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Comparing Mobile Communication Service Prices Among Providers: A Hedonic Approach

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Abstract

The present article proposes a new approach to compare mobile communication service prices among different communications service providers. To this end, a hedonic model based on monthly phone bills is employed that relates billed amounts and the quantities of consumed mobile communication services. A linear hedonic regression model is separately estimated for each provider and then used to estimate prices. Laspeyres, Paasche, and Fisher double-imputed price indices are then used to compare prices across communications service providers on an aggregate level. The sensitivity of these indices in relation to the estimated hedonic functions is investigated using a generalized additive model.

Keywords:
Mobile communication, price indices, prediction, hedonic regression.
JEL: C43, C52, C53, P42.

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1. Introduction

Mobile communication markets usually have a limited number of communications service providers (CSP). With only a few providers competing in the market, oligopolistic competition with all nuances is often present, and careful price monitoring is required. Providers mainly compete by offering different tariffs to consumers, whereas consumers try to minimize mobile communication costs. The proposed tariffs, however, usually include too large of a number of specifications to be fully included in price comparisons.

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In Switzerland, to compare prices of mobile communication services, the Federal Office of Communications (2012) uses the method suggested by the Organisation for Economic Co-operation and Development, see OECD (2010). By this method, three basic consumption baskets are constructed for small, medium, and strong consumption profiles, respectively. The monthly minimal cost tariff is determined for each provider and profile. These minimal costs for each profile are finally compared across providers. Cost-minimizing consumers, perfect information, and full flexibility in the choice of the provider are key assumptions of this approach. In reality, these hypotheses are not necessarily satisfied. Firstly, consumers do not necessarily minimize overall costs, either because they don't behave perfectly rationally, or because perfect information is not present. In fact, different contract elements such as special discounts[1] or discounts on mobile phone prices make precise comparisons very complicated and are ignored in the OECD approach. Secondly, in the Swiss market, contracts usually have minimal durations of at least one year. Consumers are often faced with so-called rollover contracts that are extended automatically after the basic duration, if not terminated explicitly. Therefore, consumers cannot switch flexibly between different contracts and providers. Finally, besides the violation of the above hypotheses, the Federal Office of Communications (2012) identifies the following problems related to the minimal cost approach: The volume of mobile data traffic is not considered, special services cannot be implemented, price discounts on phones for subscribing to a contract are neglected, demographic discounts are missing, and network quality (coverage) cannot be evaluated. Thus, although being time-efficient, the OECD method used misses many aspects of the mobile communication market.

To address these problems, we suggest adopting a hedonic approach. Hedonic methods have been mainly used to evaluate housing and high-technology goods and analyze their price behavior across time. See, for example, Hill (2012) and Triplett (2004). In the present context, the standard hedonic approach is modified to compare mobile communication prices across providers. To this end, for each consumer possessing a contract with a given provider, we identify the quantity of the consumed mobile services (call minutes, text messages, megabytes, etc.) through monthly phone bills. For each provider, consumption prices for all services are then estimated by regressing the monthly billed amount on the quantities of the consumed mobile services. Using then

[1] We consider as special discounts, for example, demographic discounts for students, free-to-call phone numbers for selected persons, and all other kind of very distinct contract modifications, which are provider-specific offers.

the estimated consumption prices, classic price index formulae can be used to compare communication costs (or final, aggregate prices) across providers. To the authors' best knowledge, this is the first time this methodology is adopted. Moreover, in contrast to the research conducted in other domains of application, an approach to evaluate the sensitivity of hedonic indices with respect to the estimated linear hedonic function is proposed.
Section 2 introduces the hedonic methodology applied to the case of mobile communication service prices. In particular, the hedonic regression model and double-imputed hedonic price indices are discussed. The used dataset and the empirical results are described in Section 3. Section 4 summarizes the key findings and provides an outlook for further research.

2. Mobile Communication Service Prices

This section is structured in two parts. In the first part, the hedonic regression approach is adapted to compare communications service providers, and model specification issues are described. Double-imputed hedonic price indices are then presented in the second part.

