Delineating Markets for Bundles with Consumer Level Data: The Case of Triple-Play*

Pedro Pereira†       Tiago Ribeiro‡       João Vareda§
AdC                   Indera                   AdC

December 20, 2011

Abstract

We extend the SSNIP test for the case of bundles and then apply it to determine if triple-play bundles of telecommunications services are a relevant product market. We collected a unique invoice based consumer level data set from Portuguese telecommunications firms. With this data, we estimated a cross-nested logit demand model. The demand for triple-play products is elastic, with own-price elasticities for the larger firms ranging between 3.2 and 1.3, and a market own-price elasticity of 1.4. The three versions of the SSNIP test performed indicate that triple-play products are a relevant product market. (We also explore the implications of heterogeneity in the geographical distribution of triple-play products.) We discuss the robustness of the results.

Key Words: Bundles, Relevant Market, SSNIP Test, Triple-play, Consumer level data.

JEL Classification: D43, K21, L44, L96.

---

*The opinions expressed in this article reflect only the authors’ views, and in no way bind the institutions to which they are affiliated. We thank G. Werden for useful comments.
†AdC, Avenida de Berna, n° 19, 7º, 1050-037 Lisboa, Portugal. E-mail: pedro.br.pereira@gmail.com.
‡Indera - Estudos Económicos, Lda, Rua do Campo Alegre, 1346 – 01 4150-175 Porto, Portugal, e-mail: tiago.ribeiro@indera.pt
§AdC, Avenida de Berna, no 19, 7o, 1050-037 Lisboa, Portugal. E-mail: joao.vareda@concorrencia.pt.
1 Introduction

Triple-play bundles, i.e., bundles of fixed telephony, fixed broadband access to the internet and subscription television, are becoming very important for the telecommunications industry. An increasing number of households seem to prefer to consume these bundles, instead of consuming their components separately. In addition, telecommunications firms seem to increasingly base their marketing strategies on these products. The growing importance of triple-play products poses several problems for competition authorities and sectoral regulators. See Pereira and Vareda (2011). One of these problems, which is the focus of this article, is whether triple-play products constitute a relevant product market, in the sense of competition policy.

The definition of the relevant product market and the analysis of market power are a fundamental component of competition and regulatory analysis. To determine whether a firm’s conduct is anticompetitive, it is necessary to establish first that the firm has, or could obtain, significant market power. In turn, the notion of market power is defined in reference to a particular relevant market.\footnote{For abuse of dominance cases, in the EU, or monopolization cases in the USA, market definition helps to determine whether a firm has enough market power to engage in anticompetitive behavior. For merger cases, market definition helps to identify the firms that could constrain possible price increases by merging parties. For regulation cases, the evaluation of whether a wholesale market is competitive is made with reference to the associated retail market.}

Delineating relevant product markets for bundles raises several questions, which are absent for individual products. Next we discuss two of them. The first issue is that a relevant product market may consist of a set of products of the same type, e.g., of triple-play products, or of a set of products of different types, e.g., of triple-play products plus double-play and even single-play products. The second issue is that for a given set of individual services, several relevant product markets for different types of bundles or products may coexist. For example, triple-play products, double-play products of fixed voice and fixed broadband, and single-play products of fixed broadband may, simultaneously, be relevant product markets. In addition, dominance in one of these markets does not imply dominance in any of the others. A firm may be dominant in the market of fixed broadband products, but not in the market of triple-play products.\footnote{Another issue is that the substitutability between different types of products, say triple-play and double-play products, may be highly asymmetric. One type of product may exert a strong competitive pressure over another type of product, while the opposite may not be true.} These new problems posed by bundles are likely to render market delinetation, and the underlying competition analysis, considerably more complex.

In this article, we perform the small but significant and non-transitory increase in price (SSNIP) test to determine if triple-play products are a relevant product market. Conducting a SSNIP test for bundles poses unique challenges that are not present for markets of individual
ual products. One of the most important of these challenges is how to estimate coherently the demand for bundles and individual products. This problem can be overcome with a careful definition of the consumer’s choice alternatives, to which we refer as consumption alternatives. Once this is done, the consumer’s choice problem can be cast within the discrete choice framework and the demand for bundles and individual products can be estimated using standard techniques.

A consumption alternative is defined as a combination of: (i) the three triple-play services, whether in a bundle or not, (ii) the type of bundle, and (iii) the supplier of each of the services. This definition is important for two reasons. First, it allows framing bundle choices in standard discrete choice models. Second, it makes possible the use of existing survey data to estimate the aggregate share of each product.

We created a unique invoice based consumer level data set with information collected from six Portuguese telecommunications firms, which account for 99% of triple-play customers. Our data set consists of a cross-section with 3,243 observations for December 2009. This choice based data set was calibrated using information from publicly available survey data.

Our data set only includes the households’ choices, not their choice sets. To deal with the problem of the non-observability of the choice set we follow the approach of Train, McFadden, and Ben-Akiva (1987). For each choice in the sample, we imputed nine other products available in the household’s area of residence. This imputation process potentially creates an endogeneity problem that we accounted for by using a control function approach in the estimation process.

We estimated several discrete choice models, including a mixed logit model. The model on which we base our analysis is a Cross-Nested logit demand model, with a nest for the type of bundle and a nest for firms. The Cross-Nested logit model inherits the theoretical foundations of random utility theory from the GEV family, and has the Multinomial logit and the Nested logit models as special cases. This parsimonious specification captures different substitution patterns between different types of bundles and between the products of different firms, while maintaining a closed form probability formula. In particular, it allows modeling the clustering of products along several dimensions, which may form non-mutually exclusive groups in particular the form of bundling and the brand of the products. See, e.g., Bierlaire (2006), Fosgerau, McFadden, and Bierlaire (2010), Wen and Koppelman (2001) Koppelman and Sethi (2007) for a discussion of the properties of the cross-nested logit model and Small (1987) and Bresnahan, Stern, and Trajtenberg (1997) for previous applications of this class of models in economics.

The estimates of the Cross-Nested logit model show that the demand for triple-play products is elastic, with own-price elasticities ranging between 3.2 and 1.3 for the largest firms, and a market own-price elasticity of 1.4.
We perform three versions of the SSNIP test. The first version, the *Unilateral Price Increase*, involves calculating the change in profits caused by a 5% or 10% price increase in different subsets of products controlled by a hypothetical monopolist. This version is based on the 1997 notice of the EC on the definition of the relevant market. The second version, the *Equilibrium Price Increase*, involves simulating the equilibrium prices that would occur if an hypothetical monopolist controlled different sets of products. This version is based on the US DOJ and FTC 1984 Merger Guidelines. Finally, the third version is based on the recently introduced *Upward Pricing Pressure* test of Farrell and Shapiro (2010).

The three versions of the SSNIP test indicate that triple-play products are a relevant product market in Portugal.

*We also explore the implications of heterogeneity in the geographical distribution of triple-play products.*

We defer the discussion of policy implications to Section 9.


The second literature strand to which our article relates is the empirical literature on market delineation, represented by, e.g., Adams, Brevoort, and Kiser (2007), Björnerstedt and Verboven (2009), Breen and Verboven (2006), Capps, Dranove, and Satterthwaite (2003), Davis (2006), Ivaldi and Lörincz (2009), and van Reenen (2004). Ivaldi and Lörincz (2009) introduce the second version of the SSNIP test and discuss the relative merits of the first and second versions approaches. The remaining articles perform the first version of the SSNIP test.

To our knowledge this is the first time a SSNIP test is performed for triple-play products. Also to our knowledge, this is the first time that price elasticities of demand are estimated for triple-play products.

The rest of the article is organized as follows. Section 2 gives an overview of the Portuguese industry. Section 4 presents the model. Section 5 describes the data, the econometric implementation and presents the basic estimation results. Section 6 performs the SSNIP test. (Section 7 explores the implications of geographical heterogeneity in the distribution of products within the country.) Section 8 discusses the robustness of the results and Section 9 concludes.
2 The Portuguese Industry

This Section gives an overview of the Portuguese telecommunications industry.

Portugal Telecom (PT) is the telecommunication incumbent in Portugal. PT was privatized in 1996.

The industry was liberalized in 2000. Initially, entrants based their offers of fixed voice and broadband access services in the wholesale access to PT's cooper wire network. Later, as they obtained a substantial customer base, entrants resorted to the unbundled access of PT's local loop. This allowed them to differentiate their products from those of PT. After 2006 there was a large increase in the number of unbundled loops. As a consequence, many innovative products, for instance bundles, were introduced in the market. In the meanwhile, some entrants invested in their own infrastructures, increasing further their autonomy. In November 2007, ZON, a cable television firm, was spinned-off from PT. This was an important change in the Portuguese industry. ZON, using its cable television network, started to compete with PT, using its telephone network. Recently, PT initiated the deployment of a fiber-optic network, while ZON upgraded its cable network by installing DOCSIS 3.0.

