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

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June 20, 2012

Abstract

A SSNIP test for bundles of telecommunication services is developed. As a first step, demand for bundles of several services, as well as the associated services, is modeled as a discrete choice problem with a potentially large number of products. A unique invoice based consumer level data set from Portuguese telecommunications firms is collected. This choice based data set is combined with survey data to characterize the market shares of all potential combinations of services available. Imputation procedures are used to handle the non-observability of the choice set. Multinomial logit, nested logit, cross-nested logit and random coefficients logit models are estimated. A cross-nested logit model is the most parsimonious description of the substitution patterns between the large number of products available. The demand model used, coupled with the definition of choice alternatives proposed, generates flexible substitution patterns, which produce reasonable price elasticities of demand. 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. Some of the products analyzed are found to be complementary. Three versions of the SSNIP test are performed; all indicate that triple-play products are a relevant product market.

Key Words: *Bundles, Relevant Market, 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.

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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 discussed in Pereira and Vareda (2011).

The definition of the relevant market and the analysis of market power are a fundamental component of competition and regulatory policy. To determine whether a firm's conduct is anticompetitive, it is necessary to establish first that the firm has, or could obtain, significant marker power. In turn, the notion of market power is defined in reference to a particular relevant market.[1]

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 market, in the sense of competition policy. To conduct a SSNIP test one has to determine the substitutability between the products candidates to the relevant market, measured by the price elasticities of demand. In the case of bundles, this exercise may be complex because it involves determining the substitutability between products of the same type and also the substitutability between products of different types. For triple-play products, one needs to determine not only the substitutability between different triple-play bundles, but also the substitutability between triple-play and double-play bundles and the substitutability between triple-play bundles and individual products. Hence, the first and most important challenge one faces when delineating markets for bundles is how to estimate coherently the demand for the various types of bundles and individual services. This problem can be overcome with a careful definition of the consumers' choice alternatives. Once this is done, the consumers' 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 ***choice 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 allows using existing survey data to estimate the aggregate share of each product.

[1] 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.

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 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 alternatives available in the household's area of residence. This imputation process potentially creates an endogeneity problem. We accounted for both the usual endogeneity problem associated with non-observable characteristics for differentiated product, and the endogeneity problem created by the imputation process, by using a control function approach in the estimation process. For an application of the control function approach in the context of discrete choice models see, e.g., Petrin and Train (2010). More generally see Powell and Blundell (2003).

We estimated several discrete choice models, namely a multinomial logit, a nested logit, a cross-nested logit and a random coefficients logit model. A cross-nested Logit demand model, with a nest for the type of bundle and a nest for firms, provides the most parsimonious description of the substitution patterns between the large number of products available.

The cross-nested logit model inherits the theoretical foundations of random utility theory from the generalized extreme value class, 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. For a discussion of the properties of the cross-nested logit model see, e.g., Bierlaire (2006), Fosgerau, McFadden, and Bierlaire (2010), Wen and Koppelman (2001) Koppelman and Sethi (2007). Previous applications of this model in economics include Adams, Brevoort, and Kiser (2007), Bresnahan, Stern, and Trajtenberg (1997) and Small (1987).

The demand model used, coupled with the definition of choice alternatives proposed, generates flexible substitution patterns, which produce reasonable price elasticities of demand. The estimates 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. Some of the products analyzed are found to be complementary.

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, the *Upward Pricing*

Pressure, is based on the recently introduced homonymous 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.

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

The rest of the article is organized as follows. Section 2 inserts the article in the literature. Section 3 gives an overview of the Portuguese industry. Section 4 describes the three SSNIP tests performed. Section 5 presents the model. Section 6 describes the data, the econometric implementation and presents the basic estimation results. Section 7 performs the SSNIP test for the relevant product market. Section 8 discusses the robustness of the results and Section 9 concludes.

2 Related Literature

Our methodological approach draws on the discrete choice literature, represented by, e.g., Domencich and McFadden (1975), McFadden (1974), McFadden (1978), and McFadden (1981), or in the industrial organization side by, e.g., Berry (1994), Berry, Levinsohn, and Pakes (1995), Goldberg (1995) and Nevo (2001).

Regarding, specifically, the way of modeling the choice over bundles several articles developed alternative approaches for bundles of two goods.[2]Augereau, Greenstein, and Rysman (2006) study the role of competition in the adoption of 56K modems by internet service providers. They use a bivariate probit model and firm level data to analyze the standard adoption choices of internet service providers, where the alternatives are: none, X2 standard, Flex standard, and both standards. Gandal, Markovich, and Riordan (2004) analyze the importance of bundling for the evolution of the PC office software market, which consists of three firms. They use a discrete choice model and firm level data to estimate the demand for word processors, spreadsheets and suites, where the alternatives are: none, a word processor, a spreadsheet, an office suite, a word processor and a spreadsheet from different firms. Gentzkow (2007) studies competition between print and online newspapers. He develops a discrete choice model that allows goods to be either substitutes or complements and uses survey data from Washington, DC, to analyze the newspaper choices of consumers, where the choice set includes three goods: the Washington Post print edition, the Washington Post online edition, and Washington times print edition.