2.1. Hedonic Approach to Mobile Communication Service Prices

Let p_i^s be the monthly billed amount of the i-th consumer belonging to provider s. The vector $\mathbf{x}_i^s := (x_{i1}^s, ..., x_{iK}^s)$ denotes the consumed quantities of mobile services (minutes, text messages, megabytes, roaming, etc.). Clearly, if all L price-relevant variables $\mathbf{x}^s := (x_1^s, ..., x_{L_s}^s)$ of a specific provider were known and quantified, the following deterministic equation would hold for each individual

$$p_i^s = \beta_1^s x_{i1}^s + ... + \beta_{L_s}^s x_{iL_s}^s, \tag{1}$$

where $\beta_1^s, ..., \beta_{L_s}^s$ may represent the prices of the consumed units. Importantly, all possible factors determining the cost of consuming mobile services (subscription type, provider-specific options, etc.) are included in this equation.
Unfortunately, the above equation cannot be used to compare total cost (or billed amounts) across providers for two reasons. The first reason is related to the high number of price-relevant variables L_s: subscriptions in the mobile communication market get more and more complex, it seems difficult to consider all these provider-specific variables in a statistical analysis. The second reason stems from the very nature of the considered problem. With the main purpose being the comparison of mobile communication service prices across providers, we must define a subset of price-relevant variables $\mathbf{x} := (x_1, ..., x_K)$, $K < L_s \; \forall s$ that is shared by all providers. This allows

us to define a set of consumption variables for which prices can be directly compared across providers.
We thus adopt a hedonic approach, and for each provider, we assume that

$$p_i = f^s(\mathbf{x}_i) + u_i^s,\ i = 1, ..., n_s, \tag{2}$$

where u_i^s is a stochastic error term, and n_s represents the number of observations of provider s. The function f^s represents the so-called hedonic function, and describes for each provider how the consumed quantities interact to build the billed amount.
Two remarks are necessary to understand the adopted hedonic model. First, in contrast to the standard methodology presented in the hedonic literature, the time dimension has been suppressed. This doesn't mean that time is not present: Communication service prices are compared for different providers over a given time interval. If the time interval spans several months, we assume that bills of different consumers are randomly sampled during this period, allowing us to consider the individual observations as independent to each other. The time dimension is introduced at the end of this section, and is handled by chaining. Time correlation is not present in the considered time interval for a given provider, and must not be considered in the hedonic model. We can thus assume that the error terms $u_i^s,\ i = 1, ...n_s$ are independent.
Second, an additive hedonic function f^s can be assumed in the present context: Although the error term u_i^s contains the provider-specific options that affect the price paid for consuming the quantities $\mathbf{x}^s := (x_1^s, ..., x_K^s)$, the total cost is given by summing the costs of the individual consumption variables. These individual costs can be modeled using non linear functions $f_1^s, ..., f_K^s$ of the consumed mobile services:

$$p_i = \beta_0 + f_1^s(x_{i1}) + ... + f_K^s(x_{iK}) + u_i^s,\ i = 1, ..., n_s. \tag{3}$$

If the stochastic error term does not contain variables affecting the price behavior of the consumed quantities, we can safely assume a linear model specification

$$p_i = \beta_0^s + \beta_1^s x_{i1} + ... + \beta_K^s x_{iK} + u_i^s,\ i = 1, ..., n_s. \tag{4}$$

