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Impact of competition and regulation on prices of mobile services: Evidence from France*

Lukasz Grzybowski[†] Ambre Nicolle[‡] Christine Zulehner[§]

Abstract

In this paper, we assess the impact of competition and regulation on prices of mobile services in France. We estimate hedonic price regressions using data on tariff plans offered by the main mobile telecommunications operator in France between May 2011 and December 2014. In this time period, the obtained quality-adjusted price index decreased by about 51% as compared to a decline in average prices without quality adjustment of 8.9%. In a second step, we relate the quality-adjusted prices to a set of competition and regulation variables and find that the launch of 4G networks by mobile operators was the main driver of price reductions for classic tariffs with commitment. Low cost tariffs without commitment which were introduced to pre-empt the entry of low cost competitor declined at the time of entry. Moreover, we find that regulation, which is approximated by the level of mobile termination charges and international roaming price caps for voice and data, has jointly a significant impact on quality-adjusted prices. In percentage terms, competition is responsible for about 68% of total price decline. We conclude that the reduction in quality-adjusted prices in the last years was largely caused by competition between established operators and by entry of fourth low cost operator.

Key Words: *Mobile telecommunications; hedonic price regression; regulation; entry*

JEL Classification: L13, L50, L96

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1 Introduction

The competitiveness of mobile telecommunications industry is commonly assessed by the industry regulators on the basis of price comparisons over time and across countries.¹ But such comparisons are not easy for industries which exhibit dynamic changes in both price and quality of products. Pricing of mobile telecommunications services has remained complex since the launch of mobile technology in 1990s. Initially, mobile operators charged different prices for calls to mobile and fixed-line numbers as well as calls made peak and off-peak, on- and off-net with different billing intervals per second, per 10 seconds, per minute, which also could differ for the first and subsequent minutes of the call. Apart from that the price of calls differed depending on tariff and monthly subscription fee, length of contract and handset subsidy. Over time, much simpler pre-paid tariffs were introduced without commitment and tariffs which included minutes allowances. But operators also started to complicate tariffs by introducing special prices for selected numbers, family offers, etc. In addition, new services were introduced which were either substitutes or complements to voice calls, including SMS, MMS, voice mail, roaming, etc. The next pricing revolution came with the development of 4G networks and increasing demand for mobile Internet access. Mobile operators now typically offer unlimited voice calls and data allowances which makes them more transparent to consumers than before. Still, a large number of tariffs is offered on monthly basis with a rapid turnaround.

The pricing strategies of mobile operators and continuous changes in the range of services make it very difficult to follow how prices evolved in the last years. At the same time, tracking price changes in mobile telecommunications is very important because they represent a significant share in monthly expenditure of every household and are typically included in the ‘basket’ of products and services used to calculate inflation.² Moreover, prices of mobile services are closely watched by industry regulators because they should be affected by termination charges which are regulated in some countries. Also, an ongoing convergence of fixed-line and mobile

¹See for example the reports published by OECD, European Commission and national regulators.

²In France, the consumer price index (CPI) for the first time took into account a price index for mobile services in January 2004. The index was calculated using the customer profile method, which was recognized as the best approach by statisticians dealing with price indices. However, both data requirements and resources needed to establish and maintain this approach are substantial.

technologies and increased popularity of bundled offers affect prices and draw attention of the policy makers.³

Mobile prices were also at the core of antitrust investigations including collusion and merger cases. For instance, collusion in mobile telephony was detected and prosecuted in France in 2005. In the last years, several mergers took place between mobile operators, including mergers which were cleared by the competition authorities such as the acquisition of tele.ring by T-Mobile in Austria in 2006, a merger between T-Mobile and Orange in the Netherlands in 2007, a merger between T-Mobile and Orange in the UK in 2010 and a merger between O2 and E-Plus in Germany in 2014⁴. Other mergers were blocked by the competition authorities, for instance the recently proposed transaction between Three and O2 in the UK. The post-merger prices were the main concern in deciding on these transactions. Apart from mergers, also when deciding about the number of new spectrum licences the regulators take into account their impact on retail prices. Even though the numbers of mobile competitors was largely decided in the 1990s during spectrum auctions for 2G and 3G technologies, the more recent 4G auctions brought changes to the market structure. It is therefore interesting to know whether entry increases competition and results in lower prices.

In this paper, we estimate hedonic price regressions using a complete database of tariff plans offered by the leading mobile telecommunications operator in France, Orange, on monthly basis between May 2011 and December 2014.⁵ We divide the tariff plans into two groups: classic contract tariffs with commitment and low cost contract tariffs without commitment and handset subsidy. In the latter case, consumers do not have to commit to stay with the operator for 12 or 24 months and can quit the contract at any time. Low cost tariffs were introduced by Orange in October 2011 before the entry of fourth mobile operator, Free Mobile. We regress the cost of tariffs on a set of characteristics including monthly dummy variables, and derive

³According to a report by Analysys Mason, about 42% of fixed broadband households in France bundled mobile voice contracts with their fixed broadband service at the end of 2012, which based on forecasts should increase to 75% by the end of 2017.

⁴See for example, Aguzzoni et al. (2015) for an ex-post analysis of two mobile telecom mergers in Austria and Netherlands

⁵Orange, formerly France Telecom, is the incumbent fixed-line operator in France. Orange is also market leader in mobile market and its pricing strategies are representative for the whole market. It was followed by the competitors in the decisions to launch low cost tariffs and 4G services. According to data from Analysys Mason Telecom Market Matrix, the market share of Orange in mobile market was 39% as of Q3 2016.

a quality-adjusted price index. In this time period, the obtained quality-adjusted price index decreased by about 51% as compared to a decline in average prices without quality adjustment of 8.9%. Next, we regress the quality-adjusted prices on a set of competition and regulation variables and find that the launch of 4G networks by mobile operators was the main driver of price reductions for classic tariffs with commitment. At the same time, low cost tariffs without commitment were introduced to pre-empt entry of low cost competitor Free Mobile and declined at the time of entry. Moreover, we find that regulation, which is approximated by the level of mobile termination charges and international roaming price caps for voice and data, has jointly a significant impact on quality-adjusted prices. In percentage terms, competition is responsible for about 68% of total price decline. Thus, we conclude that the reduction in quality-adjusted prices in the last years was largely caused by competition between established operators and by entry of fourth low cost operator. We also compare the results from our hedonic price regressions with alternative approaches which track price changes over time based on consumer usage profiles, such as the OECD usage basket method. This approach is commonly used to analyze the evolution of prices of telecommunications services. We can draw similar conclusions with respect to the role of competition and regulation based on these alternative approaches.