Our article also relates to the empirical literature on market delineation. Adams, Brevoort,

[2]See also Prince and Greenstein (2011) for an analysis of whether bundling reduces consumer churn and Crawford (2008) and Crawford and Yurukoglu (forthcoming) examine the importance of bundling in the cable television industry .

and Kiser (2007) use a panel of firm level US data to estimate a cross-nested logit model of consumer choice of depositary institutions, with a nest for type of institution, bank or thrift, and a nest for size class, single-market or multimarket. They perform the first version of the SSNIP test. Brenkers and Verboven (2006) use an European panel of firm level data to estimate a two level nested logit model of consumer choice of car models. They develop an industry model that includes a retail and a wholesale level and perform the first version of the SSNIP test. Capps, Dranove, and Satterthwaite (2003) use firm level data for San Diego from 1991 to estimate a multinomial logit model of consumer hospital choice. The demand estimates are used to build a model of health care services, with which they perform, perhaps inadvertently, the second version of the SSNIP test. Davis (2006) uses a cross-section of US firm level data for 1996 US to estimate a random coefficients logit model of consumer film choices, where location is a product attribute. He performs the first version of the SSNIP test. Ivaldi and Lörincz (2009) use a worldwide panel of firm level data to estimate a multinomial logit model of computer choices. They perform the first and second versions of the SSNIP test. In addition, they discuss at length the relative merits of the first and second versions of the SSNIP test. Ivaldi and Verboven (2005) presents a related discussion in the context of the Volvo/Scania merger analysis. Lapo Filistrucchi, Klein, and Michielsen (forthcoming) use a Dutch panel of firm level data with observation per municipality to estimate multinomial logit models for both the demand for daily printed newspapers and the demand for advertising. They build an equilibrium model of this two-sided market and perform the first and third versions of the SSNIP test.[3]

3 The Portuguese Industry

This Section gives an overview of the Portuguese telecommunications industry.

Portugal Telecom (PT), the telecommunication incumbent, 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 to PT's local loop. 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 spined-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.[4] Recently, PT initiated the deployment a fiber-optic network, while ZON upgraded its cable network by installing DOCSIS 3.0.

[3]Regarding the first version they distinguish between an European and an American version of the test.
[4]For more details see Pereira and Ribeiro (2011).

The other relevant firms in the industry include AR Telecom, Cabovisão, Optimus and Vodafone. AR Telecom began operations in 2005, basing its products mainly on FWA technology. Cabovisão, a cable television firm, was created in 1995. Optimus, originally a mobile telecommunications firm, entered the fixed services business in 2000 using local loop unbundling, with access via xDSL. After 2008 it also started deploying its fiber-optic network. Vodafone, originally a mobile telecommunications firm, entered the fixed services business in 2000, using 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%. Of these subscribers 57.4% used cable and 23.2% DTH. Finally, in 2009 the penetration rate per inhabitants of fixed broadband was 18%. Of these subscribers 57% xDSL and 40% cable modem.

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.

4 Relevant Market and SSNIP Test

This Section presents the definitions of relevant market and the three versions of the SSNIP test.

4.1 General Considerations

The ***relevant market***, in the sense of competition policy, is the smallest set of products and locations 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 (1983) and Werden (1993). Next we present the three versions of the SSNIP test performed. 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.[5] Finally, the third version, to which we refer as the ***upward pricing pressure*** (UPP) is based on the recently introduced homonymous test of Farrell and Shapiro (2010).

When sales occur at the producers' locations, location can be treated as just another product attribute. Hence, the product and the geographic markets can be delineated in a unified way. When sales occur at the consumers' location, which is our case, then the delineation of the product and geographic markets require different treatments. We will first focus on the delineation of the product market, under the assumption that competition conditions regarding triple-play products are homogeneous within the country, i.e., the geographic market is the whole country.[6] Later, in Section 8.3, we will investigate whether competition conditions regarding triple-play products vary across regions within the country.

4.2 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, by $y_i = D_i(\mathbf{p})$, the demand for product i, and by c_i, the constant marginal cost of product i. Let $\mathbf{p} := (p_1, \ldots, p_N)'$, $\mathbf{y} := (y_1, ..., y_N)'$ and $\mathbf{c} := (c_1, ..., c_N)'$.

The profit of product i is:

$$\pi_i = (p_i - c_i)\, D_i(\mathbf{p}).$$

The profit of firm $f = 1, ..., F$, which controls the set of products Ω_f is:

$$\Pi_f = \sum_{i \in \Omega_f} (p_i - c_i)\, D_i(\mathbf{p}).$$

The first-order condition for profit maximization with respect to prices for firm f is:[7]

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

where γ_{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 Γ and Φ consist of the elements $\Gamma_{ij} := \gamma_{ij}$ and $\Phi_{ij} := \frac{\partial D_j(\mathbf{p})}{\partial p_i}$, respectively. Matrix Γ represents the property structure, and matrix Φ consists of the demand estimates. 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 market equilibrium can be written in matrix form as:

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

[5] See http://www.justice.gov/atr/hmerger/11249.pdf.

[6] Portugal has a population of 10,5 million and an area of 92.000 square kilometers.

[7] We 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.

4.3 Unilateral Price Increase

> "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." (EU Commission, (1997): "Commission Notice on the Definition of the Relevant Market for the Purposes of the Community Competition Law," Official Journal of the European Communities, C/372, 9.12, p5)

This version of the SSNIP test lays the weight of market delineation 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 $p_1^0, ..., p_N^0$. Let $\mathbf{p}^0 := (p_1^0, \ldots, p_N^0)$. Suppose now that products $\Omega_m = \{1, 2\}$ are controlled by a hypothetical monopolist. Denote by $\mathbf{p}_m^0 = (p_1^0, p_2^0)$, the vector of the initial equilibrium values of the prices of products Ω_m, and denote by $\mathbf{p}_{-m}^0$, the vector of the initial equilibrium values of the remaining products. Let the hypothetical monopolist raise its prices by 5% or 10%, which then take values $\mathbf{p}_m^1 := (p_1^1, p_2^1)$.

The profit variation for the hypothetical monopolist caused by the increase in prices $\mathbf{p}_m^1$ is:

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

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 $\{1, 2, 3\}$.