The coefficients $\beta_0^s, \beta_1^s, ...\beta_K^s$ are called shadow prices of consumed units. The intercept term in equation (4) corresponds to the price to have a contract with a specific provider, that is the contract's subscription price. As shown in Section 3, the intercept is usually quite large, and shadow prices are very small, thus making the interpretation of the coefficients difficult. The constant can

be suppressed, and then the coefficients can be interpreted as average unit prices, but they are biased. Equation (4) constitutes a special application of the hedonic approach: Instead of representing the intrinsic quality of a good, the independent variables correspond to the users' consumption behavior. If users tend to choose mobile contracts according to their consumption profiles, a correlation between the consumption variables and the regression error term has to be expected. For this reason, the consumed quantities may not be considered as exogenous variables. In this case, the usual OLS estimator is biased and not consistent, and a causal interpretation of the equation is not possible. It could be solved by instrumental variables such as, for example, the contract type or maybe the age of the consumer. The endogeneity problem, however, is not necessarily always present. In the case of the Swiss mobile market, for example, one could argue in the following manner. Because users receive a discount on a new mobile phone when a mobile contract is subscribed, and the magnitude of the discount depends on the contract, the choice of the contract is mainly motivated by the discount on the new mobile phone. The choice of the contract is thus independent of the user's consumption profile, and this effect is fully contained in the implemented variable for the new mobile phone received for subscribing.
In the empirical part of the paper, equations (3) and (4) are estimated using two different regression approaches. Because the main goal of the present paper is the computation of hedonic price indices, a causal interpretation of equations (3) and (4) is not necessary. Our efforts are devoted to obtaining a good prediction performance of the hedonic model, and the endogeneity problem has not been considered. The endogeneity problem, however, deserves a rigorous statistical investigation and represents an area of further research. Additionally, the hedonic function does not need to be modeled necessarily by a linear specification; a broad set of alternatives exists that should be considered in further analyses.

2.2. Hedonic Price Indices

Let $M^s := \{\mathbf{m}_1^s, ..., \mathbf{m}_{N_s}^s\}$ denote a basket containing N_s consumption profiles of provider s, where $\mathbf{m}_i^s = (m_{i1}^s, ..., m_{iK}^s)$ represents the i-th consumption vector. The hedonic regression models estimated through equation (3) or equation (4) are used to compute the Laspeyres, Paasche, and subsequently Fisher double-imputed hedonic price indices according to the consumption basket

$$HPI_{s_1 s_2}^L(M^{s_1}) = \frac{\sum_{i=1}^{N_{s_1}} \hat{f}^{s_2}(\mathbf{m}_i^{s_1})}{\sum_{i=1}^{N_{s_1}} \hat{f}^{s_1}(\mathbf{m}_i^{s_1})} \tag{5}$$

and

$$HPI^{P}_{s_1 s_2}(M^{s_2}) = \frac{\sum_{i=1}^{N_{s_2}} \hat{f}^{s_2}(\mathbf{m}_i^{s_2})}{\sum_{i=1}^{N_{s_2}} \hat{f}^{s_1}(\mathbf{m}_i^{s_2})}. \tag{6}$$

The Laspeyres price index (equation (5)) tends, in fact, to favor the provider s_1 because the total consumption costs $\sum_{i=1}^{N_{s_1}} \hat{f}^{s_1}(\mathbf{m}_i^{s_1})$ are probably lower than $\sum_{i=1}^{N_{s_1}} \hat{f}^{s_2}(\mathbf{m}_i^{s_1})$ due to the consumers' rationality. In fact, consumers may adapt their consumption behavior to the underlying contract. Similarly, the Paasche price index (equation (6)) tends to favor the provider s_2. Computing a geometric mean of the two indices should solve this problem. We thus define the Fisher hedonic price index by

$$HPI^{F}_{s_1 s_2}(M^{s_1}, M^{s_2}) = \sqrt{HPI^{L}_{s_1 s_2}(M^{s_1}) \cdot HPI^{P}_{s_1 s_2}(M^{s_2})}. \tag{7}$$

The Fisher index describes the price for aggregate consumption.[2] Importantly, the Fisher price index allows us to counter the asymmetry present in the Laspeyres and Paasche price indices.