Our study contributes to the literature on hedonic price regressions with an application to the telecommunications industry and to the literature on the impact of competition and regulation on prices of mobile services. The hedonic price model is based on the idea that any product can be viewed as a bundle of attributes. Firms and consumers trade with each other to determine the price attached to each attribute (see Griliches (1961) and Rosen (1974) for a formal presentation of this model in perfectly competitive framework). There are only a few empirical studies of prices indices for mobile telecommunications services. For instance, Grzybowski and Karamti (2010) estimate hedonic price regression using monthly tariff data from mobile operators in France in the period between June 1996 and December 2002. They find that quality-adjusted prices decreased in the earlier part of this period and stabilized over time. There were also significant differences in quality-adjusted prices between operators which diminished over time. Greenstein and McDevitt (2010) analyze changes in quality-adjusted prices using data on 1,500 tariffs for DSL and Cable services in the U.S. in years 2004-2009 based on a

mixture of matched-model methods and consumer price indices. They find a modest decline in prices but faster than suggested by the price index for Internet access constructed by the Bureau of Labor Statistics. In another paper, Wallsten and Riso (2015) estimate a linear hedonic model using data on over 25,000 broadband prices from OECD countries in years 2007-2009, while Calzada and Martinez-Santos (2014) estimate price regressions using broadband tariffs data from 15 EU countries in years 2008-2011. Finally, Coyne and Lyons (2015) estimate hedonic price regressions using daily observations of plans offered in Ireland from 2007 to 2013. They find that average nominal prices remain stable throughout the sample period but quality of service increased dramatically over time, particularly with respect to download speed.

Among studies on the impact of regulation on prices of telecommunications services, Genakos and Valletti (2011) analyze how the regulatory intervention to cut fixed-to-mobile (F2M) termination rates impacts mobile retail prices. Using panel data of prices and profit margins for mobile operators in more than 20 countries in a period of over six years, they find that a reduction in F2M termination rates leads to an increase in retail prices,⁶ which they call the “waterbed” effect.⁷ In a more recent paper by the same authors, Genakos and Valletti (2015) estimate the impact of regulation of F2M termination rates on mobile phone bills using a large panel covering 27 countries. They find that the “waterbed” phenomenon becomes insignificant on average over the 10-year period, 2002-2011. They argue that this is due to the changing nature of the industry, whereby mobile-to-mobile traffic surpassed fixed-to-mobile traffic. Moreover, among studies on the impact of competition on prices in telecommunications markets, Genakos et al. (2015) analyze how entries and exits influence prices of mobile services and investments in networks using cross-section panel data for 33 OECD countries in years 2002-2014. They also approximate mobile prices using Teligen’s baskets and use the estimates to comment on the effects of mergers on prices and investments. They find that mobile markets become more concentrated in the analyzed period and prices increased, while the effect of concentration on

⁶They obtained information on retail prices from a consultancy firm Teligen, which collects telecommunications pricing data. The prices are expressed in terms of three representative usage baskets (heavy, medium and low) based on a number of characteristics (number of calls and messages, average call length, time and type of call, etc.), which are then held fixed across countries and over time.

⁷The “waterbed” effect suggests that pressing down prices in one part of firms’ operations causes another set of prices to rise.

investment is not significant at the industry level.⁸

The remainder of this paper is organized as follows. Section 2 discusses the main changes in mobile telecommunications industry in France. Section 3 presents the data used in the estimation. Section 4 introduces the econometric framework. Section 5 presents the estimation results. Finally, Section 6 concludes.

2 Mobile industry in France

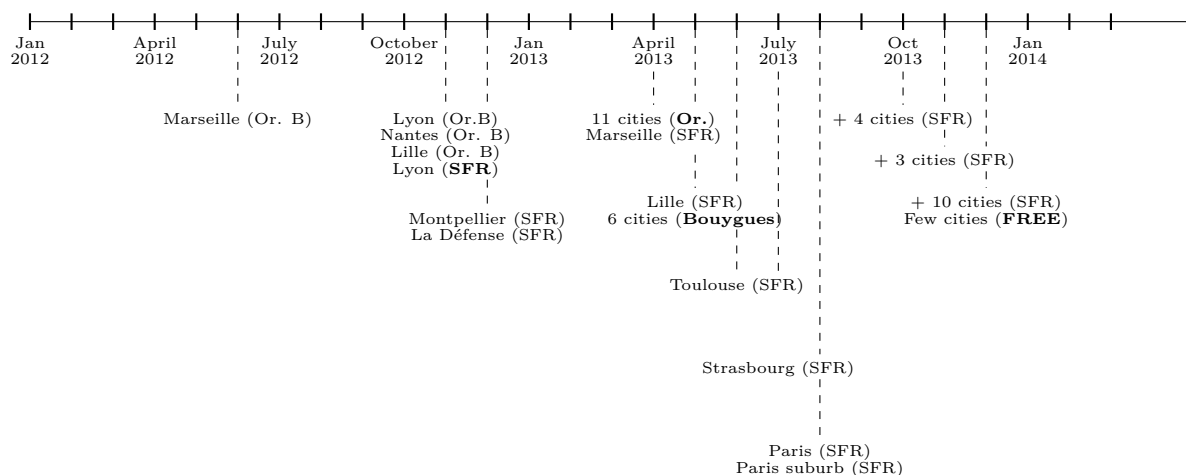
This section describes the main events that took place in the mobile telecommunications industry in France. The start of mobile telecommunications in France dates back to March 1992 when two licences for digital mobile services GSM 900 were granted to the fixed-line incumbent operator France Telecom Mobiles and Societe Francaise de Radiotelephonie (SFR). In June 1996, a third network operator, Bouygues Telecom, entered the market after being granted a licence to operate digital technology GSM 1800. In June 2001, the French government awarded two out of four 3G (UMTS) licences to France Telecom and SFR using a “beauty contest”, while Bouygues and other players pulled out of the bidding due to the high licence price. In 2002, the authorities altered the licence conditions and published a new call for two 3G licences, which were not granted in the first round. The only bidder was Bouygues, which received the licence in October 2002. Between October 2002 and December 2009, there was no new entry into the industry, except for a number of entries and exits of MVNOs.⁹ In December 2009, the French regulatory authority (ARCEP) awarded a fourth 3G license to Free Mobile. Several months later, in March 2011, Free Mobile signed a national roaming agreement with Orange for the provision of 2G and 3G services to increase its network coverage before launching mobile services. In September 2011, ARCEP awarded licences to operate 4G LTE networks to Orange, SFR, Bouygues and Free Mobile.