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

Next we discuss the information required to implement this version of the test.[8]

Current prices, $\mathbf{p}^c$, current quantities, $\mathbf{y}^c$, and the current property structure, Γ^c, are observed.

Demand functions $D_i(\cdot)$ are described in Section 5. The estimates of the parameters of the demand function, obtained using the data described in 6.1.1, are presented in Section

[8] For more details on the procedure see, e.g., Nevo (2000) or Pereira and Ribeiro (2011).

6.3.

Marginal costs are estimated as follows. Assume that the current observed scenario is one of equilibrium. Substitute the current prices, $\mathbf{p}^c$, the current property structure, Γ^c, and the estimates of the demand function, $\hat{\Phi}$, in the system of equations (1). Afterwards, solve the system in order to $\mathbf{c}$, to obtain the estimates of marginal costs, $\hat{\mathbf{c}}$.

Initial prices, $\mathbf{p}^0$, are estimated as follows. Substitute the estimates of the parameters of demand function, $\hat{\Phi}$, and the estimates of marginal costs, $\hat{\mathbf{c}}$, in the system of equations (1). Let $\Gamma = I_N$. Afterwards, solve the system in order to prices to obtain, $\mathbf{p}^0$.

4.4 Equilibrium Price Increase

> "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 market delineation on the possibility of, in ***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 $p_1^0, ..., p_N^0$. Let $\mathbf{p}^0 := (p_1^0, \ldots, p_N^0)$. Suppose now that products $\Omega_m = \{1, 2\}$ are controlled by a hypothetical monopolist, and that the equilibrium prices of this new market are $p_1^1, ..., p_N^1$. Let $\mathbf{p}^1 := (p_1^1, \ldots, p_N^1)$.

If the average of prices (p_1^1, p_2^1) is higher than the average of prices (p_1^0, p_2^0) 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 4.3, by adjusting appropriately matrix Γ to reflect the different property structures.

4.5 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 $p_1^0, ..., p_I^0$. Suppose now that products $\Omega_m = \{1, 2\}$ are controlled by a hypothetical monopolist. However, products Ω_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, τ_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 τ_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 τ_i can be interpreted as the upward pricing pressure on price i induced by the joint optimization of profits by the hypothetical monopolist. Values (τ_1, τ_2) are an approximation of the average equilibrium variation of prices (p_1^1, p_2^1) of Section 4.4, and the same exercise detailed there can be done with this approximation.

5 Econometric Model

This Section describes the demand model.

5.1 Utility Function

We propose the class of Generalized Extreme Value (GEV) models to characterize demand.[9] 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

[9] See McFadden (1978).

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. Moreover, the models of the CNL class are flexible enough to approximate any consumer choices consistent with the assumption of random utility maximization.[10]

Household $h = 1, ..., H$ derives from choice alternative $s = 1, ..., S$ utility:

$$U_{hs}(p_{hs}, \mathbf{x}_{hs}, \boldsymbol{\theta}) = V_{hs}(p_{hs}, \mathbf{x}_{hs}, \boldsymbol{\theta}) + \varepsilon_{hs}, \tag{3}$$

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

$$V_{hs}(p_{hs}, \mathbf{x}_{hs}, \boldsymbol{\theta}) := p_{hs}\alpha + \sum_{t=1}^{T} x_{hsj}\beta_t, \tag{4}$$

where α is the price coefficient and parameters β_t translate the consumer's valuation for characteristics, other than price, of the various alternatives. Let $\boldsymbol{\beta} := (\beta_1, ..., \beta_T)$ and $\boldsymbol{\theta} := (\alpha, \boldsymbol{\beta})$. Whenever possible, index h will be omitted.

5.2 Choice Probabilities

A consumer chooses 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 alternative s depends on the joint distribution of components ε_s. Different joint distributions of ε_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 alternative s from set $\mathcal{C}$ being chosen is given by:

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

where $G_s := \frac{\partial G}{\partial z_s}$, and S is the number of alternatives of set $\mathcal{C}$. Functions $G(\cdot)$ must obey certain properties, namely homogeneity of degree 1.[11] Hence, the expression above can be written as:

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

or:

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

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

[10]See, e.g., Bierlaire (2006), Fosgerau, McFadden, and Bierlaire (2010), Wen and Koppelman (2001) and Koppelman and Sethi (2007).

[11]See, e.g., McFadden (1978), for the complete characterization of function $G(\cdot)$.

The ML model follows from:

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

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

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

Let subsets $\mathcal{B}_w$ not be necessarily mutually exclusive. The CNL model follows from:

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

We let constants δ be normalized to 1.

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

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

Let:

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

and

$$P(\mathcal{B}_w|\mathcal{C}) := \frac{\left[\sum_{k \in \mathcal{B}_w} \exp(V_k/\lambda_w)\right]^{\lambda_w}}{\sum_{m=1}^{W} \left[\sum_{k \in \mathcal{B}_m} \exp(V_k/\lambda_m)\right]^{\lambda_m}}.$$

Then, one has the simple interpretation of:

$$P(s|\mathcal{C}) = \sum_{w=1}^{W} P(s|\mathcal{B}_w) P(\mathcal{B}_w|\mathcal{C}).$$

An alternative way of modeling the choice probabilities, allowing for different substitution patterns between the choice 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 random coefficients logit (RCL) model. In this case, errors ε_{hs} are independently and identically distributed across households and choice alternatives, and follow an extreme value type I distribution. In addition:

$$\theta_h := \theta + \mathbf{L}_\theta \zeta_h,$$

where $\mathbf{L}_\theta$ is a lower triangular matrix of the appropriate dimension, and ζ_h follows the distribution $\mathcal{N}(0, I)$, i.e., θ_h is normally distributed with mean $\boldsymbol{\theta}$ and variance-covariance