The main point is how to define the provider-specific basket M^s. The double-imputation method applied in the empirical part defines the consumption basket as the set of consumption vectors that have been observed for each provider: $M^s = \{\mathbf{x}_1, ..., \mathbf{x}_{n_s}\}$ and $N_s = n_s$. In this case, the consumption vectors used to estimate the hedonic regression function are also used to compute double-imputed hedonic price indices. However, other approaches to compute hedonic price indices have been suggested in the literature, see Hill (2012). The characteristic hedonic approach, for example, uses a basket M^s containing a single consumption vector. The contained units are defined as the average of the observed consumption profiles. Interestingly, Schöni (2014) has demonstrated that if equation (4) holds, the double-imputed and characteristic methods are asymptotically equivalent. For this reason, we focus on double-imputed hedonic price indices. The main motivation to use double and not single imputation is to compare "equal to equal "and, therefore, avoid comparing predicted prices of one provider to observed ones of another provider.

Hitherto, only price levels between providers have been compared. If the

[2]Note that expenditure shares are used implicitly. Observations with intense consumption are weighted stronger because the predicted billed amounts or monthly cost are relatively high. Therefore, consumers with intense consumption obtain a higher weight in the index than others. Alternatively, by weighting all consumers or observations equally, a modified version of the Törnqvist index could be used to describe the relative price for an average consumer, see Seger (2014).

time dimension will be considered, two main approaches are possible. With the first approach, prices between two providers at different points of time can be directly compared through Fisher indices as shown above. Through this approach, however, fast technical progresses in mobile communication and the corresponding new consumption units and contracts are difficult to account for. In this case, price indices are more complicated to construct, and the price behavior they describe over large time intervals is less accurate. A better solution is provided by chaining. We suggest, in a set-up with several providers and time periods, first comparing each provider to the entire market (all providers together) for a given time period. Providers are thus treated equally, and the base period is not a provider but the entire market, or, equivalently, the average of all providers. Secondly, when a new time period is considered, we also compute the period-specific price indices as in the previous period. After the hedonic indices for the two time periods have been estimated, they can be chained to compare prices across providers and time periods.

3. Empirical Results

This section contains three parts. First, the underlying dataset is described, then, the models are estimated, and finally, based on the estimations, indexes are constructed.

3.1. Swiss Mobile Communication Market and Data Description

The Swiss market for mobile communication is mainly shared by three providers. According to the Federal Communications Commission (2013), Swisscom holds the biggest market share (62.4%), followed by Sunrise (20.9%) and Orange (16.7%).
The dataset used for the present analysis is based on monthly bills belonging to students and employees of the University of Fribourg. The entire sample includes 415 bills, supplied from 60 consumers from 2012 and the first quarter of 2013 (see Table 1). Note that our dataset is neither representative for Switzerland, nor for the University of Fribourg. The aim is to show a practical implementation of the approach presented in Section 2.

Although individuals supplied several monthly bills, we assume that observations are independent in a given time period. In fact, if the proposed methodology were to be implemented in official statistics, only one bill per consumer in a time interval should be randomly sampled. The collected data allows us to implement the hedonic provider comparison explained in Section 2. As shown in Table 1, nearly all bills belong either to Swisscom or Orange for the following reasons. Firstly, Swisscom is by far the largest provider.

	Q1.12	Q2.12	Q3.12	Q4.12	Q1.13
Swisscom	0	1	66	99	50
Orange	35	44	43	49	23
Sunrise	0	0	0	3	2
Total	35	45	109	151	75

Table 1: Number of observations per quarter and provider

Secondly, some Sunrise bills did not contain complete information on consumed mobile services and could not be used for price comparison. On the contrary, missing data of Swisscom bills could be retrieved in the consumers' on-line account, but only for the past six month. Therefore, Swisscom bills are mostly available for the third and fourth quarter of 2012 as well as the first quarter of 2013. On the contrary, Orange bills are equally distributed over the entire year.