The other relevant firms in the industry include Cabo Visão, Optimus, AR Telecom and Vodafone. Cabo Visão is a cable television firm that appeared in 1995. Optimus, originally a mobile telecommunications firm, entered the industry in 2000 using local loop unbundling, with access via xDSL. After 2008 it also started offering products over its fiber-optic network. AR Telecom began operations in 2005, basing its products mainly on FWA technology. Vodafone, originally a mobile telecommunications firm, entered also the fixed services business, basing its products on local loop unbundling, with access by xDSL.

In 2009, the penetration rate per inhabitants of fixed telephony was 40%. After a long period of decline the penetration rate of fixed telephony started to increase again, slightly. Also in 2009, the penetration rate per households of subscription television was 45%. The most representative technologies for providing this service was cable, 57.4%, and DTH, 23.2%. Finally, in 2009 the penetration rate per inhabitants of fixed broadband was 18%. Most of the fixed broadband access was made by xDSL, 57%, followed by cable modem, 40%.

Table 1 presents the markets shares of the largest telecommunications firms in 2008 and 2009 for each type of service.

[Table 1]

Telecommunications bundles were first offered in Portugal in 2004 through cable television networks. Afterwards, several firms launched similar products using fixed telephone networks, either through local loop unbundling or their own networks.

---

3 For more details see Pereira and Ribeiro (2011).
3 Relevant Product Market and SSNIP Test

This Section presents: (i) the definition of relevant product market, and (ii) the three versions of the SSNIP test.

3.1 Relevant Product Market

The relevant product market, in the sense of competition policy, is the smallest set of products with respect to which an hypothetical monopolist has substantial market power.

Both economic analysis and case law indicate the SSNIP test as the correct method of delineating the relevant market. See Werden (1993). Next we present the three versions of the SSNIP test we use. The first version, to which we refer as the unilateral price increase (UPI), is based on the 1997 notice of the EU Commission: "Commission Notice on the Definition of the Relevant Market for the Purposes of Community Competition Law" (Official Journal of the European Communities, C/372, 9.12, pg. 5.). The second version, to which we refer as the equilibrium price increase (EPI), is based on the 1984 U.S. Department of Justice and Federal Trade Commission Merger Guidelines. Finally, the third version, to which we refer as the upward pricing pressure (UPP) version is based on the recently introduced homonymous test of Farrell and Shapiro (2010).

3.2 Notation

Next, we introduce notation.

Suppose that there are \( i = 1, ..., N \) products candidates to belong to the relevant product market. Denote by \( p_i \), the price of product \( i \), and let \( \mathbf{p} := (p_1, \ldots, p_N)' \). Denote by \( y_i = D_i(p) \), the demand for product \( i \), and denote by \( c_i \), the constant marginal cost of product \( i \). Let \( \mathbf{y} := (y_1, ..., y_N)' \) and \( \mathbf{c} := (c_1, ..., c_N)' \).

The profit of product \( i \) is:

\[
\pi_i = (p_i - c_i) D_i(p).
\]

The profit of firm \( f = 1, ..., F \), which controls the set of products \( \Omega_f \) is:

\[
\Pi_f = \sum_{i \in \Omega_f} (p_i - c_i) D_i(p).
\]

\( ^* \) Market power is the ability to profitably raise price above marginal cost.

The first-order condition for profit maximization with respect to prices for firm \( f \) is:

\[
\frac{\partial \Pi_f}{\partial p_i} = D_i(p) + \sum_{j=1}^{N} \gamma_{ij} \frac{\partial D_j(p)}{\partial p_i} (p_j - c_j) = 0. \tag{1}
\]

where \( \gamma_{ij} \) is a parameter such that \( \gamma_{ij} = 1 \), if products \( i \) and \( j \) are controlled by firm \( f \), and \( \gamma_{ij} = 0 \) otherwise.

Let matrices \( \Gamma \) and \( \Phi \) consist of the elements \( \Gamma_{ij} := \gamma_{ij} \) and \( \Phi_{ij} := \frac{\partial D_j(p)}{\partial p_i} \), respectively. Matrix \( \Gamma \) represents the market structure, and matrix \( \Phi \) consists of the demand estimates. Denote by \( \Gamma^c \), the matrix that reflects the current property structure. Denote by \( A \circ B \) the element by element product of matrices \( A \) and \( B \), i.e., the Hadamard product. The system that defines the equilibrium can be written as:

\[
y + (\Gamma \circ \Phi)(p - c) = 0. \tag{2}
\]

### 3.3 UPI Version of the SSNIP Test

"The question to be answered is whether the parties’ customers would switch to readily available substitutes or to suppliers located elsewhere in response to a hypothetical small (in the range 5% to 10%), but permanent relative price increase in the products and areas being considered. If substitution were enough to make the price increase unprofitable because of the resulting loss of sales, additional substitutes and areas are included in the relevant market. This would be done until the set of products and geographical areas is such that small, permanent increases in relative prices would be profitable."  


This version of the SSNIP test lays the weight of the product market definition test on the possibility of a hypothetical monopolist unilaterally raising the price of the products it controls by 5% or 10%.

Suppose that initially each product is controlled by a different firm, and that the initial equilibrium prices are \( p_1^0, \ldots, p_N^0 \). Let \( p^0 := (p_1^0, \ldots, p_N^0) \). Suppose now that products \( \Omega_m = \{1, 2\} \) are controlled by a hypothetical monopolist. Denote by \( p_m^0 = (p_1^0, p_2^0) \), the vector of the initial equilibrium values of the prices of products \( \Omega_m \), and denote by \( p_m^0 \), the vector of the initial equilibrium values of the remaining products. Suppose now that the hypothetical monopolist raises its prices by 5% or 10%, which then take values \( p_m^1 := (p_1^1, p_2^1) \).

---

6We assume that a Nash equilibrium exists for strictly positive prices. Caplin and Nalebuff (1991) proved existence in a general discrete choice model, with single product firms. Anderson and de Palma (1992) proved existence for the nested logit model with symmetric multiproduct firms.
The profit variation for the hypothetical monopolist caused by the increase in prices $p^1_m$ is:

$$\Delta \Pi_m = \sum_{i \in \Omega_m} \left[ (p^1_i - c_i)D_i(p^1_m, p^0_m) - (p^0_i - c_i)D_i(p^0) \right].$$

If the profit variation of the hypothetical monopolist is positive, $\Delta \Pi_m > 0$, products \{1, 2\} constitute a relevant product market; otherwise the exercise should be repeated with the hypothetical monopolist controlling a larger set of products, namely \{1, 2, 3\}.\footnote{Since we estimate marginal costs assuming that the initially market is in equilibrium, it makes no sense to start the SSNIP test with the hypothetical monopolist controlling only one product, since, by definition of a Nash equilibrium, any price variation would lead to a profit reduction.}

The \textit{relevant product market} is the smallest set of products whose price could be increased profitably by a hypothetical monopolist, i.e., the smallest set $\Omega_m$ for which $\Delta \Pi_m > 0$.

Next we discuss the information required to implement this version of the test.\footnote{For more details on the procedure see, e.g., Nevo (2000) or Pereira and Ribeiro (2011).}

Current prices, $p$, and current quantities, $y$, are observed.

Demand functions $D_i(\cdot)$ are described in Section \ref{sec:procedure}. The estimates of the parameters of the demand function, obtained using the data described in \ref{sec:estimation}, are presented in section \ref{sec:estimation}.

Marginal costs $c$ are estimated as follows. Assume that the current observed scenario is one of equilibrium. Substitute the current prices, $p$, the estimates of the demand function, $\Phi$, in the system of equations \ref{eq:system}. Let $\Gamma = \Gamma^0$. Afterwards, solve the system in order to $c$.

Initial prices, $p^0$, are estimated as follows. Substitute the estimates of the parameters of demand function, $\Phi$, and marginal costs, $c$, in the system of equations \ref{eq:system}. Let $\Gamma = I_N$. Afterwards, solve the system in order to prices $p^0$.

\subsection*{3.4 EPI Version of the SSNIP Test}

"Formally, a market is a product or group of products and a geographic area in which it is sold such that a hypothetical, profit-maximizing firm, not subject to price regulation, that was the only present and future seller of those products in that area would impose a small but significant and non-transitory increase in price above prevailing or likely future levels." (1984 Merger Guidelines of the U.S. Department of Justice.)

This version of the SSNIP test lays the weight of the product market definition test on the possibility of, in \textit{equilibrium}, a hypothetical monopolist increasing the prices of the products it controls.
Suppose that initially each product is controlled by a different firm, and that the initial equilibrium prices are $p_0^1, \ldots, p_0^N$. Let $\mathbf{p}^0 := (p_0^1, \ldots, p_0^N)$. Suppose now that products $\Omega_m = \{1, 2\}$ are controlled by a hypothetical monopolist, and that the equilibrium prices of this new market are $p_1^1, \ldots, p_1^N$. Let $\mathbf{p}^1 := (p_1^1, \ldots, p_1^N)$.

