendd	Income level D = 1 , other levels = 0
<b>Internet</b>	internetfora	Internet usage outside household = 1, otherwise = 0

Table 15 – Model A – Restritive Multinomial Model

Multinomial logistic regression	Number of obs	=	3081
	LR chi2(69)	=	2829.44
	Prob > chi2	=	0.0000
Log likelihood = -1583.3547	Pseudo R2	=	0.4719

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chosen50		Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
1	preoblf	-.2303647	.0209366	-11.00	0.000	-.2713997	-.1893297
	preoblm	.1036708	.0181694	5.71	0.000	.0680593	.1392822
	idade2	.0007922	.0000959	8.26	0.000	.0006043	.0009801
	rendb	-.7669286	.2996099	-2.56	0.010	-1.354153	-.1797041
	rendc	.2571364	.2636635	0.98	0.329	-.2596346	.7739074
	crian_agreg	.0627118	.2102714	0.30	0.766	-.3494125	.4748361
	agreg	.2449894	.1001054	2.45	0.014	.0487864	.4411924
	desktops	-1.055754	.1906674	-5.54	0.000	-1.429455	-.6820528
	laptops	-1.857715	.1444555	-12.86	0.000	-2.140842	-1.574587
	tvvs	-.0229222	.0915231	-0.25	0.802	-.2023042	.1564598
	consolas	-.2354337	.2349238	-1.00	0.316	-.695876	.2250086
	ensinosecund	-.9407381	.25521	-3.69	0.000	-1.44094	-.4405358
	ens_superior	-1.041035	.3410389	-3.05	0.002	-1.709458	-.3726107
	2000-4999	-.546445	.2956448	-1.85	0.065	-1.125898	.0330081
	5000-9999	-.526749	.3246088	-1.62	0.105	-1.162971	.1094726
	10000-99999	-.0637771	.2350176	-0.27	0.786	-.5244032	.396849
	mais_100000	.8035663	.3678072	2.18	0.029	.0826775	1.524455
	norte	.2172369	.2379826	0.91	0.361	-.2492004	.6836743
	alentejo	-.2329151	.2976467	-0.78	0.434	-.816292	.3504619
	algarve	-.6338544	.289925	-2.19	0.029	-1.202097	-.0656118
	raaores	.9390777	.4147154	2.26	0.024	.1262506	1.751905
	ramadeira	1.100449	.3973393	2.77	0.006	.3216778	1.879219
	internetfora	1.369597	.2410688	5.68	0.000	.897111	1.842083
	_cons	4.806494	.4903432	9.80	0.000	3.845439	5.76755

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2	preoblf	-.3469281	.0221296	-15.68	0.000	-.3903013	-.3035548
	preoblm	.2993829	.0212569	14.08	0.000	.2577202	.3410457
	idade2	.0004523	.0000954	4.74	0.000	.0002653	.0006394
	rendb	-.0572861	.261281	-0.22	0.826	-.5693876	.4548153
	rendc	.6495508	.2517038	2.58	0.010	.1562203	1.142881
	crian_agreg	-.3089041	.2012943	-1.53	0.125	-.7034337	.0856255
	agreg	.3797196	.098198	3.87	0.000	.1872551	.572184
	desktops	1.208241	.1796085	6.73	0.000	.8562148	1.560267
	laptops	-.4342946	.1211833	-3.58	0.000	-.6718094	-.1967797
	tvvs	.1223159	.0877724	1.39	0.163	-.0497149	.2943466
	consolas	.1096567	.2078172	0.53	0.598	-.2976575	.516971
	ensinosecund	-.3329246	.2366718	-1.41	0.160	-.7967928	.1309436
	ens_superior	-.3507056	.2983528	-1.18	0.240	-.9354664	.2340552
	2000-4999	-.1351797	.2867841	-0.47	0.637	-.6972661	.4269068
	5000-9999	.1932579	.3110146	0.62	0.534	-.4163196	.8028354
	10000-99999	.4900218	.2273264	2.16	0.031	.0444703	.9355734
	mais_100000	1.331124	.3521611	3.78	0.000	.6409007	2.021347
	norte	-.7078158	.23402	-3.02	0.002	-1.166487	-.2491452
	alentejo	-1.08516	.2841144	-3.82	0.000	-1.642014	-.5283059
	algarve	-1.018284	.2878316	-3.54	0.000	-1.582424	-.4541447
	raaores	.6367445	.3957594	1.61	0.108	-.1389298	1.412419
	ramadeira	1.190961	.3891348	3.06	0.002	.4282706	1.953651
	internetfora	.5315391	.225702	2.36	0.019	.0891714	.9739068
	_cons	.3583963	.4746523	0.76	0.450	-.5719051	1.288698