$\mathbf{L}_\theta \mathbf{L}'_\theta$. We restrict $\mathbf{L}_\theta$ to be diagonal. Ignoring the subscript h the probability of choice alternative s from set $\mathcal{C}$ being chosen is given by:

$$P(s|\mathcal{C}) = \int \frac{\exp(V_s(\boldsymbol{\zeta}))}{\sum_t \exp(V_t(\boldsymbol{\zeta}))} \Phi(\boldsymbol{\zeta}) d\boldsymbol{\zeta}.$$

5.3 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:

$$\varepsilon_{ij} = \begin{cases} \alpha p_i \left[1 - P(i|\mathcal{C}) + \sum_{w=1}^{W} \omega_{iw} \frac{1-\lambda_w}{\lambda_w} \left(1 - P(i|\mathcal{B}_w)\right)\right] & j = i \\ \\ -\alpha p_j \left[P(j|\mathcal{C}) + \sum_{w=1}^{W} \omega_{iw} \frac{1-\lambda_w}{\lambda_w} P(j|\mathcal{B}_w)\right] & j \neq i, \end{cases} \tag{5}$$

with

$$\omega_{iw} = \frac{P(i|\mathcal{B}_w) P(\mathcal{B}_w|\mathcal{C})}{P(i|\mathcal{C})}.$$

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

The expression for ε_{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 $\mathcal{B}_w$. Since sets $\mathcal{B}_w$ 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 $\mathcal{B}_w = \mathcal{C}$.

6 Econometric Implementation

In this Section, we describe our data set and present the estimates of the demand model.

6.1 Data

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

6.1.1 Data Request

We obtained 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 (FV), **(ii)** subscription television (TV), and **(iii)** broadband access to the Internet

(BB). A ***double-play bundle*** is a product that includes two of these three services. A ***triple-play bundle*** is a product that includes the three services.[12]

In particular, we obtained a sample of 1.000 observations from each of the 3 following populations:

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

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

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

The information obtained consisted of data about: **(i)** the contract, **(ii)** the product, and **(iii)** the client. The characteristics of the contract 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 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 access to the Internet, and the tariff plan for fixed telephony. The characteristics of the client are: age, length of the contract and residential postal code.

We also obtained 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 obtained, for Population 1, the total number of clients for each product offered, and the geographical availability of each product.

This data was complemented with information from the sectoral regulator, ICP-ANACOM, 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.

6.1.2 Choice Alternatives

A ***choice alternative*** is a combination of: **(i)** the three triple-play services, **(ii)** type of bundle or form of acquisition, and **(iii)** supplier.

[12] To overcome any misunderstanding of what a bundle of services is, 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.

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

[*Table* 2]

There are eight possible combinations of services, six possible types of bundles, 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.[13] 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 choice alternative, i.e., $S = 76$.

Table 3 illustrates some choice alternatives.

[*Table* 3]

The concept of choice 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 choice alternatives. For example, fixed telephony offered by a given firm is typically present is several choice alternatives. In fact, a product offered by a firm is present only in one choice alternative in the case of triple-play bundles. With this definition of the choice 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.

6.1.3 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]

This information, and the data obtained from firms, allowed us to determine 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]

[13] Of the total of combinations services×bundles×FV supplier×TV supplier×BB supplier= $8 \times 6 \times 7 \times 7 \times 7 = 16464$ 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.

6.1.4 Choice Alternative Market Shares

In Section 6.1.3, we present the nation-wide share of each choice alternative defined in Section 6.1.2, 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 choice alternatives defined in Section 6.1.2 are the combination of five discrete variables. The share of each choice 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 choice alternatives. The joint distribution of the five variables that define a choice 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.[14]

6.2 Choice Sets

With the data obtained from the firms, described in Section 6.1.1, we built a sample representative of the weight of each choice in the population, according to the weights described and computed in Section 6.1.4. An observation of this sample represents a consumer's choice. By direct implication of the way the sample was collected, ours is a choice based sample.

(There are several alternative techniques to correct the bias of some of the coefficients of the model. See, e.g., Manski and McFadden (1981), in particular chapters 1 and 2. The first method that appeared in the econometrics literature addressing this issue was the WESML estimator of Manski and Lerman (1977) dealing with choice based samples.

The procedure just described is essentially equivalent to the one used in Ivaldi and Verboven (2005), who instead of stipulating a value for the market share of the outside option as is done here, define a size of the potential market and implicitly define the share of the outside option as que share not captured by the observed products.)

Our data does not include the consumers' choice sets, just the consumers' choices. 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 observation in the sample, we randomly imputed nine other choice alternatives from the area of residence of the consumer observed

[14]See Haberman (1972) and Bishop, Fienberg, and Holland (1975).

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. For an application of the control function approach in the context of discrete choice models see, e.g., Petrin and Train (2010). More generally see Powell and Blundell (2003). The instruments used were: **(i)** dummy variables for choice alternatives, in accordance with the choice alternative description of Section 6.1.2, **(ii)** dummy variables for region at the NUTS3 level, **(iii)** interactions between dummy variables for region and choice alternative, whenever the number of variables allowed it, **(iv)** length of the contract, and **(v)** characteristics of the choice alternative described above and present on the utility function.

6.3 Demand Estimates

Using the data described in Section 6.1, we estimated the four models described in Section 5.1: the ML, the NL, the CNL and the RCL.

The variables included in vector $\mathbf{x}_{hs}$ 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 choice alternative, namely, number of television channels and bandwidth, **(iv)** a 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.

[*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.

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 1 illustrate the distributions of the price-elasticity of demand of triple-play products per supplier.