If the average of prices $(p_1^1, p_1^2)$ is higher than the average of prices $(p_0^1, p_0^2)$ by at least 5\% or 10\%, products $\{1, 2\}$ constitute a relevant product market; otherwise the exercise should be repeated with the hypothetical monopolist controlling a larger set of products, namely $\{1, 2, 3\}$.

The **relevant product market** is the smallest set of products whose prices, in equilibrium are at least 5\% or 10\% higher, if controlled by a hypothetical monopolist, than if controlled by separate firms.

Both the initial equilibrium prices $\mathbf{p}^0$ and the new equilibrium prices $\mathbf{p}^1$ are obtained from the system of equations (1), through the process described in Section 3.3, by adjusting appropriately matrix $\Gamma$ to reflect the different property structures.

### 3.5 Upward Pricing Pressure

This version of the SSNIP test can be interpreted as an intermediate step to calculating the full equilibrium described in the previous section.

Suppose that initially all products are controlled by different firms, and that the initial equilibrium prices are $p_0^1, \ldots, p_0^i$. Suppose now that products $\Omega_m = \{1, 2\}$ are controlled by a hypothetical monopolist. However, products $\Omega_m$ belong to separate divisions of the hypothetical monopolist, division 1 and 2, respectively. Each division chooses its prices to maximize only its divisional profit, therefore ignoring the impact of its decision on the other division’s profit. Management of the hypothetical monopolist wants to set prices that maximize joint profits, which current prices do not, and wants to do so in a decentralized manner. One first step to achieve this would be to impose a tax, $\tau_1$, on division 1’s quantities that internalizes the cannibalization on division 2’s profits. Such a tax would equate the first-order condition of division 1’s profits with respect to $p_1$ to the first-order conditions of joint profits with respect to $p_1$:

$$D_1(\mathbf{p}) + \frac{\partial D_1(\mathbf{p})}{\partial p_1}(p_1 - c_1 - \tau_1) = D_1(\mathbf{p}) + \sum_{j=1,2} \frac{\partial D_j(\mathbf{p})}{\partial p_1}(p_j - c_j),$$

from which we obtain:

$$\tau_1 = -\frac{\frac{\partial D_2(\mathbf{p})}{\partial p_1}}{\frac{\partial D_1(\mathbf{p})}{\partial p_1}}(p_2 - c_2).$$

A symmetric tax $\tau_2$ would be imposed on division 2’s quantity. Note that $\frac{\partial D_j(\mathbf{p})}{\partial p_i} / \frac{\partial D_i(\mathbf{p})}{\partial p_i}$ is the diversion ratio.
Taxes $\tau_i$ can be interpreted as the upward pricing pressure on price $i$ induced by the joint optimization of profits by the hypothetical monopolist. Values $(\tau_1, \tau_2)$ are an approximation of the average equilibrium variation of prices $(p_1, p_2)$ of section 3.4, and the same exercise detailed there can be done with this approximation.

4 Econometric Model

This Section describes the demand model.

4.1 Utility Function

We propose the class of Generalized Extreme Value (GEV) models to characterize demand. GEV models characterize the demand of individuals for products of a discrete nature, and consequently, are particularly suited to the type of products under analysis, as well to the type of data collected. The multinomial logit (ML), the nested logit (NL) and the cross-nested logit (CNL) are elements of this class. In particular, the models of the CNL class are flexible enough to encompass any consumer choices consistent with the assumption of random utility maximization.

Household $h = 1, \ldots, H$ derives from consumption alternative $s = 1, \ldots, S$ utility:

$$U_{hs}(p_{hs}, x_{hs}, \theta) = V_{hs}(p_s, x_{hs}, \theta) + \varepsilon_{hs},$$

where $p_{hs}$ is the price of product $s$ for household $h$, $x_{hs}$ is a $T \times 1$ vector of characteristics of consumption alternative $s$ for household $h$ other than price, $\theta$ is the vector of coefficients to be estimated, and $\varepsilon_{hs}$ is a non-observed utility component of consumption alternative $s$ for household $h$. We assume additionally that:

$$V_{hs}(p_{hs}, x_{hs}, \theta) := p_{hs} \alpha + \sum_{t=1}^{T} x_{hsj} \beta_t,$$

where $\alpha$ is the price coefficient and parameters $\beta_t$ translate the consumer’s valuation for characteristics of consumption alternatives other than price. Let $\beta := (\beta_1, \ldots, \beta_T)$ and $\theta := (\alpha, \beta)$. Whenever possible, index $h$ will be omitted.

4.2 Choice Probabilities

A consumer chooses consumption alternative $s$ which generates the maximum utility level $U_s$, i.e., $U_s > U_j$, for all $j \neq s$. The probability of a consumer choosing consumption

---

9See McFadden (1978).
11See Fosgerau, McFadden, and Bierlaire (2010).
alternative $s$ depends on the joint distribution of components $\varepsilon_s$. Different joint distributions of $\varepsilon_s$ lead to different demand models. Let $z_s := \exp(V_s)$. The GEV class of demand models can be characterized by probability generating functions $G(z_1, \ldots, z_S)$, and the probability of consumption alternative $s$ from set $C$ being chosen is given by:

$$P(s|C) = \frac{z_s G_s(z_1, \ldots, z_S)}{G(z_1, \ldots, z_S)},$$

where $G_s := \frac{\partial G}{\partial z_s}$, and $S$ is the number of alternatives of set $C$. Functions $G$ must obey certain properties, namely homogeneity of degree 1.\footnote{See, e.g., McFadden (1978), for the complete characterization of function $G$.} Hence, the expression above can be written as:

$$P(s|C) = \frac{z_s G_s(z_1, \ldots, z_S)}{\sum_t z_t G_t(z_1, \ldots, z_S)};$$

or:

$$P(s|C) = \exp(V_s + \ln G_s) \sum_t \exp(V_t + \ln G_t).$$

Different choices of $G(\cdot)$ lead to different demand models.

The ML model follows from:

$$G(z_1, \ldots, z_S) = \sum_{s=1}^S z_s.$$

Let $B_w$, with $w = 1, \ldots, W$, be mutually exclusive subsets which form a partition of $C$. The NL model follows from:

$$G(z_1, \ldots, z_S) = \sum_{w=1}^W \left( \sum_{s \in B_w} z_s^{1/\lambda_w} \right)^{\lambda_w}.$$

Let subsets $B_w$ not be necessarily mutually exclusive. The CNL model follows from:

$$G(z_1, \ldots, z_S) = \sum_{w=1}^W \left( \sum_{s \in B_w} \delta_{ms} z_s^{1/\lambda_w} \right)^{\lambda_w}.$$

We let constants $\delta$ be normalized to 1.

Applying the definition of $P(s|C)$ with the function $G$ defined for the CNL, and making use of the normalization, one obtains:

$$P(s|C) = \sum_{w=1}^W 1_{s \in B_w} \frac{\exp(V_s/\lambda_w)}{\sum_{k \in B_w} \exp(V_k/\lambda_w)} \frac{\left[ \sum_{k \in B_w} \exp(V_k/\lambda_w) \right]^{\lambda_w}}{\sum_{m=1}^W \left[ \sum_{k \in B_m} \exp(V_k/\lambda_m) \right]^{\lambda_m}}.$$

Let:

$$P(s|B_w) := 1_{s \in B_w} \frac{\exp(V_s/\lambda_w)}{\sum_{k \in B_w} \exp(V_k/\lambda_w)},$$

Preliminary version – December 20, 2011
and
\[ P(B_w|C) := \frac{\left[ \sum_{k \in B_w} \exp(V_k / \lambda_w) \right]^{\lambda_w}}{\sum_{m=1}^{W} \left[ \sum_{k \in B_m} \exp(V_k / \lambda_m) \right]^{\lambda_m}}. \]

Then, one has the simple interpretation of:
\[ P(s|C) = \sum_{w=1}^{W} P(s|B_w) P(B_w|C). \]

An alternative way of modeling the choice probabilities, allowing for different substitution patterns between the consumption alternatives under analysis, is to consider that the unobserved component of the utility function has a distribution which is a mixture between an extreme value type I error term and a multivariate Gaussian, yielding the mixed logit (ML) model. In this case, errors \( \varepsilon_h \) are independently and identically distributed across households and consumption alternatives, and follows an extreme value type I distribution. In addition:
\[ \theta_h := \theta + L \theta \zeta_h, \]
where \( L \theta \) is a lower triangular matrix of the appropriate dimension, and \( \zeta_h \) follows the distribution \( \mathcal{N}(0, I) \), i.e., \( \theta_h \) is normally distributed with mean \( \theta \) and variance-covariance \( L \theta L' \). We restrict \( L \theta \) to be diagonal. Ignoring the subscript \( h \) the probability of consumption alternative \( s \) from set \( C \) being chosen is given by:
\[ P(s|C) = \int \frac{\exp(V_s(\zeta))}{\sum_t \exp(V_t(\zeta))} \Phi(\zeta) d\zeta. \]