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3 | (base outcome)

4	preoblfl	-.1995089	.032651	-6.11	0.000	-.2635036	-.1355141
	preoblm	.1080789	.0304718	3.55	0.000	.0483552	.1678026
	idade2	.0001092	.0001961	0.56	0.578	-.0002752	.0004936
	rendb	-.0013189	.447878	-0.00	0.998	-.8791437	.8765058
	rendc	.851828	.4375471	1.95	0.052	-.0057485	1.709404
	crian_agreg	.1872671	.3697716	0.51	0.613	-.537472	.9120061
	agreg	-.0324912	.1853241	-0.18	0.861	-.3957199	.3307374
	desktops	1.681679	.2820756	5.96	0.000	1.128821	2.234537
	laptops	.5034917	.1783885	2.82	0.005	.1538566	.8531267
	tvns	.2394683	.1443367	1.66	0.097	-.0434265	.5223631
	consolas	.7213516	.2843065	2.54	0.011	.1641211	1.278582
	ensinosecund	.0216162	.4313636	0.05	0.960	-.823841	.8670734
	ens_superior	.5025303	.5145522	0.98	0.329	-.5059734	1.511034
	2000-4999	.6550612	.4593084	1.43	0.154	-.2451668	1.555289
	5000-9999	-1.411023	1.087346	-1.30	0.194	-3.542182	.7201368
	10000-99999	.3202764	.4111196	0.78	0.436	-.4855032	1.126056
	mais_100000	.3544771	.584475	0.61	0.544	-.7910728	1.500027
	norte	-1.678658	.4997622	-3.36	0.001	-2.658174	-.6991418
	alentejo	-1.060369	.5404577	-1.96	0.050	-2.119646	-.0010913
	algarve	-1.369674	.5899682	-2.32	0.020	-2.525991	-.2133579
	raaores	.3115875	.604832	0.52	0.606	-.8738614	1.497036
	ramadeira	.9450611	.6820744	1.39	0.166	-.3917801	2.281902
	internetfora	.9909557	.3727677	2.66	0.008	.2603445	1.721567
	_cons	-1.667091	.891516	-1.87	0.061	-3.41443	.0802484

Dependent variable: 1: BB; 2: FBB; 3: MBB; 4: MBB and FBB.

Table 16 –Model B – Restritive Multinomial Model

Multinomial logistic regression	Number of obs	=	2965
	LR chi2(96)	=	3681.70
	Prob > chi2	=	0.0000
Log likelihood = -1640.5521	Pseudo R2	=	0.5288

	chosen9	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
1	preoadsl	-.2990151	.0284726	-10.50	0.000	-.3548204	-.2432098
	preocabo	-.0821222	.0260028	-3.16	0.002	-.1330868	-.0311575
	preoblm	.1627902	.0192366	8.46	0.000	.1250871	.2004933
	idade2	.0008497	.0000997	8.53	0.000	.0006544	.0010451
	rendb	-1.019365	.3583298	-2.84	0.004	-1.721679	-.3170519
	rendc	.0014366	.3254713	0.00	0.996	-.6364754	.6393486
	rendd	-.3311765	.2561059	-1.29	0.196	-.8331349	.1707819
	crian_agreg	.1650513	.2208194	0.75	0.455	-.2677467	.5978494
	agreg	.1835572	.1054505	1.74	0.082	-.0231219	.3902363
	desktops	-1.093978	.1964763	-5.57	0.000	-1.479064	-.7088913
	laptops	-1.649504	.1450764	-11.37	0.000	-1.933848	-1.365159
	pdas	-.9827183	.4787707	-2.05	0.040	-1.921092	-.0443448
	tvns	-.063342	.0938846	-0.67	0.500	-.2473525	.1206685
	consolas	-.3078753	.2484904	-1.24	0.215	-.7949076	.179157
	ensinosecund	-.9207461	.2717271	-3.39	0.001	-1.453321	-.3881708
	ens_superior	-1.053575	.3650702	-2.89	0.004	-1.7691	-.3380511
	2000-4999	-.6352834	.3018065	-2.10	0.035	-1.226813	-.0437536
	5000-9999	-.8058903	.3381122	-2.38	0.017	-1.468578	-.1432026
	10000-99999	-.1791912	.2480073	-0.72	0.470	-.6652767	.3068942
	mais_100000	.5526387	.3661506	1.51	0.131	-.1650032	1.270281
	norte	.5999409	.2216637	2.71	0.007	.165488	1.034394
	raaores	.5821477	.4143878	1.40	0.160	-.2300375	1.394333
	ramadeira	1.281811	.4395356	2.92	0.004	.4203372	2.143285
	internetfora	1.425864	.2538268	5.62	0.000	.9283722	1.923355
	_cons	6.888837	.6616314	10.41	0.000	5.592063	8.18561