Table 2 shows the collected bills' data. All the data with exception of the phone discount is contained in phone bills. The first variable describes the

Grouped	Single	Description	Mean	Median	SD	Min	Max
Billed amount	Billed amount	Exclusively for mobile communication services, in CHF	55.61	45.64	33.05	1.10	264.20
Minutes	Fix net	Calls on fix net	41.85	18.73	60.15	0.00	436.50
	Mobile	Calls on mobile net	114.40	73.68	135.53	0.00	927.10
Text messages	SMS	SMS sent	50.30	41.00	88.68	0.00	658.00
	MMS	MMS sent	1.55	0.00	4.38	0.00	35.50
MB	MB	Megabyte used	442.50	234.50	663.66	0.00	5954.00
Roaming minutes	CH minutes roaming	Calls out of Switzerland	7.90	0.00	53.25	0.00	583.70
	Roaming minutes	Outgoing and incoming calls abroad	1.27	0.00	4.35	0.00	34.05
Roaming text	CH SMS roaming	SMS out of Switzerland	2.65	0.00	8.14	0.00	103.00
	Roaming SMS	Roaming, SMS abroad	2.31	0.00	8.25	0.00	94.00
	Roaming MMS	Roaming, MMS abroad	0.02	0.00	0.16	0.00	2.00
Roaming MB	Roaming MB	Roaming, MB abroad	1.00	0.00	6.88	0.00	95.98
Phone discount	Phone discount	Monthly discount on mobile phone price, in CHF	13.45	14.58	9.64	0.00	38.55

Table 2: Data from phone bills

billed amount on a monthly phone bill. Occasionally, additional services such as purchases with text messages or costly hotline calls are charged on phone bills. These services are provided by third-party firms and are thus excluded from the index by subtracting them from billed amounts and consumed quantities.

Consumption variables have been divided into grouped and single categories. Single variables listed in Table 2 correspond to consumption units as reported on phone bills. For estimation purposes, these single variables have subsequently been grouped together. Note that all variables (except the billed amount) possess a minimal value of zero, thus forbidding the use of several model specifications such as, for example, semi- and double-logarithmic models.

As already mentioned, the phone discount is not present on the bills, and its computation requires additional information. Because of the major role the discount plays in the choice of the provider, it should not be excluded from the model. It requires the following informations for every contract holder or consumer: phone model received for signing a contract, price to be paid for the phone to the provider, purchase date, and the minimal duration of the contract. Based on the phone model and the purchase date, the average market price of the phone model in a given point of time can be determined.[3] The monthly phone discount is finally obtained as the difference between the average market price at the purchase date and the price paid to the provider, divided by the minimal duration of the contract (in months). Detailed informations on all issues related to practical problems, data management, consumer surveys, and phone discounts can be found in Seger (2014).

3.2. Model Estimation

Equations (3) and (4) have been estimated with the gradient boosting and OLS methods, respectively. Table 3 shows the results of the OLS estimation with and without influential observations.[4] The grouped variables presented in the previous section have been used for the following reasons. First, grouped variables seem to lessen the multicollinearity problem, thus reducing the variance of the predicted costs. Second, the estimation of the GAM model presented in the next section with ungrouped variables was unfeasible/unreliable because of the ill conditioning of the regressors' matrix. Third, statistical tests on the functional form and heteroscedasticity display better results.

As reported in Table 3, most of the coefficients of both providers are left unchanged after deleting influential observations (6% and 7.7% of the total observations of Swisscom and Orange have been discarded, respectively). Importantly, Orange's model specification and heteroscedasticity seem to greatly improve after removing influential observations. Although removing

[3]We used `www.toppreise.ch` to determine the average market price of a phone at a given point in time. There, average phone prices over time are plotted. The prices are the average among a set of offers from different online stores.

[4]Influential observations have been identified by using the DFFIT values of each observation and removing the observations possessing a DFFIT value greater than a given threshold value.