### 4.3 Price-Elasticities of Demand

For the case of the CNL model, the elasticity of product \( i \) with respect to the price of product \( j \) is:
\[ \varepsilon_{ij} = \begin{cases} \alpha_p_i \left[ 1 - P(i|C) + \sum_{w=1}^{W} \omega_{iw} \frac{1-\lambda_w}{\lambda_w} (1 - P(i|B_w)) \right] & j = i \\ -\alpha_p_j \left[ P(j|C) + \sum_{w=1}^{W} \omega_{iw} \frac{1-\lambda_w}{\lambda_w} P(j|B_w) \right] & j \neq i, \end{cases} \quad (5) \]
with
\[ \omega_{iw} = \frac{P(i|B_w) P(B_w|C)}{P(i|C)}. \]

Note that by definition: \( \sum_{w=1}^{W} \omega_{iw} = 1. \)

The expression for \( \varepsilon_{ij} \) for the ML and NL models can be obtain as particular cases of (5). For the NL model, \( \omega_{iw} = 0 \) if \( i \) does not belong to \( B_w \). Since sets \( B_w \) are mutually exclusive, \( \sum_{w=1}^{W} \omega_{iw} \) only has one strictly positive element. For the ML model, we have in addition that \( \lambda_w = 1 \) and \( B_w = C \).
5 Econometric Implementation

In this Section we: (i) describe our data set, and (ii) present the estimates of the demand model.

5.1 Data

Next we describe how we obtained our data set and how we constructed the sample used in the demand estimation.

5.1.1 Data Request

To conduct our analysis, we requested data from six Portuguese electronic communication firms, which accounted in December 2009 for 99% of triple-play customers. For confidentiality reasons, we will refer to these firms as $f_1, ..., f_6$.

A client is a holder of a service contract. The services under analysis are: (i) fixed telephony, (ii) subscription television, and (iii) broadband access to the Internet. A double-play bundle is a package that includes two of these three services. A triple-play bundle is a package that includes the three services.\(^{13}\)

The information requested corresponded to a sample of 1,000 observations from each of the 3 following universes:

**Universe 1**: clients that, in the last quarter of 2009, had a contract for the supply of at least one of three services;

**Universe 2**: clients that, in the last quarter of 2009, only had a contract for the supply of triple-play bundles;

**Universe 3**: clients that, in the last quarter of 2009, only had a contract for the supply of double-play bundles.

The information requested consisted of data about: (i) the contract, (ii) the product, and (iii) the client. The characteristics of the contract requested are: the monthly fee, discounts or joining offers, the commencement date of the contract, and the characteristics of the product. The characteristics of the product requested are: the brand name, the number of normal and premium television channels and the possibility of access to video-on-demand, if the product included subscription television, bandwidth, traffic limits, number of E-mail accounts and the possibility of mobile broadband, if the product included fixed broadband.

\(^{13}\)To overcome any misunderstanding by the firms of what constitutes a bundle of services, we defined a bundle as a product that includes two or more services, if they are sold jointly: (i) with a discount, or (ii) through one invoice.
access to the Internet, and the tariff plan for fixed telephony. The characteristics of the client requested are: age, length of the contract and residential postal code.

We also requested billing information for the last quarter of 2009, with full detail of invoices, including the fixed monthly fee and variable components, e.g., movie rentals, channel rentals, internet traffic above contracted limits, expenditure on telephone calls and minutes of conversation.

Finally, we requested firms to indicate, for Universe 1, the total number of clients for each product offered, and the geographical availability of each product.

In addition, we also requested information from the sectoral regulator, ICP-ANA COM, drawn from the survey “Inquérito ao consumo dos serviços de comunicações electrónicas - População residencial – Dezembro de 2009”, from, hereon “Inquérito ao consumo”, which characterizes the typical national consumer of electronic communication services.

5.1.2 Consumption Alternatives

We define a consumption alternative as a combination of: (i) fixed telephony (FV), (ii) subscription television (TV), (iii) fixed broadband access to the internet (BB), (iv) form of acquisition, in a bundle or separately, and (v) supplier.

Table 2 details the possible combinations of: services, forms of acquisition and firms.

|Table 2|

There are eight possible combinations of services, six possible forms of acquisition, and seven possible suppliers, with one, $f_0$, corresponding to the inexistence of a supplier. There are 475 possible combinations of: services, bundles and supplier.\(^{14}\) Since some firms do not supply certain combinations of services and bundles, the total combinations effectively available is 76. Each one of these combinations is treated as a distinct consumption alternative, i.e., $S = 76$.

Table 3 illustrates some possible combinations.

|Table 3|

Note that the concept of consumption alternative does not coincide with the concept of a product offered by a firm. A product offered by a firm may be present in several consumption alternatives. E.g., fixed telephony offered by a given firm is typically present

\(^{14}\)Of the total of combinations services $\times$ bundles $\times$ FV supplier $\times$ TV supplier $\times$ BB supplier $= 8 \times 6 \times 7 \times 7 = 16464$ we eliminated the combinations: (i) without supplier and with product; (ii) with supplier and without product; (iii) double-play with different suppliers for the double-play services, and (iv) triple-play with different suppliers for the triple-play services.

Preliminary version – December 20, 2011
is several consumption alternatives. In fact, a product offered by a firm is present only in one consumption alternative in the case of triple-play bundles. With this definition of the consumption alternative, the consumer’s choice problem can be cast within the discrete choice framework, and standard techniques can be applied to estimate the demand for bundles and individual products coherently.

5.1.3 Market Distribution of Services

The information from *Inquérito ao consumo* allowed us to relate the electronic communication services consumed by households to the way they are acquired, and to obtain the percentage of households that do not consume any of these services.

Table 4 presents the distribution of services by type of bundle in 2009.

| Table 4 |

The three services were consumed by 23.5% of households, of which 1.8% consumed the three services separately; 3.4% consumed the fixed telephony and fixed broadband access services in a bundle and subscription television separately; 11% consumed fixed telephony services separately and the other services in a bundle; and 17.2% consumed triple-play bundles.

This information, and the data requested from firms, allowed us to obtain the distributions of the services per household and the market shares per firm for each service, shown in Table 5 and for each type of bundle, shown in Table 6.

| Table 5 |

| Table 6 |

Regarding the distribution of each service per household, fixed telephony was consumed by 55.4% of households, while subscription television was consumed by 51.6%, and fixed broadband access services was consumed by 37.6%.

In terms of triple-play bundles, and according to the information obtained from the firms, firm $f_2$ had the largest market share of [40-50%]. The second largest supplier of triple-play products was firm $f_1$ with a market share of [30-40%], followed by firm $f_3$ with [10-20%].

The percentage of households that consumed double-play bundles lied between 5.8% and 7.6%. Regarding market shares the situation is very heterogeneous. While for the bundle of fixed telephony and subscription television, firm $f_1$ was the largest with a market share of [40-50%], for the bundle of subscription television and fixed broadband access to the internet, firm $f_2$ was the largest with a market share of [50-60%]. Finally, for the bundle of fixed telephony and fixed broadband access to the internet, firm $f_4$ was the largest with a market share of [80-90%].
The data on billing requested from the firms also allowed us to compute a price index by comparing the average revenue of each individual service and bundle with the average revenue of all products in our sample. Figure 1 presents the average billing per service.

The triple-play bundle is the most expensive product, with an average price which is twice the average price of the products in our sample. The double-play bundles of fixed telephony and fixed broadband access to the internet are substantially cheaper, although their average price is 60% higher than the average price of all products in our sample. The remaining products have average prices below the average price for all products in our sample.

5.1.4 Product Market Shares

In Section 5.1.3, we present the nation-wide share of each consumption alternative defined in section 5.1.2, which is estimated from the aggregate information obtained from the firms, namely the total number of clients of each product, and from Inquérito ao consumo. Moreover, the data from Inquérito ao consumo, shown in Table 4, allow us to relate the services consumed to the way they are acquired, and to obtain the percentage of households that do not consume any of these services. Finally, the aggregate data we obtained from the firms allowed us to determine the shares by firm for each service separately, shown in Table 5, and by type of bundle, shown in Table 6.

The consumption alternatives defined in Section 5.1.2 are the combination of five discrete variables. The share of each consumption alternative is given by the joint distribution of these variables. Tables 4, 5, and 6 have the marginal distributions of the five variables that define the consumption alternatives. The joint distribution of the five variables that define a consumption alternative is computed from the partial information contained in Tables 4, 5, and 6 through a maximum likelihood procedure. This estimation procedure is standard in the analysis of multivariate discrete distributions with partial data, and the computation can be made, e.g., using the "Iterative Proportional Fitting" algorithm.