In October 2011, the three existing mobile operators, Orange, Bouygues Telecom and SFR,

⁸There is a burgeoning theoretical literature on the impact of mobile termination rates on prices, which started with the seminal works of Armstrong (1998) and Laffont et al. (1998). For surveys, see Armstrong (2002) and Laffont and Tirole (2000).

⁹A Mobile Virtual Network Operator (MVNO) provides mobile services without having allocated own spectrum and thus relying on network and spectrum of mobile network operators. MVNOs can apply own pricing strategies and provide customer service.

Figure 1: Early deployment of 4G services



‘Or. B’ denotes Orange Business offers. The bold text denotes the date of official launch of commercial 4G networks by each operator which we consider in our analysis.

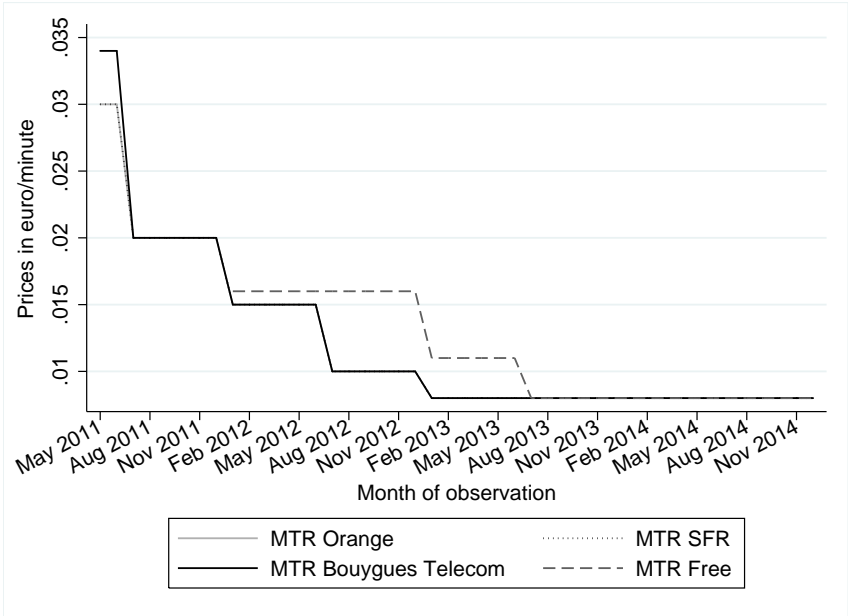
launched offers under new brands called respectively Sosh, B&You and RED with the aim to pre-empt market entry of Free Mobile. These brands offered tariffs with no handset subsidy and no commitment. After entry in January 2012, Free Mobile also launched two tariffs with no handset subsidy and no commitment. About a year later, in November 2012, SFR publicly launched its 4G services. SFR wanted to be a pioneer in 4G services, which however were initially available in one city only (Lyon). Orange on the other hand, pioneered 4G business offers, which started in June 2012 in Marseille and expanded to three other cities in November 2012. Residential 4G offers were launched in April 2013 in 11 cities. Bouygues Telecom had the best 4G coverage thanks to spectrum refarming authorization on its 1800 Mhz band, which enabled the operator to cover 40% of the French Metropolitan population when starting its 4G services.¹⁰ It started commercializing its 4G offers in May 2013, but the official launch was eventually in October 2013. At this time Bouygues Telecom offered 4G mobile plan for 15 Euros per month, which was considered to be the best available 4G tariff on the market. Finally, Free Mobile launched its 4G services in December 2013. Figure (1) shows the timeline of the launch of 4G networks by mobile operators in France.

As discussed above, during the time period of our analysis, there were two major market

¹⁰Spectrum refarming is reallocation of bands in the radio spectrum to gain more efficiency.

disruptions: entry of a fourth operator Free Mobile and commercial launch of 4G networks by all four operators. We analyze how these events influenced prices of mobile services in France. Moreover, we consider whether regulation of termination rates and roaming charges impacted quality-adjusted prices. The papers by Genakos and Valletti (2011) and Genakos and Valletti (2015) used F2M termination rates to explain changes in mobile retail prices. Since at the time of our analysis, the calls from fixed to mobile networks were not so important anymore, we use instead mobile-to-mobile (M2M) termination rates in our regressions. The theoretical literature does not provide clear guidelines on the impact of M2M termination rates on retail prices (see Armstrong (1998) and Laffont, Rey and Tirole (1998)). Moreover, due to increasing importance of mobile data, the share of M2M termination rates in operators’ revenues is decreasing and the regulation of these charges becomes less important. M2M termination rates in France are regulated by ARCEP and declined over time, as shown in Figure (2).¹¹