	With influential observations		Without influential observations	
	Swisscom	Orange	Swisscom	Orange
Constant	35.23^{***}	43.91^{***}	29.93^{***}	42.17^{***}
	(3.02)	(4.25)	(2.20)	(3.25)
Minutes mobile	$-0.02^{\cdot}$	0.08^{***}	$-0.01^{\cdot}$	0.08^{***}
	(0.01)	(0.02)	(0.01)	(0.02)
Minutes fix	0.10^{***}	-0.04	0.11^{***}	0.01
	(0.03)	(0.03)	(0.02)	(0.02)
Megabytes	0.02^{***}	0.00	0.02^{***}	0.00
	(0.00)	(0.01)	(0.00)	(0.00)
Text messages	0.02	0.00	0.02^{*}	0.01
	(0.01)	(0.02)	(0.01)	(0.02)
Roaming minutes	0.14^{***}	0.88^{***}	0.15^{***}	0.78^{***}
	(0.02)	(0.15)	(0.03)	(0.20)
Roaming text	$0.23^{\cdot}$	0.84^{***}	0.22^{*}	1.09^{***}
	(0.12)	(0.16)	(0.10)	(0.24)
Roaming MB	1.37^{***}	1.39^{***}	1.93^{***}	1.47
	(0.22)	(0.33)	(0.55)	(1.40)
Phone discount	0.09	-0.16	0.37^{*}	$-0.23^{\cdot}$
	(0.20)	(0.17)	(0.15)	(0.13)
Adj. R^2	0.68	0.41	0.64	0.39
RESET	0.11	0.00	0.34	0.92
Koenker	0.14	0.00	0.93	0.15
Num. obs.	216	194	203	179

$^{***}p < 0.001$, $^{**}p < 0.01$, $^{*}p < 0.05$, $^{\cdot}p < 0.1$

Table 3: OLS estimation

Swisscom's influential observations does not seem to bring evident advantages, they are nevertheless removed to guarantee an equality of data treatment between the two providers. Note that deleting influential observations excludes parts of the truly observed consumption and might bias the index. However, it is finally a trade-off between estimation accuracy and including all sampled phone bills.
Importantly, the functional form and heteroscedasticity tests are valid if the linear model's hypotheses are satisfied. In the case of endogenous regressors, these tests would not be reliable, and other approaches to investigate the functional form are necessary.

3.3. Sensitivity Analysis

Due to the possible problems related to the functional form, a generalized additive model corresponding to equation (4) has thus been estimated using a gradient-boosting approach with smooth components (the individual functions $f_1, ..., f_K$ are estimated using P-splines, i.e. the individual price functions are polynomials of the consumed quantities).[5] To improve

[5] A multiple Box-Cox transformation of the regressors was initially attempted. However, because many variables possess zero values, the approach could not be implemented.