5.2 Choice Sets

With the data obtained from the firms, described in section 5.1.1, we built a sample representative of the weight of each consumption alternative in the universe, according to the weights described and computed in section 5.1.4. An observation of this sample represents a consumer’s choice.

---

15 See Haberman (1972) and Bishop, Fienberg, and Holland (1975).
For each observation in the sample, we randomly imputed nine other consumption alternatives from the area of residence of the consumer observed in the sample. Hence, for each consumer, we created a choice set with ten alternatives. The final data set consists of the choices of 3,243 individuals, and each individual has a set of ten alternative choices.

The imputation process of the non-observed choices creates, potentially, an endogeneity problem. The prices of the non-chosen alternatives by a given consumer are imputed from observed choices made by other consumers in the sample. Some prices, e.g., involving discounts, may depend on the consumers’ characteristics. As a consequence, the imputed prices might differ from those that would be observed, and the difference might depend on the characteristics of the consumers. To eliminate from the price effect this additional variability among individuals, induced by the imputation mechanism, we included a control variable. This procedure corresponds to the application of the instrumental variables approach in non-linear models, through a control function approach. The instruments used were: (i) dummy variables for consumption alternatives, in accordance with the consumption alternative description of section 5.1.2, (ii) dummy variables for region at the NUTS3 level, (iii) interactions between dummy variables for region and consumption alternative, whenever the number of variables allowed it, (iv) length of the contract, and (v) characteristics of the consumption alternative described above and present on the utility function.

### 5.3 Demand Estimates

Using the data described in Section 5.1 we estimated the four models described in Section 4.1: the ML, the NL, the CNL, and the ML.

The variables included in vector $\mathbf{x}$ are: (i) dummy variables for the type of bundle, namely double-play and triple-play, (ii) dummy variables for firms, (iii) characteristics of the services contained in each consumption alternative, namely, number of television channels and bandwidth, (iv) dummy variable for fixed telephony, and (v) price. The number of television channels varies between 20 and 143, and the bandwidth varies between 1 and 100 Mbps.

Table 7 reports the results for the ML, the NL and the CNL models.

$\text{Table 7}$

The estimate of the coefficient of the control variable for exogeneity is statistically significant. This justifies the correction performed by the control function.

---

16Our data does not include the consumers’ choice sets, just the consumers’ choices. The procedure used to construct choice sets is similar to the one used by Train, McFadden, and Ben-Akiva (1987).

17In the context of discrete choice models see, e.g., Petrin and Train (2010). More generally see Powell and Blundell (2003)
The estimate of the coefficient of the price variable is negative and statistically significant, which implies negative sloping demand curves, in accordance with economic theory.

The price coefficient is fundamental to determine the price-elasticities of demand. The way this coefficient is reflected in the price-elasticity of demand helps the interpretation of its magnitude. The graphics in Figure 2 illustrate the distributions of the price-elasticity of demand of triple-play products per supplier.

Each consumption alternative belonging to a different bundle of single-play, double-play and triple-play, was included in a different bundle nest. The purpose of this procedure was to capture the possible existence of different market segments where the substitutability among consumption alternative of the same segment is higher than the substitutability of consumption alternative of different segments. The estimate of the coefficient of the double-play nest is not significantly different from 1. Consequently, its value was fixed at 1. There is a separate nest for the inexistence of any consumption alternative, whose coefficient is normalized to 1.

We also considered firm nests. We present the estimates of the coefficients of firm nests for only three firms: \( f_1 \), \( f_2 \) and \( f_3 \). For the other firms, the coefficients of the firm nests were fixed at 1, because their estimates were not significantly different from that value.

The estimates of the coefficients of the nests we present are all significantly different from 1. This implies the rejection of the multinomial logit model. Since the estimates are all smaller than 1, they are consistent with economic theory. In addition, the estimates of the coefficients of the firm nests are significantly different from 1. This implies the rejection of the nested logit model where only bundle nests are considered. Similarly for the nested logit model where only firm nests are considered.

For comparison purposes we also estimated a ML model. Table 8 presents the estimates.

The ML presented can be considered an alternative approximation to a flexible substitution pattern to the one offered by the cross-nested. The random terms associated with the dummy variables that define the nests can be seen as generating correlation between the products within that nest, therefore a similar effect to the one that occurs in nested and cross-nested models. The ML model presented has additional random terms associated to other characteristics, namely price. The small standard error associated with the standard deviation of the price coefficient suggests that there is heterogeneity in price sensitivity.

---

18 The ML was estimated using maximum simulated likelihood with Halton draws. In the class of ML models, the estimation of a random subset of alternatives, without further correction, does not yield consistent estimates, in contrast with the class of GEV models.
amongst consumers. Nevertheless, this model despite having more coefficients has a lower likelihood than the CNL model of Table 7.

As a consequence of the previous discussion, we selected the CNL model to conduct our analysis.\textsuperscript{19}

5.4 Elasticities

Table 9 presents the price elasticities of demand, from the point of view of the firm, i.e., not of each consumption alternative with respect to its price, but of each product in isolation, based on estimates of the CNL model of Table 7.

[Table 9]

The demand for triple-play products is elastic, with own-price elasticities for the larger firms ranging between 3.2 and 1.3.

Table 10 presents the aggregate price elasticities of demand.

[Table 10]

The market demand for triple-play is also elastic, but not much, with a market own-price elasticity of 1.4. The demand for triple-play is less sensitive to the prices of the other products considered, than the demand of those other products is sensitive to the price of triple-play.

6 SSNIP Test

This Section uses the demand estimates of Section 5.3 to compute the UPI, EPI, and UPP versions of the SSNIP test, according to the methods defined in Section 3.

6.1 UPI Version

Next, we present the profit variations that would occur if an hypothetical monopolist increased the prices of its products by 5\% and by 10\%. This corresponds to the UPI version of the SSNIP test. Table 11 presents the results.

[Table 11]

\textsuperscript{19} The model and the specification presented are the result of a selection procedure that considered several demand models, several explanatory variables, and several instruments.
Each line in Table 11 corresponds to a set of products controlled by an hypothetical monopolist. E.g., sign "f_1 + f_2" refers to a hypothetical monopolist that controls the triple-play bundles of firms f_1 and f_2. Columns labeled Δπ_5 and Δπ_10 indicate, whether a price increase of 5% and 10%, respectively, would increase or decrease the hypothetical monopolist's profits.²⁰

For all sets of triple-play products reported in Table 11 price increases of 5% and 10% are profitable.

6.2 EPI Version

Next, we present the percentage price variations that would occur as one moves from a market structure where each firm controls one product, to market structures where the hypothetical monopolist controls an increasing number of products. This corresponds to the EPI version of the SSNIP test. The results are presented in Table 11.

Once again, each line corresponds to a different set of products. Column labelled Δp / P (s) indicates the equilibrium price variation.

An hypothetical monopolist that controlled all triple-play products, would, in equilibrium, increase, on average, the price of those products by 12.8%, compared to the case where each triple-play product, as well as the other products, is controlled by a different firm.

6.3 UPP Version

Next we present the UPP version of the SSNIP test. The results are presented in Table 11.

Once again, each line corresponds to a different set of products. The column labeled Δp / P (u) indicates the UPP price variation.

An hypothetical monopolist that controlled all triple-play products would, in equilibrium, increase the prices of those products by 16.5%, compared to the case where each triple-play product, as well as the other products, is controlled by a different firm.

6.4 Conclusion

According to all three versions of the SSNIP test performed, triple-play products are a relevant market in the sense of competition policy.

²⁰An upward arrow indicates a profit increase and a downward arrow indicates a profit decrease.
7 Geographical Analysis

TBC

8 Robustness

This section discusses the robustness of the results of the SSNIP test with respect to:
(i) the specification of the model, (ii) uncertainty about the parameter estimates, (iii) the
tenetration rate of triple-play, and (iv) portfolio effects.

8.1 Demand Model

The value of the estimated price and profit variations change with the various demand
models we estimated, namely the ML and the NL with bundle nests. However, the results of
the SSNIP test do not change qualitatively. E.g., NL models with nests for bundles, which
translate the notion that the market is differentiated at this level, lead to equilibrium price
variations of an hypothetical monopolist that are always larger than those of models where
this characteristic is absent.

8.2 Uncertainty about the Estimates

We analyzed the sensitivity of the results of the SSNIP test with respect to the uncer-
tainty implicit in the estimates of the demand model. For this purpose, we built confidence
intervals for the price variation by generating 100 vectors of parameters of the demand
function with a joint normal distribution with an average equal to the estimate of the pa-
rameters and a variance-covariance equal to the estimated variance-covariance. For each of
these parameter vectors we computed the price variation caused by a hypothetical monopo-
list. From this exercise we obtained a 95% confidence interval of $+/-1.2\%$ of the estimated
value for the price variation, i.e., a price increase of 12.8% that a hypothetical monopolist
that controlled all triple-play products could obtain, in equilibrium, has a 95% confidence
interval of $[11.6\%, 14\%]$.