$[Figure\ 1]$

Each choice 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 choice alternative of the same segment is higher than the substitutability of choice alternative of different segments.[15] 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 choice 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 ML 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 NL model where only bundle nests are considered. Similarly for the NL model where only firm nests are considered.

For comparison purposes we also estimated a RCL model.[16] Table 8 presents the estimates.

$[Table\ 8]$

The RCL 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 RCL 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 amongst consumers. Nevertheless, this model despite having more coefficients has a lower likelihood than the CNL model of Table 7.[17]

[15] If the value of the coefficient of the nest is 0, the products in the nest are independent of the other products; if the value of the coefficient of the nest is 1, the products in the nest and outside of the nest are equally substitutable.

[16] The RCL was estimated using maximum simulated likelihood with Halton draws.

[17] In addition, the imputation process we follow to deal with the non-observability of the choice set, following Train, McFadden, and Ben-Akiva (1987), induces an additive shift in the linear index component,

As a consequence of the previous discussion, we selected the CNL model to conduct our analysis in Section 7.

6.4 Elasticities

Table 9 presents the price elasticities of demand, based on estimates of the CNL model of Table 7.[18]

[*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. Even so, comparing with all the other products, the triple-play product is the one with the highest own-price elasticity, which may result from the fact that all the other products may in some way constitute an alternative to triple-play, while for double-play products the remaining double-play products are not a good alternative since it would imply sacrificing one of the parts of the bundle to buy another service.

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. This reflects an asymmetric competitive pressure between the different products.

7 SSNIP Test

This Section uses the demand estimates of the CNL model of Table 7, to compute the UPI, EPI, and UPP versions of the SSNIP test, according to the methods defined in Section 4.

i.e., the utility of the alternative if the model is correctly specified as being in the GEV family. The GEV class is closed closed under location shifts and the ML is not a member of the GEV class. See Bierlaire, Bolduc, and McFadden (2008) for a discussion.

[18] These are the elasticities of demand of the products offered by the firms with respect to prices, not the elasticities of choice alternative with respect to its prices.

7.1 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%. Table 11 presents the results.

[*Table* 11]

Each line in Table 11 corresponds to a set of products controlled by an hypothetical monopolist. For example, sign "f_1+f_2" refers to a hypothetical monopolist that controls the triple-play bundles of firms f_1 and f_2. The rightward section labeled "Cross-Nested" reports the results based on that model. Columns labeled "$\Delta\pi_5$" and "$\Delta\pi_{10}$" indicate, whether a price increase of 5% and 10%, respectively, would increase or decrease the hypothetical monopolist's profits.[19]

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

7.2 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. Table 11 presents the results.

Each line corresponds to a different set of products. The rightward section labeled "Cross-Nested" reports the results based on that model. Column labelled "$\frac{\Delta p}{p}_{(s)}$" 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.

We analyzed, for the EPI version, the sensitivity of the results of the SSNIP test with respect to the uncertainty 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 parameters 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 monopolist. From this exercise we obtained a 95% confidence interval of the estimated value for the price variation, presented in the column labeled CI of Table 11.[20]

[19] An upward arrow indicates a profit increase and a downward arrow indicates a profit decrease.

[20] In principle, one could re-estimate the model used and the SSNIP price variation for several bootstrap samples and obtain, as a result, confidence intervals that also take into account the effect of the sampling variation in the SSNIP test.

For example, a hypothetical monopolist controlling the triple-play products of all firms could raise prices, in equilibrium, by 12.8% with a 95% confidence interval of $[11.27\%, 14.33\%]$.

7.3 UPP Version

Next we present the UPP version of the SSNIP test. The results are presented in Table 12.

Each line corresponds to a different set of products. The rightward section labeled "Cross-Nested" reports the results based on that model. The column labeled "$\frac{\Delta p}{p}_{(u)}$" 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.

7.4 Conclusion

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

8 Robustness

This Section discusses the robustness of the results of the SSNIP test with respect to: **(i)** the model specification, **(ii)** the penetration rate of triple-play, and **(iii)** the geographic market. In addition we also discuss portfolio effects.

8.1 Demand Model

Table 12 presents the results of the UPI, EPI and UPP versions of the SSNIP test for the ML and NL model with bundle nests of Table 7.

$[Table\ 12]$

The value of the estimated profit and price variations change with the ML model and the NL model with bundle nests. However, the results of the SSNIP test do not change qualitatively. For example, the NL model with bundle nests, which translate the notion that the market is differentiated at this level, leads to equilibrium price variations of an hypothetical monopolist that are always larger than those of models where this characteristic is absent, as reported in the section labeled "Nested" in Table 12.

8.2 Penetration Rate of Triple-Play

We analyzed the sensitivity of the results of the SSNIP test with respect to the penetration rate of triple-play per household.[21] This exercise consisted of reducing the market share of triple-play implicit in the estimated demand model, through a decrease in the estimate 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 would 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 increases 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%, as well as for periods posterior to those of our sample.

8.3 Geographic Market

We investigate whether competition conditions regarding triple-play products vary across regions within the country. if do so by estimating demand models for the five NUTS 2 regions of the country. We chose to conduct the analysis at the NUTS 2 level to ensure that the samples of all regions were representative. It is unclear to us whether NUTS 2, NUTS 3 or the central office are the correct level to conduct the analysis. Hence, the analysis of this Section should be seen as an illustration of how this methodology can be applied to the delineation of the geographic market.

Figure 2 plots the coefficient estimates for the NL model.[22] For comparison purposes, we also plot in red the estimates of the country level model of Table 7. Vertical lines depict 95% confidence intervals.