-----							
2	preoadsl	-.207962	.0226195	-9.19	0.000	-.2522953	-.1636286
	preocabo	.0425403	.0118322	3.60	0.000	.0193495	.065731
	preoblml	.1388696	.0193394	7.18	0.000	.1009652	.1767741
	idade2	.000411	.0001015	4.05	0.000	.000212	.00061
	rendb	.1383051	.3386657	0.41	0.683	-.5254676	.8020778
	rendc	.9866928	.3258725	3.03	0.002	.3479944	1.625391
	rendd	.1775039	.277639	0.64	0.523	-.3666585	.7216663
	crian_agreg	-.4609318	.215259	-2.14	0.032	-.8828317	-.0390319
	agreg	.4426993	.1074775	4.12	0.000	.2320472	.6533513
	desktops	1.417031	.1902334	7.45	0.000	1.04418	1.789882
	laptops	-.4718544	.1302589	-3.62	0.000	-.7271571	-.2165517
	pdas	-.2091558	.3815805	-0.55	0.584	-.9570397	.5387282
	tv	-.030092	.0920903	-0.33	0.744	-.2105858	.1504017
	consolas	.1753112	.220701	0.79	0.427	-.2572547	.6078771
	ensinosecu~o	-.1254936	.2532573	-0.50	0.620	-.6218689	.3708816
	ens_superior	-.3404604	.3283798	-1.04	0.300	-.9840729	.3031522
	2000-4999	-.3556809	.2997104	-1.19	0.235	-.9431024	.2317406
	5000-9999	.1222715	.3319068	0.37	0.713	-.5282538	.7727969
	10000-99999	.0584497	.2509192	0.23	0.816	-.4333429	.5502423
	mais_100000	1.015026	.369771	2.75	0.006	.2902885	1.739764
	norte	-.3904372	.2269366	-1.72	0.085	-.8352249	.0543504
	raaores	1.010221	.3967429	2.55	0.011	.2326196	1.787823
	ramadeira	-1.319832	.4319579	-3.06	0.002	-2.166454	-.4732103
	internetfora	.4404931	.2420029	1.82	0.069	-.0338239	.9148101
	_cons	-1.684627	.5496859	-3.06	0.002	-2.761992	-.6072629
-----							

-----							
3	preoadsl	.1663274	.0292597	5.68	0.000	.1089794	.2236754
	preocabo	-.5271334	.0326626	-16.14	0.000	-.5911509	-.4631158
	preoblml	.155336	.0224554	6.92	0.000	.1113242	.1993479
	idade2	.0005029	.0001096	4.59	0.000	.0002881	.0007177
	rendb	-.1873717	.3600925	-0.52	0.603	-.89314	.5183966
	rendc	.2654358	.3542626	0.75	0.454	-.4289061	.9597777
	rendd	-.5054898	.299209	-1.69	0.091	-1.091929	.0809491
	crian_agreg	-.1802287	.2391726	-0.75	0.451	-.6489984	.288541
	agreg	.2118335	.1161255	1.82	0.068	-.0157684	.4394354
	desktops	.8017872	.2043873	3.92	0.000	.4011954	1.202379
	laptops	-.5275912	.1415585	-3.73	0.000	-.8050408	-.2501417
	pdas	-3.570086	.9581123	-3.73	0.000	-5.447951	-1.69222
	tv	.2037479	.0995872	2.05	0.041	.0085604	.3989353
	consolas	.0418557	.2475111	0.17	0.866	-.4432571	.5269684
	ensinosecund	-.6309095	.2860314	-2.21	0.027	-1.191521	-.0702983
	ens_superior	-.7040345	.3572815	-1.97	0.049	-1.404293	-.0037756
	2000-4999	.075048	.3413792	0.22	0.826	-.5940429	.7441388
	5000-9999	.0327915	.3933717	0.08	0.934	-.7382029	.8037859
	10000-99999	.8799472	.2704146	3.25	0.001	.3499443	1.40995
	mais_100000	1.450524	.3784164	3.83	0.000	.7088411	2.192206
	norte	-.054096	.2635613	-0.21	0.837	-.5706666	.4624747
	raaores	-1.211085	.4315193	-2.81	0.005	-2.056847	-.3653223
	ramadeira	5.158735	.5149943	10.02	0.000	4.149365	6.168105
	internetfora	.8625762	.2652645	3.25	0.001	.3426673	1.382485
	_cons	4.839246	.7110201	6.81	0.000	3.445672	6.23282
-----							