8.3 Penetration Rate of Triple-Play

We analyzed the sensitivity of the results of the SSNIP test with respect to the penen-
tration rate of triple-play per household.\footnote{See table 6} This exercise consisted of reducing the market share
of triple-play implicit in the estimated demand model, through a decrease in the estimate

\footnote{See table 6}
of the triple-play coefficient, and afterwards repeating the SSNIP test. We simulated the reduction of the penetration rate of triple-play up to the point where a 10% price increase became unprofitable for a hypothetical monopolist controlling all triple-play products. That point was reached with a penetration rate of 7.5%. This reduction in the penetration rate of triple-play corresponds to a particular way of calibrating the model for periods where the penetration rate was different from that observed in the period under analysis, and assumes that the other parameters that characterize consumers’ preferences remain unchanged. For values of the penetration rate higher than 7.5% our conclusions hold.

Assume that the penetration rate has increased over time. Taking this exercise as an approximation to a calibration that reflects the firms’ penetration rates in a given period, one may conclude that the results of the SSNIP test are valid for periods prior to those of our sample, as long as in those periods the penetration rate was no smaller than 7.5%.

8.4 Portfolio Effects

We implemented the SSNIP test assuming that: (i) initially each firm controlled only one product, and (ii) the hypothetical monopolist controls only triple-play products. In particular, we excluded the possibility that the hypothetical monopolist might control several types of products, namely the individual products that constitute triple-play bundles. Ignoring these portfolio effects corresponds to the scenario usually considered in the literature, and is the most reasonable for markets of individual products, i.e., markets that do not include bundles.

For markets of bundles, it might seem awkward to allow a firm to offer bundles of services, but prevent it from offering also the services that constitute those bundles. In addition, by ignoring portfolio effects one under-estimates the market power of the hypothetical monopolist, since there is potentially some substitutability between triple-play bundles and these other products or their combinations.

When the result of the SSNIP test is positive, as in the case under analysis, ignoring portfolio effects is not a problem. If when under-evaluating the market power of the hypothetical monopolist one concludes that triple-play products are a relevant market, increasing the hypothetical monopolist’s market power can only reinforce the conclusion.

However, when the result of the SSNIP test is negative, it might be useful to explore the impact of portfolio effects. There are at least three approaches to address this issue. The first approach consists of the following. Suppose that initially each triple-play product is controlled by a different firm. In addition, each of these firms controls also the individual products and double-play products associated with its triple-play product. Suppose now that the sets of products of two of these initial firms are controlled by a hypothetical monopolist. Then, perform one of the versions of the SSNIP test. An obvious problem with this approach is that it tests whether the hypothetical monopolist has market power with respect to all
of its products, and not specifically whether the hypothetical monopolist has market power with respect to triple-play products. The second approach consists of the following. Suppose that initially each product is controlled by a different firm, with the exception of one firm, the hypothetical monopolist, which controls a triple-play product and also the individual products and double-play products associated with its triple-play product. Suppose now that the hypothetical monopolist, in addition to its initial products, controls one of the other triple-play products available in the market. Then, perform one of the three versions of the SSNIP test. An obvious problem with this approach is that the market power of the hypothetical monopolist will, in principal, depend heavily not only on the "attractiveness" of the triple-play products that it controls, but also of the "attractiveness" of the individual products and double-play products associated with its initial triple-play products. Two hypothetical monopolists with the same set of triple-play play products, but with different sets of double-play and individual products, may have very different levels of market power. The third approach consists of the following. Suppose that initially each triple-play product is controlled by a different firm. In addition, each of these firms controls also the individual products and double-play products associated with its triple-play product. Within each firm, the triple-play product and the remaining products are controlled by two different divisions: the triple-play division and the other-products division. Suppose now that two firms form a coalition that agrees on the following. Within each firm, the triple-play division chooses the price of its triple-play product to maximize the firm’s profit plus the profit of the triple-play product of the other firm, whereas the other-product division chooses the prices of its products to maximize the firm’s profit only. Then, perform one of the versions of the SSNIP test with respect to the coalition of firms. An obvious problem with this approach is that it tests whether a given coalition of firms has incentives to collude, selectively, on triple-play. In this sense this approach seems more amenable to test for coordinated effects, rather than for unilateral effects, which is at the center of the SSNIP test.

9 Conclusion

This article showed how the SSNIP test can be extended to bundles and applied the procedure to triple-play products. We collected a unique invoice based consumer level data set from Portuguese telecommunications firms. An adequate definition of consumption alternatives allowed us to cast within the discrete choice framework the consumer’s choice problem and estimate coherently the demand for bundles and individual products. The estimates of these model demand models were used to performed three versions of the SSNIP test.

Our article sheds light on the discussion about the impact of bundles on competition and competition policy. In Portugal, triple-play products are a relevant product market in the sense of competition policy. This implies that future competition or regulatory proceedings
in the telecommunications industry should not only consider the potential existence of markets of products consisting of individual services, but also of markets of products consisting of bundles of services, namely of triple-play products. Delineating relevant product markets for bundles raises several questions, which are absent for individual products. One of these new issues is that a relevant product market may consist of a set of products of the same type, e.g., triple-play products, or of a set of products of different types, e.g., triple-play products plus double-play products. Another issue is that for a given set of individual services, several relevant product markets for different types of bundles or products may coexist with dominance differing across these markets. For example, triple-play products, double-play products of fixed voice and fixed broadband, and single-play products of fixed broadband may, simultaneously, be relevant product markets, with different firms being dominant in these markets. In the presence of bundles, market delineation and competition analysis are likely to become more complex. Nevertheless, both market delineation and competition analysis can be still be performed using the traditional tools of competition policy.
References


Economic Alternative to Market Definition,” The B.E. Journal of Theoretical Economics, 
10(1 (Policies and Perspectives)), Article 9.

FOSGERAU, M., D. MCFADDEN, AND M. BIERLAIRE (2010): “Choice probability gener-

GOLDBERG, P. K. (1995): “Product Differentiation and Oligopoly in International Markets: 
The Case of the U.S. Automobile Industry,” Econometrica, 63(4), 891-951.


Policy: Application to Computer Servers,” Discussion paper, Toulouse School of E-
conomics.


——— (1978): “Modeling the choice of residential location,” in Spatial interaction theory 
and planning models, ed. by A. Karlkvist, L. Lundkvist, F. Snickars, and J. Weibull, pp. 

in Structural Analysis of Discrete Data and Econometric Applications, ed. by C. F. Manski,
and D. L. McFadden, chap. 5. Cambridge: The MIT Press.


metria, 69(2), 307–42.

PEREIRA, P., AND T. RIBEIRO (2011): “The impact on broadband access to the Internet of 
the dual ownership of telephone and cable networks,” International Journal of Industrial 
Organization, 29(2), 283 – 293.


A Tables
### Table 1: Market shares

<table>
<thead>
<tr>
<th></th>
<th>Fixed voice</th>
<th>Pay-TV</th>
<th>Broadband</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2008</td>
<td>2009</td>
<td>2008</td>
</tr>
<tr>
<td>PT</td>
<td>65.7%</td>
<td>61.6%</td>
<td>13.6%</td>
</tr>
<tr>
<td>ZON</td>
<td>4.4%</td>
<td>10.2%</td>
<td>72.3%</td>
</tr>
<tr>
<td>Optimus</td>
<td>16.3%</td>
<td>14.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>Vodafone</td>
<td>5.1%</td>
<td>6.1%</td>
<td>-</td>
</tr>
<tr>
<td>Cabovisão</td>
<td>3.3%</td>
<td>3.6%</td>
<td>12.4%</td>
</tr>
<tr>
<td>AR Telecom</td>
<td>1.7%</td>
<td>1.4%</td>
<td>1.0%</td>
</tr>
<tr>
<td>Others</td>
<td>0.7%</td>
<td>0.5%</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

Market share in terms of subscribers, except for fixed telephony which is in terms of traffic. Source: ICP-ANACOM (Relatórios trimestrais)

### Table 2: Products - Notation

#### Bundles

<table>
<thead>
<tr>
<th>N</th>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>p000</td>
<td>no serv.</td>
</tr>
<tr>
<td>2</td>
<td>p110</td>
<td>Double play FV + TV</td>
</tr>
<tr>
<td>3</td>
<td>p011</td>
<td>Double play TV + BB</td>
</tr>
<tr>
<td>4</td>
<td>p111</td>
<td>Triple play FV + TV + BB</td>
</tr>
</tbody>
</table>

#### Services

<table>
<thead>
<tr>
<th>N</th>
<th>Notation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>f0</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>f1</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>f2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>f3</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>f4</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>f5</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>f6</td>
<td></td>
</tr>
</tbody>
</table>
Table 3: Products - Examples