$[Figure\ 2]$

The regional coefficients are, by and large, the same as the country level ones. In fact, a likelihood ratio test does not reject the null hypothesis that they are all equal. We also note that given the smaller sample sizes many more of the coefficients are not statistically different from zero. This exercise does not reveal substantial variation in the competition conditions across regions at the NUTS 2 level.

[21] See Table 6.

[22] The sample sizes of some of the regions did not allow a numerical identification of the CNL model.

Given the data collected, a more detailed construction of samples at a regional level could be carried out. This would obviate some of the size problems of the regional samples.

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 approach usually considered in the literature and by Competition Authorities, and is the most reasonable for markets of individual products.

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. However, that is the correct procedure to determine if a set of bundles constitutes a relevant product market. Suppose, to the contrary, 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. In this context, a SSNIP test evaluates whether the hypothetical monopolist has market power with respect to ***all*** of its products, and not specifically with respect ***only*** to triple-play products, which is what one is interested in knowing.[23]

9 Conclusion

In the presence of bundles, market delineation and competition analysis are likely to become more complex for a number of reasons. First, estimating the demand for bundles, as well as individual products, may be challenging. Second, 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. When the latter occurs, the issue of which path to follow when conducting the SSNIP test becomes non-trivial, and the results may be very sensitive to the particular path chosen. Third, 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

[23]By ignoring portfolio effects, typically, 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. Hence, when the result of the SSNIP test is positive, as in our case, ignoring portfolio effects does not affect qualitatively the result.

markets.[24] Under these circumstances, the results of competition analysis may depend on the market on which the analysis is framed.

In spite of the these difficulties, both market delineation and competition analysis can still be performed in the presence of bundles using the traditional tools of competition policy. Indeed, this article showed how the SSNIP test can be extended to bundles and illustrated the procedure with triple-play products.

We collected a unique invoice based consumer level data set from Portuguese telecommunications firms. An adequate definition of choice 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 demand models were used to perform three versions of the SSNIP test, all of which point to the conclusion that, in Portugal, triple-play products are a relevant product market in the sense of competition policy.

Our article sheds light on the discussion about the impact of bundles on competition and regulatory policy in the telecommunications industry. Future competition and regulatory proceedings in the telecommunications industry should consider the potential existence not only of markets of products consisting of individual services, but also of markets of products consisting of bundles of services, namely of triple-play products. This implies that the number of markets under consideration may increase. But more importantly, if the focus of the analysis shifts from markets of individual products to markets of bundles, the underlying competition analysis may change considerably. Dominance in the markets of individual products may not carry through to markets of bundles of these services. Hence, depending on which markets the analysis is framed, the conduct of a given firm may be found anticompetitive or not.

[24] For example, a firm may be dominant in the markets of fixed telephony products and fixed broadband products, while another firm may be dominant in the market for triple-play products.

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A Tables

Table 1: Market shares

	Fixed voice		Pay-TV		Broadband	
	2008	2009	2008	2009	2008	2009
PT	65.7%	61.6%	13.6%	23.0%	41.6%	44.5%
ZON	4.4%	10.2%	72.3%	64.4%	31.3%	32.2%
Optimus	16.3%	14.5%	0.5%	1.0%	12.5%	9.2%
Vodafone	5.1%	6.1%	-	0.3%	2.8%	3.9%
Cabovisão	3.3%	3.6%	12.4%	10.2%	9.3%	8.0%
AR Telecom	1.7%	1.4%	1.0%	0.9%	1.5%	1.4%
Others	0.7%	0.5%	0.1%	0.1%	1.0%	0.8%

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

Services

N	Notation	Description
1	000	no serv.
2	100	FV
3	010	TV
4	001	BB
5	110	FV+TV
6	101	FV+BB
7	011	TV+BB
8	111	FV+TV+BB

Bundles

N	Notation	Description
1	p000	no serv.
2	no b	No bundle - Single play
3	p110	Double play FV+TV
4	p101	Double play FV+BB
5	p011	Double play TV+BB
6	p111	Triple play FV+TV+BB

Firms

N	Notation
1	f_0
2	f_1
3	f_2
4	f_3
5	f_4
6	f_5
7	f_6

Table 3: Products - Examples

N	Services	Bundles	S. FV	S. TV	S. BB	Description
0	000	p000				No services
1	100	no b	f_1			Fixed voice from f_1
2	111	p111	f_2	f_2	f_2	Triple-play from f_2
3	010	no b		f_2		Pay-TV from f_2
4	111	p111	f_1	f_1	f_1	Triple-play from f_1
5	101	p101	f_4		f_4	Double play (FV+BB) from f_4
6	110	no b	f_1	f_2		Fixed voice from f_1 + Pay-TV from f_2
...						

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

Table 4: Services vs. bundles

	Bundles						
Services	p000	no b	p110	p101	p011	p111	Total
000	[26-28%]	0%	0%	0%	0%	0%	[26-28%]
100	0%	[14-16%]	0%	0%	0%	0%	[14-16%]
010	0%	[10-12%]	0%	0%	0%	0%	[10-12%]
001	0%	[0-2%]	0%	0%	0%	0%	[0-2%]
110	0%	[4-6%]	[4-6%]	0%	0%	0%	[10-12%]
101	0%	[0-2%]	0%	[4-6%]	0%	0%	[4-6%]
011	0%	[0-2%]	0%	0%	[4-6%]	0%	[6-8%]
111	0%	[0-2%]	0%	[2-4%]	[0-2%]	[16-18%]	[22-24%]
Total	[26-28%]	[36-38%]	[4-6%]	[6-8%]	[4-6%]	[16-18%]	100%

Distribution of services consumed per type of bundle, 2009. Source: ICP-ANACOM, "Inquï£¡rito ao consumidor"