4 (base outcome)

-----							
5	preoadsl	-.0141724	.03553	-0.40	0.690	-.0838099	.0554652
	preocabo	-.0149666	.0271979	-0.55	0.582	-.0682734	.0383403
	preoblml	-.0232107	.0244493	-0.95	0.342	-.0711305	.0247091
	idade2	.0000673	.0002041	0.33	0.742	-.0003328	.0004674
	rendb	1.061703	.699456	1.52	0.129	-.309206	2.432611
	rendc	1.966287	.6963642	2.82	0.005	.6014381	3.331136
	rendd	1.266603	.655697	1.93	0.053	-.0185395	2.551745
	crian_agreg	.0139299	.3752865	0.04	0.970	-.7216182	.749478
	agreg	-.0486859	.1905137	-0.26	0.798	-.4220858	.324714
	desktops	1.686823	.2869763	5.88	0.000	1.12436	2.249287
-----							



```

-----+-----
BL          |          (base)
-----+-----
alternativa equations
-----+-----
alternativa1 |
  _cons      |          (base)
-----+-----
alternativa2 |
  _cons      |  -.8848955   .3153491   -2.81   0.005   -1.502968   -.2668226
-----+-----
alternativa3 |
  _cons      | -1.042047   .3272907   -3.18   0.001   -1.683525   -.4005694
-----+-----
alternativa4 |
  _cons      | -.7746265   .3065521   -2.53   0.012   -1.375458   -.1737954
-----+-----
alternativa5 |
  _cons      | -1.396313   .3681997   -3.79   0.000   -2.117971   -.6746551
-----+-----
dissimilarity parameters
-----+-----
typez       |
  /NBL_tau   |          1
  /BL_tau    | -.2840016   .0563923
-----+-----
LR test for IIA (tau = 1):          chi2(1) =   369.67   Prob > chi2 = 0.0000
-----+-----

```

Table 18 – Marginal effects of price for ADSL (alternative=ADSL) - Model C

alternativa	Summary of dpdadsl		
	Mean	Std. Dev.	Freq.
1	-.0019115	.00170335	2965
2	-.01243078	.01192935	2965
3	.00804164	.00765202	2965
4	.00518459	.00587961	2965
5	.00111609	.00161965	2965
Total	6.836e-09	.00991847	14825

Dependent variable- 1: No BB, 2: ADSL; 3: Cable; 4: MBB; 5: MBB and FBB

Table 19 – Marginal effects of price for cable (alternative=cable) – Model C

alternativa	Summary of dpdcabo		
	Mean	Std. Dev.	Freq.
1	-.00375946	.00296353	2965
2	-.00439345	.00638019	2965
3	-.00383882	.00552312	2965
4	.00968418	.00923681	2965
5	.0023077	.0027996	2965
Total	2.844e-08	.00800494	14825

Dependent variable- 1: No BB, 2: ADSL; 3: Cable; 4: MBB; 5: MBB and FBB

Table 20 – Marginal effects of price for MBB (alternative=MBB) – Model C

alternativa	Summary of dpdblml		Freq.
	Mean	Std. Dev.	
1	-.00482574	.00360025	2965
2	.00079525	.00197074	2965
3	.00065639	.00195803	2965
4	.00031599	.00161364	2965
5	.0030582	.00383684	2965
Total	1.577e-08	.00378946	14825

Dependent variable- 1: No BB, 2: ADSL; 3: Cable; 4: MBB; 5: MBB and FBB

Table 21 – Model *Nested Logit D*

Tree:

typeR	N	alternativa	N	k
NBL	2965	---	1	2965 1743
SOBLF	5930	---	2	2965 391
		+ -	3	2965 514
BLM	5930	---	4	2965 257
		+ -	5	2965 60
			total	14825 2965