<table>
<thead>
<tr>
<th>N</th>
<th>Services</th>
<th>Bundles</th>
<th>S. FV</th>
<th>S. TV</th>
<th>S. BB</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>000</td>
<td>p000</td>
<td></td>
<td></td>
<td></td>
<td>No services</td>
</tr>
<tr>
<td>1</td>
<td>100</td>
<td>no b</td>
<td></td>
<td></td>
<td></td>
<td>Fixed voice from f1</td>
</tr>
<tr>
<td>2</td>
<td>111</td>
<td>p111</td>
<td>f2</td>
<td></td>
<td></td>
<td>Triple-play from f2</td>
</tr>
<tr>
<td>3</td>
<td>010</td>
<td>no b</td>
<td></td>
<td></td>
<td></td>
<td>Pay-TV from f2</td>
</tr>
<tr>
<td>4</td>
<td>111</td>
<td>p111</td>
<td>f1</td>
<td>f1</td>
<td>f1</td>
<td>Triple-play from f1</td>
</tr>
<tr>
<td>5</td>
<td>101</td>
<td>p101</td>
<td>f4</td>
<td></td>
<td></td>
<td>Double play (FV+BB) from f4</td>
</tr>
<tr>
<td>6</td>
<td>110</td>
<td>no b</td>
<td>f1</td>
<td></td>
<td>f2</td>
<td>Fixed voice from f1 + Pay-TV from f2</td>
</tr>
</tbody>
</table>

S. FV - supplier of FV; S. TV - supplier of TV; S. BB - supplier of BB

Table 4: Services vs. bundles

<table>
<thead>
<tr>
<th>Bundles</th>
<th>Services</th>
<th>p000</th>
<th>no b</th>
<th>p110</th>
<th>p101</th>
<th>p011</th>
<th>p111</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>000</td>
<td>26.2%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>26.2%</td>
</tr>
<tr>
<td>100</td>
<td>0%</td>
<td>14.5%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>14.5%</td>
</tr>
<tr>
<td>010</td>
<td>0%</td>
<td>10.4%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>10.4%</td>
</tr>
<tr>
<td>001</td>
<td>0%</td>
<td>1.9%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>1.9%</td>
</tr>
<tr>
<td>110</td>
<td>0%</td>
<td>5.7%</td>
<td>5.6%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>11.3%</td>
</tr>
<tr>
<td>101</td>
<td>0%</td>
<td>1.4%</td>
<td>0%</td>
<td>4.3%</td>
<td>0%</td>
<td>0%</td>
<td>0%</td>
<td>5.7%</td>
</tr>
<tr>
<td>011</td>
<td>0%</td>
<td>1.4%</td>
<td>0%</td>
<td>0%</td>
<td>4.7%</td>
<td>0%</td>
<td>0%</td>
<td>6.1%</td>
</tr>
<tr>
<td>111</td>
<td>0%</td>
<td>1.8%</td>
<td>0%</td>
<td>3.4%</td>
<td>1.1%</td>
<td>17.2%</td>
<td>23.5%</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>26.2%</td>
<td>37.1%</td>
<td>5.6%</td>
<td>7.7%</td>
<td>5.8%</td>
<td>17.2%</td>
<td>100%</td>
<td></td>
</tr>
</tbody>
</table>

Distribution of services consumed per type of bundle, 2009. Source: ICP-ANACOM, "Inquérito ao consumidor"

Table 5: Distribution and market shares

<table>
<thead>
<tr>
<th>FV</th>
<th>TV</th>
<th>BB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Dist.</td>
<td>MkS</td>
</tr>
<tr>
<td>no serv.</td>
<td>44.6%</td>
<td>-</td>
</tr>
<tr>
<td>f1</td>
<td>[30-40%]</td>
<td>[50-60%]</td>
</tr>
<tr>
<td>f2</td>
<td>[0-10%]</td>
<td>[10-20%]</td>
</tr>
<tr>
<td>f3</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
</tr>
<tr>
<td>f4</td>
<td>[0-10%]</td>
<td>[10-20%]</td>
</tr>
<tr>
<td>f5</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
</tr>
<tr>
<td>f6</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
</tr>
</tbody>
</table>

Distribution of market shares (regarding the number of clients) per service, 2009. Source: data from operators
Table 6: Distribution and market shares per bundle

<table>
<thead>
<tr>
<th></th>
<th>Dist.</th>
<th>MkS</th>
<th>Dist.</th>
<th>MkS</th>
<th>Dist.</th>
<th>MkS</th>
<th>Dist.</th>
<th>MkS</th>
</tr>
</thead>
<tbody>
<tr>
<td>no serv.</td>
<td>94.0%</td>
<td>-</td>
<td>92.4%</td>
<td>-</td>
<td>94.2%</td>
<td>-</td>
<td>82.8%</td>
<td>-</td>
</tr>
<tr>
<td>f₁</td>
<td>[0-10%]</td>
<td>[40-50%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[30-40%]</td>
<td>[0-10%]</td>
<td>[30-40%]</td>
</tr>
<tr>
<td>f₂</td>
<td>[0-10%]</td>
<td>[30-40%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[50-60%]</td>
<td>[0-10%]</td>
<td>[40-50%]</td>
</tr>
<tr>
<td>f₃</td>
<td>[0-10%]</td>
<td>[20-30%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[10-20%]</td>
</tr>
<tr>
<td>f₄</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[80-90%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
</tr>
<tr>
<td>f₅</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
</tr>
<tr>
<td>f₆</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
<td>[0-10%]</td>
</tr>
</tbody>
</table>

Distribution of market shares (regarding the number of clients) per type of bundle, 2009.
Source: data from operators

Table 7: Modelos de procura

<table>
<thead>
<tr>
<th>Variável</th>
<th>Logit</th>
<th>Nested</th>
<th>Cross-Nested</th>
</tr>
</thead>
<tbody>
<tr>
<td>single</td>
<td>1.509 ** 0.086</td>
<td>1.382 ** 0.126</td>
<td>0.877 ** 0.116</td>
</tr>
<tr>
<td>dual</td>
<td>0.531 *** 0.098</td>
<td>0.174 0.112</td>
<td>-0.148 0.132</td>
</tr>
<tr>
<td>triple</td>
<td>2.087 *** 0.123</td>
<td>1.768 *** 0.153</td>
<td>1.350 *** 0.145</td>
</tr>
<tr>
<td>f₁</td>
<td>-1.174 *** 0.073</td>
<td>-0.929 *** 0.093</td>
<td>-1.023 *** 0.093</td>
</tr>
<tr>
<td>f₂</td>
<td>-0.136 0.073</td>
<td>-0.003 0.014</td>
<td>-0.448 *** 0.103</td>
</tr>
<tr>
<td>f₃</td>
<td>-0.204 * 0.112</td>
<td>-0.026 0.094</td>
<td>-0.471 *** 0.125</td>
</tr>
<tr>
<td>f₄</td>
<td>-2.284 *** 0.144</td>
<td>-1.981 *** 0.215</td>
<td>-2.298 *** 0.165</td>
</tr>
<tr>
<td>f₅</td>
<td>-3.676 *** 0.116</td>
<td>-2.974 *** 0.163</td>
<td>-3.457 *** 0.168</td>
</tr>
<tr>
<td>f₆</td>
<td>-3.905 *** 0.227</td>
<td>-3.494 *** 0.271</td>
<td>-3.795 *** 0.250</td>
</tr>
<tr>
<td># channels</td>
<td>-0.019 0.034</td>
<td>-0.000 0.000</td>
<td>0.032 0.041</td>
</tr>
<tr>
<td>bandwidth</td>
<td>-0.008 0.037</td>
<td>-0.029 0.051</td>
<td>-0.028 0.033</td>
</tr>
<tr>
<td>fixed voice</td>
<td>0.522 *** 0.062</td>
<td>0.497 *** 0.097</td>
<td>0.367 *** 0.061</td>
</tr>
<tr>
<td>CF</td>
<td>0.569 *** 0.087</td>
<td>0.536 *** 0.107</td>
<td>0.462 *** 0.112</td>
</tr>
<tr>
<td>price</td>
<td>-1.347 *** 0.091</td>
<td>-1.232 *** 0.098</td>
<td>-1.054 *** 0.127</td>
</tr>
<tr>
<td>nest(singel)</td>
<td>0.703 *** 0.039</td>
<td>0.166 *** 0.055</td>
<td></td>
</tr>
<tr>
<td>nest(triple)</td>
<td>0.859 0.140</td>
<td>0.520 ** 0.241</td>
<td></td>
</tr>
<tr>
<td>nest(f₁)</td>
<td>0.453 ** 0.058</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nest(f₂)</td>
<td>0.984 0.147</td>
<td></td>
<td></td>
</tr>
<tr>
<td>nest(f₃)</td>
<td>0.637 ** 0.145</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Log Lik 5580 5557 5501
Pseudo R² 0.294 0.297 0.304
N 3432 3432 3432