Figure 2: Evolution of M2M Termination Rates in France

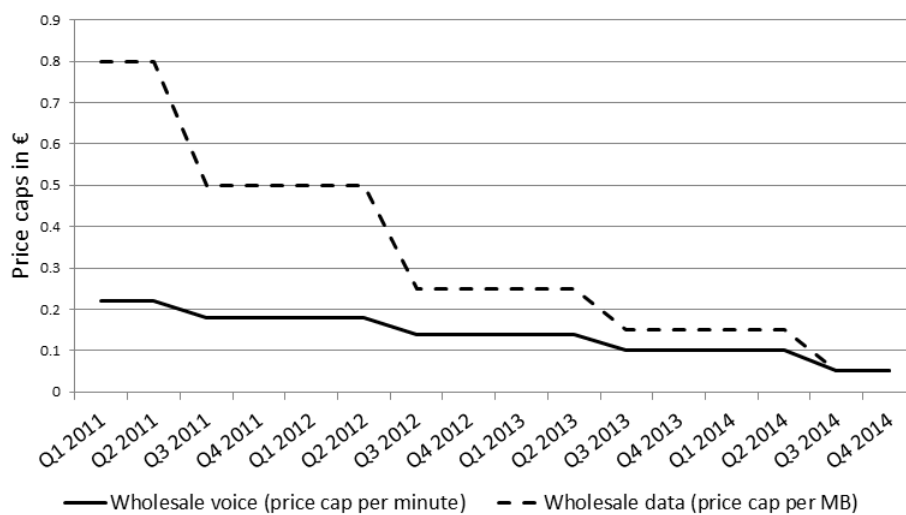


Source: ARCEP website

¹¹The termination rate is the fee that Operator A pays Operator B when one of Operator A’s customers calls one of Operator B’s customers. It pays Operator B for the cost of carrying the call on its network. Based on the European Commission’s Recommendation from 2009, MTRs should be set on a ‘pure LRIC’ basis, i.e., reflecting the long run incremental cost exclusive of any fixed and common costs. See “Commission Recommendation on the Regulatory Treatment of Fixed and Mobile Termination Rates in the EU Implications for Industry, Competition and Consumers (07/05/2009)”.

In addition, it was often stated by the operators that regulating roaming charges will result in higher retail prices. Thus, we consider the impact of roaming regulation on retail prices. Roaming charges within the European Union are regulated by the European Commission, which sets both the charges a mobile network operator can impose on its subscribers for using telephone and data services outside of the network’s country, and the wholesale rates networks can charge each other to allow their subscribers access to each other’s networks. Since 2007, the roaming regulations have steadily lowered the maximum roaming charges allowable. Figure (3) shows euro-tariffs, which are the retail price-cap that cannot be exceeded by the operators when charging fees to their customers for calling and using Internet in another EU country.

Figure 3: Roaming euro-tariffs and wholesale prices for European operators



Source: European Commission Digital Single Market website

3 The Data

For the purpose of our analysis, we combine the following data sets. First, we use a complete list of mobile tariffs offered between May 2011 and December 2014 by the main mobile operator in France, Orange. The number of unique tariffs in this period was 1,075 and the number of available tariffs on monthly basis with repetitions was 5,998. Each tariff is characterized by: (i) voice and data allowances; (ii) unit prices of voice and data over the voice and data allowances;

(iii) indicator of quadruple play tariff (QP), which includes a fixed access to Internet via DSL or FttH technology; (iv) indicator for handset subsidy; (v) commitment period of 12 or 24 months; (vi) indicator for low cost tariffs without commitment. Table (1) shows the number of unique tariffs with the starting date in a given year with summary statistics for their characteristics.

Table 1: Descriptive statistics

Year	Av.Price	Av.Data allowance	Av.Voice allowance	Share of unlimited calls plan (%)	Share of low cost (%)	Share of QP tariffs (%)	Number of unique tariffs
2011	45.37	0.65	123.9	7.4	1.6	10.8	378
2012	42.91	0.79	104.0	19.9	4.1	15.7	467
2013	39.56	1.14	101.6	36.6	8.0	20.6	525
2014	43.58	2.14	96.0	48.8	10.8	29.0	389
All	44.64	1.38	113.8	33.0	8.9	21.6	1,075

Prices are in euros, data allowance in GB and voice allowance in minutes.

Second, we use an unbalanced panel of roughly 100,000 customers observed between May 2011 and December 2014 from the same mobile operator to compute the number of subscribers to each tariff in each month. Both tariff catalogs and individual-level data were provided to us by the operator. The list of available tariffs in each month and the number of subscribers per tariff are merged together. Third, information about the level of M2M termination rates are collected from the website of ARCEP and information on roaming price caps from the website of the European Commission.

4 Econometric Model

We estimate the impact of tariff characteristics and monthly dummy variables on the cost of tariffs based on the following hedonic price regression:

$$y_{it} = \alpha + X_{it}\beta + \delta_k d_t \mathbf{1}(k = t) + u_{it} \quad (1)$$

where y_{it} denotes the list price in Euros of tariff i which was available in month t .¹² The vector of tariff characteristics X_{it} includes: (i) dummy variables for unlimited national and unlimited

¹²As a robustness check, we also estimate the model using log of dependent variable, for which the resulting quality-adjusted price index remains unchanged.

national/international voice calls; (ii) voice allowance for tariffs with limited voice minutes; (iii) dummy variables for data allowance of 0.5 GB, 1 GB, 2 GB, 3 GB, 5 GB, 6 GB, 10 GB and 14 GB; (iv) dummy variables for quadruple play tariff with DSL and FttH connections; (v) a dummy variable for handset subsidy; (vi) dummy variables for commitment period of 12 and 24 months; (vii) dummy variables for low cost mobile plans and fixed-price contract;¹³ (viii) a dummy variable for a discount of 5 Euros for 3G tariffs at the time of launching 4G tariffs. At the time of introduction of 4G services, new tariffs were introduced offering 4G Internet access, while exactly the same tariffs with 3G Internet access were offered with a discount of 5 Euros. The estimated coefficients δ_t of the monthly dummy variables $d_t \mathbf{1}(k = t)$ represent the quality-adjusted price index. The normally distributed error term is denoted by u_{it} , and the vector of coefficients $\gamma = (\alpha, \beta, \delta)$ is estimated using ordinary least squares (OLS) and weighted least squares (WLS) with shares of subscribers to particular tariffs in a month used as weights.¹⁴

In a next step, we regress the quality-adjusted price index δ_t on a set of competition and regulation variables:

$$\delta_t = \gamma + Z_t \eta + R_t \lambda + \varepsilon_t \tag{2}$$

where Z_t denotes a set of dummy variables for competition: (i) the introduction of new tariffs without commitment and handset subsidies; (ii) entry of Free Mobile; (iii) launch of 4G networks by SFR, Orange, Bouygues and Free Mobile; and R_t includes regulatory variables: (i) mobile termination rates on Orange's network and (ii) wholesale roaming price caps for voice and data. Finally, ε_t is normally distributed error term.

5 Estimation Results

We show our estimation results in two parts. We start with the estimation results of the hedonic price equation (1) in Subsection 5.1 and then provide the estimation results of the price index

¹³A fixed-price contract is a tariff which ensures that consumer's bill does not surpass the price of tariff. For these tariffs, consumption beyond allowances is not possible. These contracts are mostly targeted at teenagers.