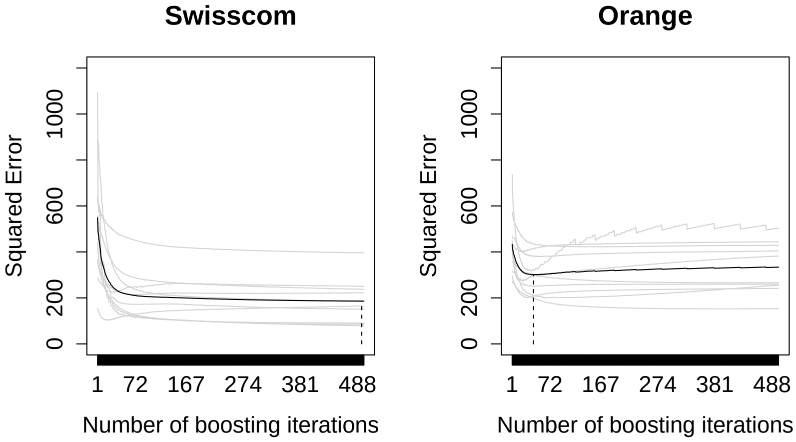

Figure 1: Boosting GAM, cross-validated models

the models' out-of-sample prediction accuracy, the number of boosting iterations has been determined using a cross-validation approach. Figure 1 shows the average mean squared prediction errors of Swisscom and Orange and the optimal number of boosting iterations. Although not having obtained coefficients' estimates, we can observe the partial dependency of the function f^s with respect to the individual variables.[6] Figures 2 and 3 show the partial dependency plot of Swisscom and Orange, respectively. Two interesting facts can be observed in these figures. Firstly, the GAM and linear model do not differ concerning the impact of the individual variable on the cost function: Variables possessing a coefficient not significantly different from zero, also possess a partial dependence plot represented by a constant nearly equal to zero. Secondly, significant variables in the classic linear model also display an almost linear partial dependence plot. This implies that the subscription options included in the error term seem not to affect the price behavior of the individual variables, thus supporting the use of the ordinary linear regression model.

The prediction performance of the two regression models has been compared using a cross-validation approach. Although the boosting approach has been tuned to improve his out-of-sample prediction accuracy, the OLS method seem to provide a slightly better prediction performance, thus further suggesting the use of the classical reference model in equation (4). However, the

[6]In the present context, a partial dependence plot represents the effect of one consumption variable on the global cost function f^s after accounting for the average effects of the other consumption variables. See Hastie et al. (2003) for further details.