Values reported under "Log Lik" are the negative of the likelihood function.
### Table 8: Demand Models - II

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>single</td>
<td>2.039</td>
<td>0.152</td>
<td>0.005</td>
<td>0.052</td>
</tr>
<tr>
<td>dual</td>
<td>0.966</td>
<td>0.217</td>
<td>1.086</td>
<td>0.401</td>
</tr>
<tr>
<td>triple</td>
<td>3.132</td>
<td>0.244</td>
<td>2.225</td>
<td>0.475</td>
</tr>
<tr>
<td>( f_1 )</td>
<td>-1.176</td>
<td>0.118</td>
<td>0.022</td>
<td>0.048</td>
</tr>
<tr>
<td>( f_2 )</td>
<td>0.029</td>
<td>0.105</td>
<td>0.024</td>
<td>0.062</td>
</tr>
<tr>
<td>( f_3 )</td>
<td>-0.978</td>
<td>0.267</td>
<td>1.205</td>
<td>0.377</td>
</tr>
<tr>
<td>( f_4 )</td>
<td>-2.761</td>
<td>0.262</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f_5 )</td>
<td>-3.854</td>
<td>0.173</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( f_6 )</td>
<td>-4.942</td>
<td>0.454</td>
<td></td>
<td></td>
</tr>
<tr>
<td>( # \text{channels} )</td>
<td>-0.156</td>
<td>0.058</td>
<td>0.567</td>
<td>0.110</td>
</tr>
<tr>
<td>bandwidth</td>
<td>-0.985</td>
<td>0.179</td>
<td>1.526</td>
<td>0.201</td>
</tr>
<tr>
<td>( \text{fixed voice} )</td>
<td>0.402</td>
<td>0.086</td>
<td>0.297</td>
<td>0.273</td>
</tr>
<tr>
<td>CF</td>
<td>0.367</td>
<td>0.132</td>
<td>0.069</td>
<td>0.046</td>
</tr>
<tr>
<td>price</td>
<td>-1.451</td>
<td>0.151</td>
<td>0.991</td>
<td>0.204</td>
</tr>
<tr>
<td>Log Lik</td>
<td>5515</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pseudo R2</td>
<td>0.302</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>3432</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 9: Elasticity I

<table>
<thead>
<tr>
<th>( \partial p )</th>
<th>111</th>
<th>111</th>
<th>111</th>
<th>111</th>
<th>111</th>
<th>110</th>
<th>101</th>
<th>011</th>
<th>100</th>
<th>010</th>
<th>001</th>
</tr>
</thead>
<tbody>
<tr>
<td>( f_1 )</td>
<td>-2.029</td>
<td>0.329</td>
<td>0.257</td>
<td>0.005</td>
<td>0.005</td>
<td>0.073</td>
<td>0.015</td>
<td>0.080</td>
<td>0.073</td>
<td>0.216</td>
<td>0.141</td>
</tr>
<tr>
<td>( f_2 )</td>
<td>0.304</td>
<td>-1.304</td>
<td>0.171</td>
<td>0.004</td>
<td>0.004</td>
<td>0.073</td>
<td>0.015</td>
<td>0.075</td>
<td>0.036</td>
<td>0.157</td>
<td>0.076</td>
</tr>
<tr>
<td>( f_3 )</td>
<td>0.284</td>
<td>0.211</td>
<td>-3.151</td>
<td>0.004</td>
<td>0.004</td>
<td>0.080</td>
<td>0.015</td>
<td>0.153</td>
<td>0.047</td>
<td>0.417</td>
<td>0.094</td>
</tr>
<tr>
<td>( f_4 )</td>
<td>0.107</td>
<td>0.103</td>
<td>0.082</td>
<td>-0.948</td>
<td>0.004</td>
<td>0.070</td>
<td>0.015</td>
<td>0.074</td>
<td>0.035</td>
<td>0.154</td>
<td>0.075</td>
</tr>
<tr>
<td>( f_5 )</td>
<td>0.080</td>
<td>0.087</td>
<td>0.070</td>
<td>-0.403</td>
<td>0.004</td>
<td>0.070</td>
<td>0.015</td>
<td>0.074</td>
<td>0.035</td>
<td>0.154</td>
<td>0.075</td>
</tr>
<tr>
<td>( f_6 )</td>
<td>0.074</td>
<td>0.102</td>
<td>0.082</td>
<td>0.004</td>
<td>0.004</td>
<td>-1.036</td>
<td>0.070</td>
<td>0.015</td>
<td>0.074</td>
<td>0.035</td>
<td>0.154</td>
</tr>
</tbody>
</table>

### Table 10: Elasticity II

<table>
<thead>
<tr>
<th>( \partial p )</th>
<th>111</th>
<th>110</th>
<th>101</th>
<th>011</th>
<th>100</th>
<th>010</th>
<th>001</th>
</tr>
</thead>
<tbody>
<tr>
<td>( \partial Q )</td>
<td>-1.352</td>
<td>0.073</td>
<td>0.015</td>
<td>0.091</td>
<td>0.050</td>
<td>0.225</td>
<td>0.101</td>
</tr>
<tr>
<td>( \partial Q )</td>
<td>0.243</td>
<td>-1.143</td>
<td>0.015</td>
<td>0.076</td>
<td>0.038</td>
<td>0.163</td>
<td>0.177</td>
</tr>
<tr>
<td>( \partial Q )</td>
<td>0.235</td>
<td>0.070</td>
<td>-0.452</td>
<td>0.075</td>
<td>0.035</td>
<td>-0.176</td>
<td>0.075</td>
</tr>
<tr>
<td>( \partial Q )</td>
<td>0.284</td>
<td>0.072</td>
<td>0.015</td>
<td>-1.137</td>
<td>0.010</td>
<td>0.190</td>
<td>0.086</td>
</tr>
<tr>
<td>( \partial Q )</td>
<td>0.340</td>
<td>0.075</td>
<td>0.015</td>
<td>0.020</td>
<td>-0.789</td>
<td>-0.145</td>
<td>-0.016</td>
</tr>
<tr>
<td>( \partial Q )</td>
<td>0.314</td>
<td>0.022</td>
<td>0.015</td>
<td>0.085</td>
<td>-0.005</td>
<td>0.071</td>
<td>-0.343</td>
</tr>
<tr>
<td>( \partial Q )</td>
<td>0.233</td>
<td>0.070</td>
<td>0.015</td>
<td>0.074</td>
<td>0.035</td>
<td>0.154</td>
<td>0.075</td>
</tr>
<tr>
<td></td>
<td>Logit</td>
<td>Nested</td>
<td>Cross-Nested</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>-------</td>
<td>--------</td>
<td>--------------</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>$\Delta \pi_5$</td>
<td>$\Delta \pi_{10}$</td>
<td>$\Delta \pi_5$</td>
<td>$\Delta \pi_{10}$</td>
<td>$\Delta \pi_5$</td>
<td>$\Delta \pi_{10}$</td>
<td></td>
</tr>
<tr>
<td>$f_1 + f_2$</td>
<td>$\nearrow$</td>
<td>$\searrow$</td>
<td>$6.0$</td>
<td>$4.1$</td>
<td>$\nearrow$</td>
<td>$\searrow$</td>
<td>$6.8$</td>
</tr>
<tr>
<td>$f_1 + f_2 + f_3$</td>
<td>$\nearrow$</td>
<td>$\nearrow$</td>
<td>$7.6$</td>
<td>$5.4$</td>
<td>$\nearrow$</td>
<td>$\nearrow$</td>
<td>$8.8$</td>
</tr>
<tr>
<td>$f_1 + f_2 + f_3 + f_4$</td>
<td>$\nearrow$</td>
<td>$\nearrow$</td>
<td>$10.0$</td>
<td>$7.7$</td>
<td>$\nearrow$</td>
<td>$\nearrow$</td>
<td>$11.3$</td>
</tr>
<tr>
<td>$f_1 + f_2 + f_3 + f_4 + f_5$</td>
<td>$\nearrow$</td>
<td>$\nearrow$</td>
<td>$11.2$</td>
<td>$9.1$</td>
<td>$\nearrow$</td>
<td>$\nearrow$</td>
<td>$13.1$</td>
</tr>
<tr>
<td>$f_1 + f_2 + f_3 + f_4 + f_5 + f_6$</td>
<td>$\nearrow$</td>
<td>$\nearrow$</td>
<td>$11.6$</td>
<td>$9.5$</td>
<td>$\nearrow$</td>
<td>$\nearrow$</td>
<td>$13.5$</td>
</tr>
</tbody>
</table>
B Figures
Price index with respect to the average billing of the set of the products included in the sample (average of the 3 last bills of 2009). Source: data from operators.
Figure 2: Triple-play elasticities - distribution per operator