¹⁴It is common to use weights when computing changes in prices over time. This is also the case of consumer price index (CPI) which is used as a measure of inflation.

equation (2) in Subsection 5.2. Finally in Subsection 5.3, we compare our results to other price indices which are constructed using the consumer usage basket methodology. These indices are commonly used by OECD, European Commission and national regulators including ARCEP in France.

5.1 Hedonic Price Regressions

Table 2 shows the estimation results for the hedonic price equation (1) based on all tariffs using OLS in column (1) and WLS in column (2).¹⁵ The results for both regressions are comparable. Both regressions have relatively high R-squared values equal to 0.75 for OLS and 0.86 for WLS. We discuss the results of WLS estimation because it accounts for differences in the popularity of tariffs.

All tariff characteristics in the regressions are highly significant with expected signs. Data and voice allowances have a positive impact on the cost of tariffs. For instance, compared to tariffs without data allowance, tariffs with 2 GB data allowance are about 15.1 Euros more expensive, with 5 GB allowance are about 33.3 Euros more expensive and with 14 GB allowance are about 138.4 Euros more expensive. If a tariff is bundled with fixed broadband services, additional 25.5 Euros are added to the contract for DSL connection and 28.2 Euros for FttH connection. Tariffs with unlimited national voice calls are 24.4 Euros more expensive and tariffs with unlimited national and international calls are 27.8 Euros more expensive. For tariffs with limited minutes, one minute costs about 11 cents. Tariffs with subsidized handsets are on average 11.8 Euros more expensive. Tariffs with 24 months commitment are on average 7 Euros cheaper than tariffs without commitment and also tariffs with 12 months commitment. Furthermore, web only tariffs are 18.6 Euros cheaper, while fixed price contracts are 5.9 Euros cheaper. Finally, tariffs with 3G Internet are about 4.9 Euros cheaper than tariffs with 4G Internet. As mentioned earlier, this is because at the time of introduction of 4G services, new tariffs were introduced offering 4G Internet access, while exactly the same tariffs with 3G Internet access were offered with a discount of 5 Euros.

¹⁵The estimates of 44 monthly dummy variables for these two regressions are shown in Table (A.1) in the appendix due to space constraints.

Table 2: Hedonic price regressions for all tariffs

	(1)		(2)	
	OLS		WLS	
Data allowance				
data=0.5GB	7.31***	(0.62)	4.09***	(0.67)
data=1GB	13.25***	(1.10)	9.71***	(0.81)
data=2GB	24.03***	(0.85)	15.13***	(0.84)
data=3GB	35.84***	(1.68)	21.09***	(1.67)
data=5GB	43.15***	(1.80)	33.29***	(1.76)
data=6GB	62.83***	(5.03)	40.50***	(1.59)
data=10GB	96.78***	(17.23)	66.30***	(12.28)
data=14GB	150.60***	(1.79)	138.42***	(1.14)
Bundle with fixed line				
Quadruple Play with broadband Internet	22.67***	(0.51)	25.48***	(0.47)
Quadruple Play with fiber Internet	24.85***	(0.71)	28.20***	(0.65)
Voice				
Voice allowance in minute if not unlimited	0.08***	(0.01)	0.11***	(0.00)
Dummy for unlimited national calls	23.84***	(1.62)	24.40***	(0.82)
Dummy for unlimited international calls	35.96***	(5.54)	27.77***	(2.11)
Other attributes				
Handset subsidy dummy	13.53***	(0.45)	11.84***	(0.52)
Commitment period of the mobile plan=12	-3.91***	(0.60)	-2.06	(1.29)
Commitment period of the mobile plan=24	-7.65***	(0.65)	-6.99***	(1.19)
Discount 3G=1	-17.52***	(2.63)	-4.93**	(1.49)
Web-only mobile plan	-21.03***	(1.51)	-18.63***	(1.80)
Dummy for fixed price contract	-6.60***	(0.56)	-5.86***	(0.64)
Constant	19.96***	(0.85)	17.47***	(1.51)
Observations	5995		5995	
R^2	0.75		0.86	

Standard errors in parentheses.

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Data allowance reference group is zero allowance.

Data allowances below 0.5 are grouped in data=0.5.

Data allowance of 4GB are grouped with data allowance of 5GB.

Data allowance of 7GB are grouped with allowance of 6GB.

Discount for 3G tariffs was introduced when 4G tariffs were launched.

We plot the estimated coefficients of the monthly dummy variables for both OLS and WLS regressions in Figure 4. These coefficients reflect the quality-adjusted price index. The estimates of time dummy variables are highly significant and become more negative over time relative to the starting month which is May 2011. This means that quality-adjusted prices decrease over time. We observe that decline in quality-adjusted prices is slow at the early period of our data but then accelerates with a particularly large decrease in April-May 2013. In an attempt to associate particular market events with observed price changes we plot three vertical lines. The first line reflects the reaction of incumbents to the announced entry of Free Mobile by launching

new tariffs without commitment, to which we refer as ‘fighting brands’¹⁶. The second one is the actual entry of Free Mobile and the third one is the launch of 4G networks and in consequence the introduction of 4G tariffs.

We notice that prices seem to react with a lag to the introduction of ‘fighting brands’. The acceleration of the price decrease starts briefly after the incumbents introduced ‘fighting brands’ but before the entry of Free Mobile. After Free Mobile had entered the market, Orange tariffs experienced further reductions in quality-adjusted prices. The largest price drop in our observation period seems to be induced by the introduction of 4G tariffs. Afterwards, quality-adjusted prices still decline but at a much smaller rate. For a comparison, we also show the estimates of monthly dummy coefficients based on the OLS estimation without any tariff characteristics, which reflect price changes without adjusting for quality. These prices decreased only by approximately 11% during the period of this analysis, as compared with about 44% decrease in quality-adjusted prices. This comparison also emphasizes the importance to account for product characteristics as otherwise the price decrease would have been underestimated.