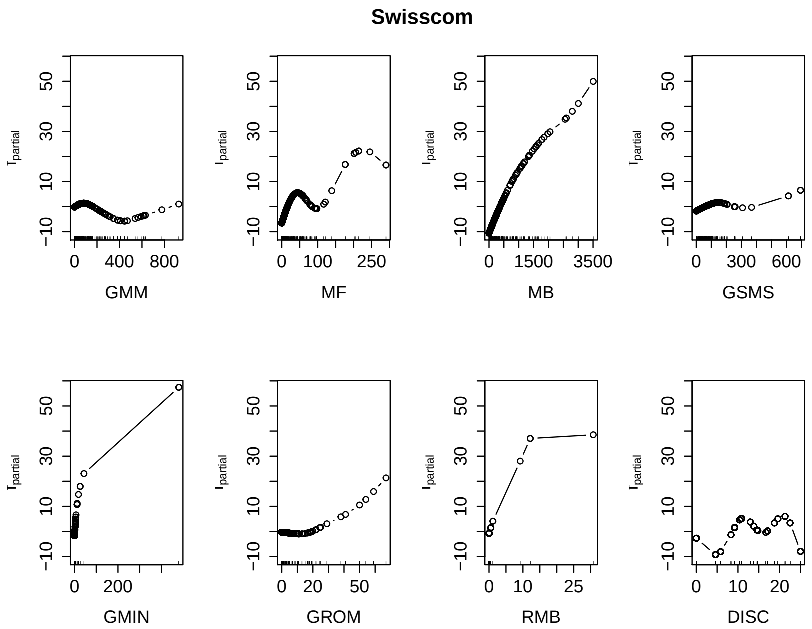

Figure 2: Swisscom partial functions

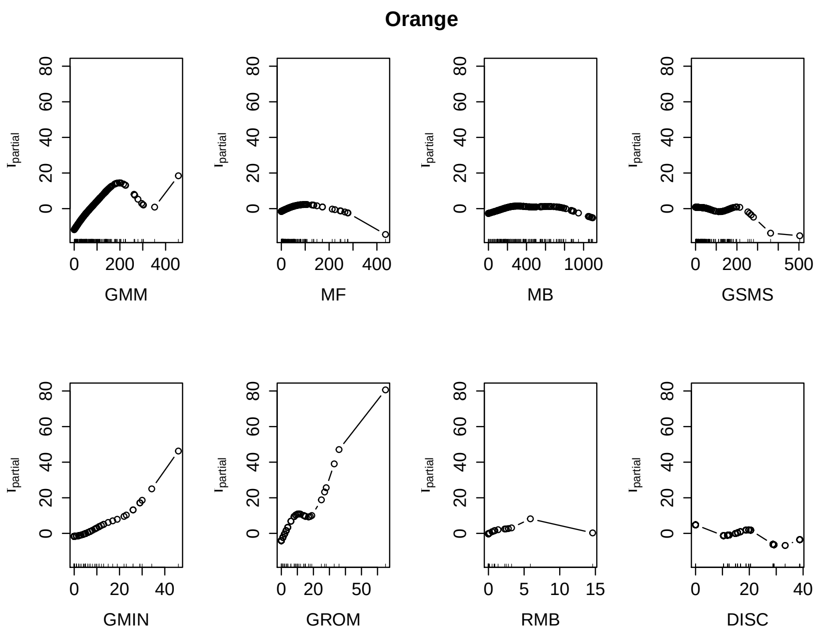

Figure 3: Orange partial functions

prediction performance of the OLS approach is more unstable for the two providers (the mean squared prediction error greatly varies depending on the out-of-sample data).

3.4. Index Numbers

The Laspeyres, Paasche, and Fisher hedonic price indices have been estimated using a double-imputation approach and are shown in Table 4. As can be seen, Laspeyres and Paasche price indices estimated using the model in equation (4) and the OLS technique display greater price differences than those estimated with the model in equation (3) and the boosting technique. This is probably due to the fact that generalized additive models possess a greater flexibility, and their tuning parameters (number of boosting iterations) have been selected to improve the out-of-sample prediction accuracy. In fact, the hedonic price indices values obtained with the generalized additive model are more plausible than the values provided by the classic linear approach. Remarkably, the Fisher price indices of both approaches are equal.

	Laspeyres	Paasche	Fisher
OLS	1.26	0.85	1.04
GAM	1.11	0.97	1.04

Table 4: Hedonic price indices, Swisscom as base

4. Conclusions

In the present paper, we proposed a new application of hedonic methods to compare mobile communication prices across providers. In particular, Laspeyres, Paasche, and Fisher double-imputed hedonic price indices have been computed for two leading providers of the Swiss mobile communication market. Moreover, a hedonic regression model specific to the consumption of mobile services has been proposed and its sensitivity tested in the empirical part.

In contrast to the method presently used by the OECD, all the variables influencing the consumption of mobile services are considered in the index. Using a hedonic approach allows us to evaluate prices according to truly observed consumption and to treat all contracts or tariffs equally. Assumptions on perfect information and rational consumers are not needed.

Three main conclusions can be drawn from our study. Firstly, the generalized additive model confirms the use of the ordinary linear regression model: Individual consumption variables enter linearly in the price function, even if some

unobserved variables are included in the stochastic error term. Secondly, although it has a prediction performance similar to the linear model for a given provider, the GAM model estimated with a boosting approach and smooth components displays more reasonable prediction results when the hedonic regression estimated for one provider is used to predict the consumption prices of the other provider. Thirdly, independently of the regression method, the Fisher hedonic price index is stable. The provided methodology seems therefore to provide a better alternative to the methods currently used to compare mobile communication prices across providers.
Importantly, many technical aspects have not been treated in the present paper. From an econometric point of view, a causal interpretation of the hedonic price function, for example, could be important to understanding which variables contribute the most to the bill amount for each provider. Such interpretation is not easily achieved, mainly because of the potential endogeneity and multicollinearity problems. From the point of view of price index theory, the proposed methodology could be extended to compare mobile communication prices of providers across several periods, thus providing the possibility to observe how the pricing system of mobile communication providers evolves during a given time period. These questions, however, represent the subject of further research.

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Abstract
The present article proposes a new approach to compare mobile communication service prices among different communications service providers. To this end, a hedonic model based on monthly phone bills is employed that relates billed amounts and the quantities of consumed mobile communication services. A linear hedonic regression model is separately estimated for each provider and then used to estimate prices. Laspeyres, Paasche, and Fisher double-imputed price indices are then used to compare prices across communications service providers on an aggregate level. The sensitivity of these indices in relation to the estimated hedonic functions is investigated using a generalized additive model.

Keywords
Mobile communication, price indices, prediction, hedonic regression

JEL Classification
C43,C52, C53, P42

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