Table 5: Distribution and market shares

	FV		TV		BB	
	Dist.	MkS	Dist.	MkS	Dist.	MkS
no serv.	[44-46%]	-	[48-50%]	-	[62-64%]	-
f_1	[30-40%]	[50-60%]	[10-20%]	[20-30%]	[10-20%]	[30-40%]
f_2	[0-10%]	[10-20%]	[20-30%]	[50-60%]	[10-20%]	[20-30%]
f_3	[0-10%]	[0-10%]	[0-10%]	[10-20%]	[0-10%]	[0-10%]
f_4	[0-10%]	[10-20%]	[0-10%]	[0-10%]	[0-10%]	[10-20%]
f_5	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]
f_6	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]

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

Table 6: Distribution and market shares per bundle

	p110		p101		p011		p111	
	Dist.	MkS	Dist.	MkS	Dist.	MkS	Dist.	MkS
no serv.	[94-96%]	-	[92-94%]	-	[94-96%]	-	[92-94%]	-
f_1	[0-10%]	[40-50%]	[0-10%]	[0-10%]	[0-10%]	[30-40%]	[0-10%]	[30-40%]
f_2	[0-10%]	[30-40%]	[0-10%]	[0-10%]	[0-10%]	[50-60%]	[0-10%]	[40-50%]
f_3	[0-10%]	[20-30%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[10-20%]
f_4	[0-10%]	[0-10%]	[0-10%]	[80-90%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]
f_5	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]
f_6	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]	[0-10%]

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

Table 7: Demand Models

	Logit			Nested			Cross-Nested		
Variable	Coef.		St. Err.	Coef.		St. Err.	Coef.		St. Err.
single	1.509	***	0.086	1.382	***	0.126	0.877	***	0.116
dual	0.531	***	0.098	0.174		0.112	-0.148		0.132
triple	2.073	***	0.123	1.768	***	0.153	1.350	***	0.145
f_1	-1.174	***	0.073	-0.929	***	0.093	-1.023	***	0.093
f_2	-0.136	*	0.073	-0.003		0.014	-0.448	***	0.103
f_3	-0.204	*	0.112	-0.026		0.094	-0.471	***	0.125
f_4	-2.284	***	0.144	-1.981	***	0.215	-2.298	***	0.165
f_5	-3.676	***	0.116	-2.974	***	0.163	-3.457	***	0.168
f_6	-3.905	***	0.227	-3.494	***	0.271	-3.795	***	0.250
# channels	-0.019		0.034	-0.000		0.000	0.032		0.041
bandwidth	-0.008		0.037	-0.029		0.051	-0.028		0.033
fixed voice	0.522	***	0.062	0.497	***	0.097	0.367	***	0.061
CF	0.569	***	0.087	0.536	***	0.107	0.462	***	0.112
price	-1.347	***	0.091	-1.232	***	0.098	-1.054	***	0.127
nest(single)				0.703	***	0.039	0.166	***	0.055
nest(triple)				0.859		0.140	0.520	**	0.241
nest(f_1)							0.453	***	0.058
nest(f_2)							0.984		0.147
nest(f_3)							0.637	**	0.145
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. ***, ** and * represent significance at 1%, 5% and 10% confidence levels respectively. The null hypothesis for the nest parameters is that they are equal to 1.

Table 8: Demand Models - II

	Mixed Logit					
Variable	Mean	St. Err.		St. Dev.	St. Err.	
single	2.039	0.152	***	0.005	0.052	
dual	0.966	0.217	***	1.086	0.401	***
triple	3.132	0.244	***	2.225	0.475	***
f_1	-1.176	0.118	***	0.022	0.048	
f_2	0.029	0.105		0.024	0.062	
f_3	-0.978	0.267	***	1.205	0.377	***
f_4	-2.761	0.262	***			
f_5	-3.854	0.173	***			
f_6	-4.942	0.454	***			
# channels	-0.156	0.058	***	0.567	0.110	***
bandwidth	-0.985	0.179	***	1.526	0.201	***
fixed voice	0.402	0.086	***	0.297	0.273	
CF	0.367	0.132	***	0.069	0.046	
price	-1.451	0.151	***	0.991	0.204	***
Log Lik	5515					
Pseudo R2	0.302					
N	3432					

Values reported under "Log Lik" are the negative of the likelihood function. ***, ** and * represent significance at 1%, 5% and 10% confidence levels respectively.

Table 9: Elasticity I

			∂p					
			111	111	111	111	111	111
			f_1	f_2	f_3	f_4	f_5	f_6
∂Q	111	f_1	-2.029	0.339	0.257	0.005	0.000	0.005
	111	f_2	0.304	-1.304	0.171	0.004	0.000	0.004
	111	f_3	0.284	0.211	-3.151	0.004	0.000	0.004
	111	f_4	0.107	0.103	0.082	-0.948	0.000	0.004
	111	f_5	0.080	0.087	0.070	0.004	-0.403	0.004
	111	f_6	0.106	0.102	0.082	0.004	0.000	-1.036

Table 10: Elasticity II

		∂p						
		111	110	101	011	100	010	001
∂Q	111	-1.352	0.073	0.015	0.091	0.050	0.225	0.101
	110	0.243	-1.143	0.015	0.076	0.038	0.163	0.017
	101	0.235	0.070	-0.452	0.075	0.035	-0.176	0.075
	011	0.284	0.072	0.015	-1.137	0.010	0.199	0.086
	100	0.340	0.075	0.015	0.020	-0.789	-0.145	-0.016
	010	0.323	0.074	-0.016	0.091	-0.031	-0.834	0.045
	001	0.314	0.022	0.015	0.085	-0.005	0.071	-0.343
	000	0.233	0.070	0.015	0.074	0.035	0.154	0.075