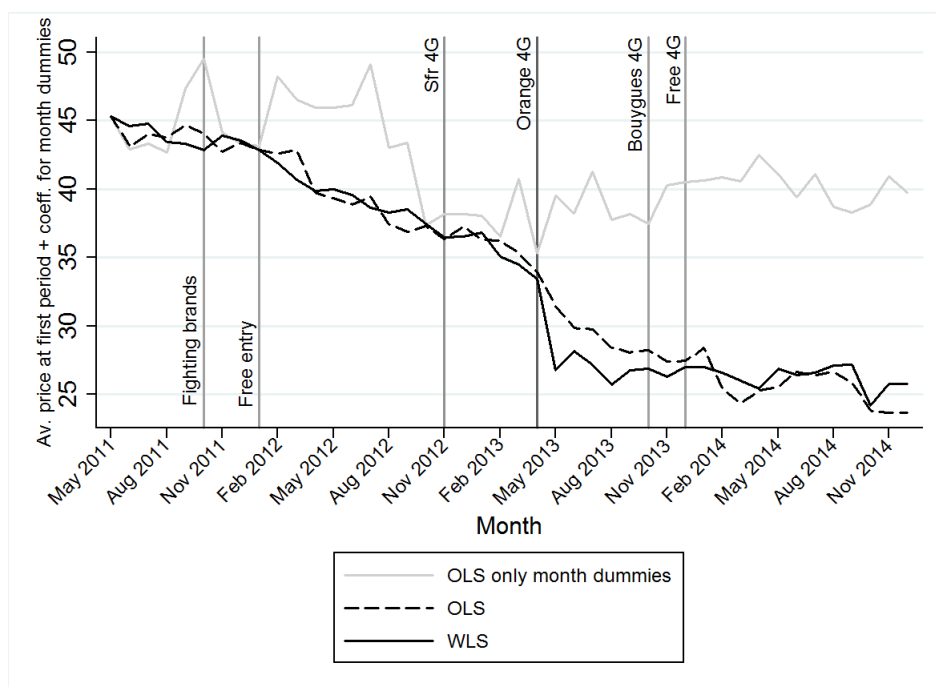
As the entry of Free might mainly affect low cost tariffs rather the classic tariffs, we additionally distinguish between these two categories of tariffs and run separate hedonic price regressions. Table 3 shows the estimation results based on WLS.¹⁷ The results are broadly comparable to the estimation for all tariffs, except for the magnitude of some variables. For instance, compared to tariffs without data allowance, tariffs with 2 GB data allowance are about 20.4 Euros more expensive for classic tariffs and 8 Euros for low cost tariffs. The cost of a minute in tariffs with allowance is about 11 cents for classic tariffs and 2 cents for low cost tariffs.

Again, we plot the estimated coefficients of the monthly dummies. Figure 5 shows them separately for classic tariffs and low cost tariffs and in comparison to previous estimates for all tariffs based on WLS. The estimates of monthly dummy variables differ significantly across tariff categories, which suggests that quality-adjusted prices for classic and low cost tariffs follow a

¹⁶In marketing, a ‘fighting brand’ is a lower-priced offering launched by a company to combat a competitor that is threatening to take market share away from a company’s main brand. See Johnson and Myatt (2003) for a theoretical exposition and Bourreau, Sun and Verboven (2016) for a structural analysis of mobile industry in France at the time of entry of Free Mobile

¹⁷Again, due to space constraints we show the estimated coefficients of monthly dummy variables for these regressions in Table (A.2) in the appendix.

Figure 4: Month dummies coefficients + av. price in May 2011



different time pattern. The low cost tariffs were introduced shortly before entry of Free Mobile and their quality-adjusted price decreased when Free Mobile entered the market in January 2012, and again around the time when 4G networks were launched but remained roughly constant afterwards. The quality-adjusted prices for classic tariffs kept declining during the whole time period but with a large drop at the time when 4G networks were launched.

5.2 Determinants of Quality-Adjusted Price Index

For the second part of our analysis, we use the estimated coefficients of the 44 monthly dummy variables which form the quality-adjusted price index and serve as the dependent variable in our second set of regressions. First, we use the estimates for all tariffs from Table (A.1) and then the estimates which we obtain from the separate regressions for classic and low cost tariffs from Table (A.2) in Appendix A. We regress the quality-adjusted prices on variables that describe competition and regulation. Competition is described by the introduction of ‘fighting brands’, entry of Free Mobile, launch of 4G networks by SFR, Orange, Bouygues and Free Mobile. Regulation is described by mobile termination rates on Orange network and wholesale roaming

Table 3: Hedonic price regressions for classic and low cost tariffs (WLS)

	(1)		(2)	
	Classic tariffs		Low cost tariffs	
Data				
data=0.5GB	7.91***	(0.41)		
data=1GB	12.61***	(0.78)	5.93***	(0.83)
data=2GB	20.39***	(0.57)	7.99***	(0.97)
data=3GB	27.63***	(1.75)	10.36***	(0.18)
data=5GB	38.01***	(1.49)	12.31***	(1.04)
data=6GB	45.60***	(1.57)		
data=10GB	71.12***	(12.16)		
data=14GB	143.74***	(1.06)		
Bundle with fixed line				
Quadruple Play with broadband Internet	24.72***	(0.43)	26.31***	(0.70)
Quadruple Play with fiber Internet	27.31***	(0.63)		
Voice				
Voice allowance in minute if not unlimited	0.11***	(0.00)	0.02**	(0.01)
Dummy for unlimited national calls	25.59***	(0.87)	7.76***	(0.98)
Dummy for unlimited international calls	28.90***	(2.00)		
Other attributes				
Handset subsidy dummy	10.68***	(0.58)		
Commitment period of the mobile plan=12	-3.13*	(1.29)		
Commitment period of the mobile plan=24	-7.87***	(1.20)		
Discount 3G=1	-6.64***	(1.51)	1.62	(0.93)
Dummy for fixed price contract	-5.95***	(0.60)	0.37	(0.23)
Constant	17.31***	(1.54)	16.33***	(1.20)
Observations	5774		221	
R^2	0.86		0.98	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Data allowance reference group is zero allowance.

Data allowances below 0.5 are grouped in data=0.5.

Data allowance of 4GB are grouped with data allowance of 5GB.

Data allowance of 7GB are grouped with allowance of 6GB.