RUM-consistent nested logit regression                                 Number of obs                     =             14825  
Case variable: id                                                                     Number of cases                  =             2965

Alternative variable: alternativa                                             Alts per case: min =             5  
                                                                                                                   avg =                     5.0  
                                                                                                                   max =                     5

Log likelihood = -2243.583                                                     Wald chi2(27)                     =             966.66  
                                                                                                                   Prob > chi2                     =             0.0000

	transl	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
alternativa						
preo		.0058576	.0067446	0.87	0.385	-.0073616   .0190768

typeR equations

NBL	idade	.0353593	.0038268	9.24	0.000	.0278588   .0428597
	norte	1.311753	.1825152	7.19	0.000	.9540293   1.669476
	centro	.6834469	.1990759	3.43	0.001	.2932653   1.073628
	alentejo	.8888251	.2252422	3.95	0.000	.4473584   1.330292
	algarve	.7660627	.226287	3.39	0.001	.3225484   1.209577
	ramadeira	.2669332	.2073854	1.29	0.198	-.1395348   .6734011
	raaores	.6092004	.2239021	2.72	0.007	.1703603   1.04804
	desktops	-2.425882	.1203978	-20.15	0.000	-2.661857   -2.189906
	laptops	-1.538886	.1044325	-14.74	0.000	-1.74357   -1.334202
	agreg	-.0658448	.0522235	-1.26	0.207	-.1682011   .0365115
	rendb	-1.130714	.2116706	-5.34	0.000	-1.545581   -.7158476
	rendc	-.7113371	.1810973	-3.93	0.000	-1.066281   -.3563929
	rendd	-.1056597	.1556792	-0.68	0.497	-.4107852   .1994659

SOBLF (base)



BLM	idade	-.0291655	.0054213	-5.38	0.000	-.0397911	-.0185399
	norte	.5004495	.2149394	2.33	0.020	.0791761	.9217229
	centro	.2013176	.2429463	0.83	0.407	-.2748485	.6774836
	alentejo	.8712979	.2406894	3.62	0.000	.3995552	1.343041
	algarve	.8971889	.2585431	3.47	0.001	.3904538	1.403924
	ramadeira	-.5418279	.2856522	-1.90	0.058	-1.101696	.0180401
	raaores	-.3423758	.3010639	-1.14	0.255	-.9324502	.2476987
	desktops	-.8271898	.1313618	-6.30	0.000	-1.084654	-.5697253
	laptops	.4712549	.0893298	5.28	0.000	.2961717	.6463381
	agreg	-.1828878	.0667102	-2.74	0.006	-.3136373	-.0521383
	rendb	-.0729732	.2275206	-0.32	0.748	-.5189055	.3729591
	rendc	-.4833413	.2313641	-2.09	0.037	-.9368067	-.029876
	rendd	-.0148734	.2047269	-0.07	0.942	-.4161308	.386384

alternativa equations

alternativa1							
_cons		(base)					
alternativa2							
_cons		-.9790752	.3291108	-2.97	0.003	-1.624121	-.3340299
alternativa3							
_cons		-.9991688	.3392878	-2.94	0.003	-1.664161	-.3341769
alternativa4							
_cons		-.5168672	.411281	-1.26	0.209	-1.322963	.2892288
alternativa5							
_cons		-.611184	.4606895	-1.33	0.185	-1.514119	.2917508

dissimilarity parameters

typeR							
/NBL_tau		.9179802	102829.5			-201541.1	201543
/SOBLF_tau		-.0260559	.0301401			-.0851294	.0330176
/BLM_tau		-.0478548	.0568389			-.1592569	.0635474

LR test for IIA (tau = 1):                      chi2(3) =   305.29    Prob > chi2 = 0.0000

Table 22 –Model *Nested Logit E* (Base Only FBB)

Tree:						
types	N		alternativa	N		k
NBL	2965	---	1	2965		1743
SoBLF	5930	---	2	2965		391
		+-	3	2965		514
BLM	2965	---	4	2965		257
BLMeBLF	2965	---	5	2965		60
				total	14825	2965

RUM-consistent nested logit regression  
 Case variable: id

Number of obs = 14825  
 Number of cases = 2965

Alternative variable: alternativa

Alts per case: min = 5  
 avg = 5.0  
 max = 5

Log likelihood = -2213.0866

Wald chi2(40) = 1003.93  
 Prob > chi2 = 0.0000

---

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
alternativa						
preo	-.0094489	.0060713	-1.56	0.120	-.0213484	.0024507