Table 11: SSNIP Test

	Cross-Nested				
	$\Delta\pi_5$	$\Delta\pi_{10}$	$\frac{\Delta p}{p}_{(u)}$	$\frac{\Delta p}{p}_{(s)}$	CI
f_1+f_2	$\nearrow$	$\nearrow$	10.9	6.9	[5.7,8.1]
f_1+f_2+f_3	$\nearrow$	$\nearrow$	13.0	8.7	[7.3,10.1]
f_1+f_2+f_3+f_4	$\nearrow$	$\nearrow$	15.1	10.9	[9.4,12.4]
f_1+f_2+f_3+f_4+f_5	$\nearrow$	$\nearrow$	15.1	12.4	[10.9,13.9]
f_1+f_2+f_3+f_4+f_5+f_6	$\nearrow$	$\nearrow$	16.5	12.8	[11.3,14.3]

Each line corresponds to a set of products controlled by an hypothetical monopolist. For example, 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 $\Delta\pi_5$ and "$\Delta\pi_{10}$" indicate, whether a price increase of 5% and 10%, respectively, would increase or decrease the hypothetical monopolist's profits. The column labeled $\frac{\Delta p}{p}_{(u)}$ indicates the UPP price variation and the column labelled $\frac{\Delta p}{p}_{(s)}$ indicates the equilibrium price variation. Finaly the column labelled CI indicates a 95% confidence interval of $\frac{\Delta p}{p}_{(s)}$ obtained by bootstrap.

Table 12: SSNIP Test - 2

	Logit				Nested			
	$\Delta\pi_5$	$\Delta\pi_{10}$	$\frac{\Delta p}{p}_{(u)}$	$\frac{\Delta p}{p}_{(s)}$	$\Delta\pi_5$	$\Delta\pi_{10}$	$\frac{\Delta p}{p}_{(u)}$	$\frac{\Delta p}{p}_{(s)}$
f_1+f_2	$\nearrow$	$\searrow$	6.0	4.1	$\nearrow$	$\searrow$	6.8	4.7
f_1+f_2+f_3	$\nearrow$	$\nearrow$	7.6	5.4	$\nearrow$	$\nearrow$	8.8	6.3
f_1+f_2+f_3+f_4	$\nearrow$	$\nearrow$	10.0	7.7	$\nearrow$	$\nearrow$	11.3	8.9
f_1+f_2+f_3+f_4+f_5	$\nearrow$	$\nearrow$	11.2	9.1	$\nearrow$	$\nearrow$	13.1	11.1
f_1+f_2+f_3+f_4+f_5+f_6	$\nearrow$	$\nearrow$	11.6	9.5	$\nearrow$	$\nearrow$	13.5	11.6

Each line corresponds to a set of products controlled by an hypothetical monopolist. For example, 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 $\Delta\pi_5$ and "$\Delta\pi_{10}$" indicate, whether a price increase of 5% and 10%, respectively, would increase or decrease the hypothetical monopolist's profits. The column labeled $\frac{\Delta p}{p}_{(u)}$ indicates the UPP price variation and the column labelled $\frac{\Delta p}{p}_{(s)}$ indicates the equilibrium price variation.

B Figures

Figure 1: Triple-play elasticities - distribution per operator

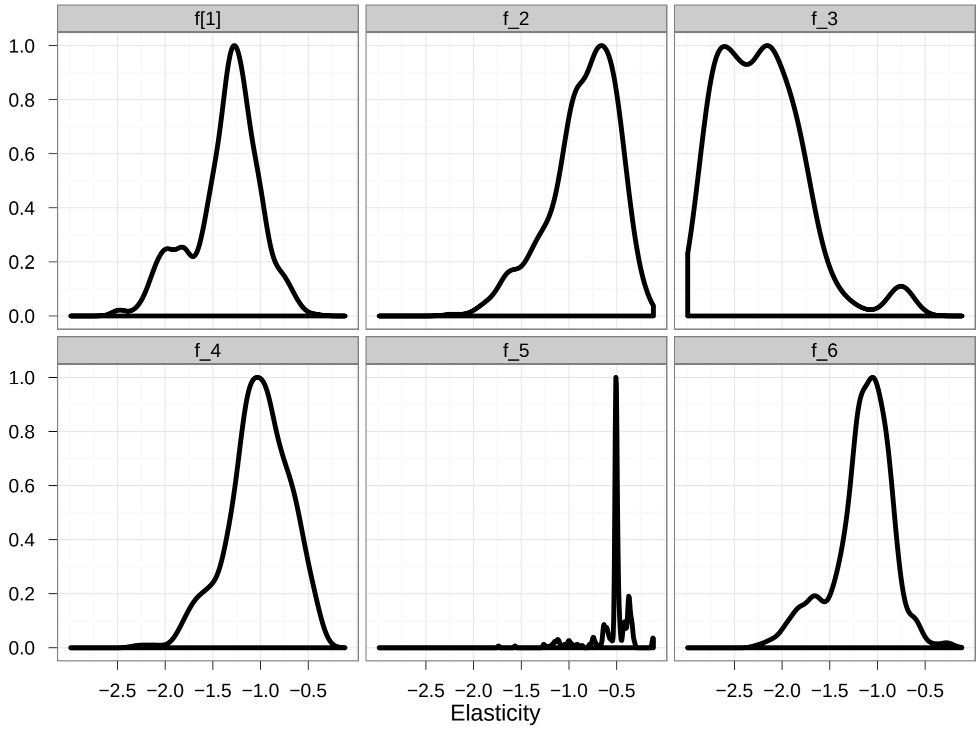

Figure 2: Models by region