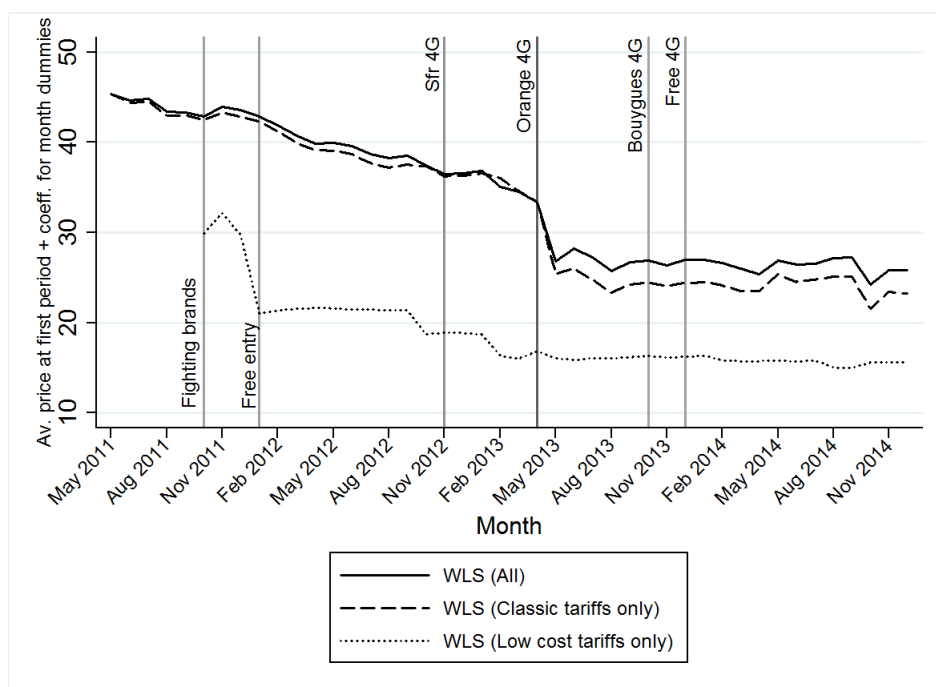
Data allowance of 0.5GB are grouped with allowance of 1GB for low cost data allowance.

Discount for 3G tariffs was introduced when 4G tariffs were launched.

price caps for voice and data. As shown in Figures (2) and (3), mobile termination rates and wholesale roaming price caps decrease stepwise over time.

The estimation results are shown in Table (4). The results indicate that the introduction of ‘fighting brands’ by itself had no impact on the quality-adjusted prices of classic tariffs. There were two events at which the prices of classic tariffs decreased. First, there was a drop by 4.96 Euros on average after entry of Free Mobile. Second, the main reduction by 9.36 Euros on average came with the launch of 4G network by Orange. Prices also declined with the launch of 4G network by SFR which took place a few months before Orange (with significance level of 10%). The regulatory variables used in the regression do not have significant impact on the

Figure 5: Month dummies coefficients + av. price in first period. Classic vs. Low cost tariffs



Note: The average price of tariffs in May 2011 is 45.32€. The average price of low cost tariffs is 29.9€ in October 2011

quality-adjusted prices of classic tariffs in separation. However, since, as shown in Table (B.1) in Appendix B, wholesale roaming price caps for voice and data and mobile termination rates are highly correlated, it is difficult to comment on the impact of particular regulatory variables. An F-test, testing the joint significance of regulatory variables does not allow rejecting that the regulatory variables have jointly a significant impact on the quality-adjusted prices for classic tariffs.

In the regression for low cost tariffs, the entry of Free Mobile had a negative impact on the level of quality-adjusted prices, which dropped on average by 4.70 Euros. There is also a significant but smaller effect of the launch of 4G networks by SFR, which led to decline of low cost tariffs by 1.89 Euros on average. Termination rates have a significant and positive impact. The roaming price caps for voice and data are also significant but with opposing signs, which may be due to high correlation of 0.95. The impact of regulatory variables should be therefore interpreted with caution. Again, testing the joint significance of regulatory variables

does not allow rejecting that the regulatory variables have jointly a significant impact on the quality-adjusted prices for low cost tariffs.

Since classic tariffs have a greater weight in the price index than low cost tariffs, the estimation results for all tariffs are similar to the estimation results for classic tariffs. The entry of Free Mobile reduced prices on average by 4.26 Euros and the launch of 4G tariffs by Orange by 7.55 Euros, while the launch of 4G tariffs by SFR led to additional reduction by 2.86 Euros. The regulatory variables are significant jointly but not in separation. Overall, our results confirm that low cost tariffs were introduced to compete with new entrant Free Mobile, while classic tariffs compete with the other established operators in the market.

Overall, the average cost of classic tariffs weighted by sales increased marginally from 44.3 Euros in May 2011 to 44.5 Euros in December 2014. In the same time period, the average quality-adjusted prices declined by 50%, as indicated by time coefficients plotted on Figure 5. The average cost of low cost tariffs declined by 35.4% from 26.6 Euros in October 2011 to 14.3 Euros in December 2014. In the same time period, the quality-adjusted prices declined by 46%. Finally, the average cost of all tariffs declined by 8.9% from 44.3 Euros in May 2011 to 40.4 Euros in December 2014, while the quality-adjusted prices declined by 51%. We can compute the contribution of competition variables to total price decline, which is the summation of coefficients on competition variables divided by total price decline in absolute value. In percentage terms, competition is responsible for about 68% of total price decline for all tariffs. Classic tariffs declined by 74% due to competition and low cost tariffs by 52%.