---

typeS equations

---

NBL	idade2	.0003906	.0000446	8.76	0.000	.0003032	.000478
	norte	1.350182	.1842525	7.33	0.000	.9890539	1.711311
	centro	.6803478	.2006037	3.39	0.001	.2871716	1.073524
	alentejo	.9258412	.2275656	4.07	0.000	.4798207	1.371862
	algarve	.7904002	.2284439	3.46	0.001	.3426584	1.238142
	ramadeira	.2164267	.2089167	1.04	0.300	-.1930424	.6258959
	raaores	.6014024	.2249399	2.67	0.008	.1605283	1.042276
	desktops	-2.483254	.1221501	-20.33	0.000	-2.722664	-2.243844
	laptops	-1.579308	.1050744	-15.03	0.000	-1.78525	-1.373366
	agreg	-.0603558	.0525969	-1.15	0.251	-.1634438	.0427323
	rendb	-1.136718	.2119599	-5.36	0.000	-1.552151	-.7212838
	rendc	-.7456625	.1818475	-4.10	0.000	-1.102077	-.389248
	rendd	-.1235745	.1565011	-0.79	0.430	-.430311	.1831619

---

SoBLF (base)

---

BLM	idade2	-.000446	.0000832	-5.36	0.000	-.0006092	-.0002829
	norte	.8373899	.2379182	3.52	0.000	.3710788	1.303701
	centro	.2198263	.2822866	0.78	0.436	-.3334453	.7730979
	alentejo	1.178844	.2650328	4.45	0.000	.6593891	1.698298
	algarve	1.136293	.2813104	4.04	0.000	.584935	1.687652
	ramadeira	-.3652502	.3169028	-1.15	0.249	-.9863682	.2558679
	raaores	-.321163	.3553854	-0.90	0.366	-1.017706	.3753795
	desktops	-1.282769	.1523696	-8.42	0.000	-1.581408	-.9841302
	laptops	.267658	.1000311	2.68	0.007	.0716006	.4637154
	agreg	-.1779683	.0721143	-2.47	0.014	-.3193097	-.0366268
	rendb	-.1984403	.2446	-0.81	0.417	-.6778475	.280967
	rendc	-.6709462	.2498948	-2.68	0.007	-1.160731	-.1811613
	rendd	-.1039762	.214363	-0.49	0.628	-.52412	.3161676

---

BLMeBLF

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	idade2	-.0004072	.0001605	-2.54	0.011	-.0007218	-.0000926
	norte	-.951284	.4820378	-1.97	0.048	-1.896061	-.0065073
	centro	.0681033	.4028757	0.17	0.866	-.7215186	.8577253
	alentejo	-.1141735	.5007278	-0.23	0.820	-1.095582	.867235
	algarve	-.0406934	.560374	-0.07	0.942	-1.139006	1.057619
	ramadeira	-.9365518	.5870083	-1.60	0.111	-2.087067	.2139632
	raaores	-.240755	.4931726	-0.49	0.625	-1.207355	.7258455
	desktops	.4038083	.2169234	1.86	0.063	-.0213538	.8289705
	laptops	.9040886	.1440281	6.28	0.000	.6217988	1.186379
	agreg	-.1521931	.1429231	-1.06	0.287	-.4323173	.1279311
	rendb	1.034011	.5812492	1.78	0.075	-.105216	2.173239
	rendc	.8812591	.5961241	1.48	0.139	-.2871227	2.049641
	rendd	.8446326	.5810084	1.45	0.146	-.294123	1.983388

---

alternativa equations

alternativa1	(base)					
_cons						
alternativa2						
_cons	-1.422476	.2890154	-4.92	0.000	-1.988936	-.8560167
alternativa3						
_cons	-1.388794	.2988362	-4.65	0.000	-1.974502	-.803086
alternativa4						
_cons	-1.173827	.3852161	-3.05	0.002	-1.928837	-.4188176
alternativa5						
_cons	-4.793085	.8273848	-5.79	0.000	-6.414729	-3.17144

dissimilarity parameters

types					
/NBL_tau	1	340206.8		-666792.1	666794.1
/SoBLF_tau	.0416693	.026765		-.0107892	.0941277
/BLM_tau	1	434711		-852017	852019
/BLMeBLF_tau	1	382857.1		-750385	750387

LR test for IIA (tau = 1):                    chi2(4) =    270.21    Prob > chi2 = 0.0000