5.3 Comparison to Other Indices

We also compare the quality-adjusted price index constructed using our hedonic price regression with price indices constructed using the consumer usage basket methodology, which is commonly used by OECD, European Commission and national regulators including ARCEP in France. Table (C.1) in Appendix C shows definitions of different usage baskets according to ARCEP and OECD and their evolution in years 2011-2014. While the OECD baskets stay constant over time, the ARCEP baskets take into account potential changes in the consumer behavior

Table 4: OLS with time dummies coefficient from hedonic regression

	(1)	(2)	(3)
	All tariffs	Classic tariffs	Low cost tariffs
Fighting Brands	-0.19 (1.04)	-0.56 (1.25)	0.00 (.)
Dummy Free	-4.26* (1.85)	-4.96* (2.22)	-4.70** (1.65)
Sfr 4G	-2.86** (0.83)	-1.98+ (0.99)	-1.89** (0.61)
Orange 4G	-7.55** (0.85)	-9.36** (1.02)	-0.90+ (0.48)
Bouygues 4G	-0.84 (1.10)	-1.16 (1.31)	0.02 (0.60)
Free 4G	0.18 (1.04)	0.41 (1.24)	-0.28 (0.57)
MTR Orange	-307.42 (358.51)	-436.61 (429.04)	887.28** (312.52)
Wholesale roaming voice	-16.29 (35.79)	-18.68 (42.83)	59.72* (23.07)
Wholesale roaming data	18.05 (14.39)	22.36 (17.22)	-24.41* (9.90)
Constant	-1.65 (6.34)	-1.00 (7.59)	-15.60** (5.25)
Observations	44	44	39
R^2	0.97	0.97	0.98
F-stat (All variable)	149.96	126.61	162.14
Prob > F	0.0000	0.0000	0.0000
F-stat (Regulatory variables)	4.29	4.05	3.92
Prob > F	0.0113	0.0146	0.0179

Standard errors in parentheses

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

in France. To obtain a price index for these baskets, we calculate the bill of a representative consumer with a given usage basket using all tariff plans of Orange, which are available in each month. Next, we select the tariff which yields the lowest bill in a month. We do this once for all tariffs and then for tariffs with handset subsidies only. Price index constructed based on tariffs with handset subsidy corresponds to classic tariffs in our analysis and price index constructed based on all tariffs corresponds to low cost tariffs in our analysis.¹⁸

To compare baskets approach with our quality-adjusted price indices, we now regress selected OECD and ARCEP baskets on competition and regulation variables. The estimation results are shown in Table 5. These regressions broadly confirm our conclusions. ‘Fighting brands’ introduced to pre-empt entry of Free Mobile and launch of 4G networks are the main contributors to price reductions. As before, the effect of ‘fighting brands’ is stronger on the price indices based on all tariffs and the effect of 4G launch is stronger for the price indices based on tariffs with handset subsidy. The impact of regulatory variables is jointly significant and similar to our hedonic price regressions.

The price indices based on the OECD and ARCEP baskets suggest stronger reductions than the quality-adjusted price index based on hedonic regressions. While both methodologies have advantages and disadvantages, we prefer the hedonic price approach. First, the methodology using baskets considers the cost of a bill paid by a representative consumer, and the quality-adjusted price index represents the producer’s price after controlling for quality of tariffs. The latter is independent on usage which is an advantage. Second, through the weighting by quantities we account for the popularity of tariffs. The basket method, whereas, cannot consider these preferences. It also assumed perfectly rational behavior of the representative consumer choosing the cheapest tariff.

¹⁸Figures (C.1) and (C.2) in Appendix C show price indices constructed using ARCEP basket methodology, respectively based on the price of the cheapest tariff among all tariffs considered and based on the cheapest tariff with handset subsidy. Figures (C.3) and (C.4) also in Appendix C show analogous price indices for OECD baskets.

Table 5: OLS with prices from ARCEP and OECD baskets

	(1)	(2)	(3)	(4)
	Prices from ARCEP baskets All tariffs	Prices from ARCEP baskets Only handset sub.	Prices from OECD baskets All tariffs	Prices from OECD baskets Only handset sub.
Fighting Brands	-38.28** (2.21)	-12.33** (3.24)	-38.28** (2.21)	-11.51** (3.26)
Dummy Free	-1.25 (3.92)	-21.41** (5.74)	-1.28 (3.92)	-18.72** (5.79)
Sfr 4G	-4.53* (1.75)	-2.48 (2.56)	-4.52* (1.75)	-0.92 (2.58)
Orange 4G	-4.39* (1.80)	-15.01** (2.63)	-4.37* (1.80)	-16.92** (2.65)
Bouygues 4G	-0.61 (2.32)	1.06 (3.40)	-0.60 (2.32)	0.75 (3.43)
Free 4G	0.26 (2.20)	-0.18 (3.22)	0.26 (2.20)	-0.14 (3.25)
MTR Orange	2763.00** (759.14)	-1350.53 (1111.78)	2757.23** (758.08)	-448.65 (1119.88)
Wholesale roaming voice	161.70* (75.78)	-265.46* (110.99)	161.22* (75.68)	-193.59+ (111.80)
Wholesale roaming data	-76.79* (30.47)	127.42** (44.62)	-76.57* (30.43)	92.51* (44.95)
Constant	32.21* (13.42)	93.31** (19.66)	32.30* (13.40)	81.54** (19.80)
Observations	44	44	44	44
R^2	0.99	0.97	0.99	0.97
F-stat (All var)	327.38	137.08	327.85	144.46
Prob > F	0.0000	0.0000	0.0000	0.0000
F-stat (Regulatory variables)	8.22	15.38	8.22	14.15
Prob > F	0.0003	0.0000	0.0003	0.0000

Standard errors in parentheses

+ $p < 0.10$, * $p < 0.05$, ** $p < 0.01$

6 Conclusions

Based on a database that includes tariffs offered by the main mobile telecommunications operator in France, Orange, between May 2011 and December 2014, we assessed the impact of competition and regulation on prices of mobile services. In a first step, we estimated hedonic price regressions that account for the effect of product characteristics and obtained a quality-adjusted prices index. In a second step, we used this price index and related it to variables measuring competition and regulation in the industry. We looked at all tariffs, classic contract tariffs with commitment and low cost tariffs without commitment, which were introduced by Orange in October 2011 before the entry of fourth mobile operator, Free Mobile.

Over the analyzed time period, the obtained quality-adjusted price index decreased by about 51% as compared to a decline in average prices without quality adjustment of 8.9%. We find that main driver of price reductions for classic tariffs with commitment was the launch of 4G networks by mobile operators. Low cost tariffs without commitment which were introduced to pre-empt the entry of a low cost competitor declined mainly at the time of entry of Free Mobile. Moreover, we find that regulation, which is approximated by the level of mobile termination charges and international roaming price caps for voice and data, has jointly a significant impact on quality-adjusted prices.

In percentage terms, competition is responsible for about 68% of total price decline. Classic tariffs declined by 74% due to competition and low cost tariffs by 52%. Thus, our main conclusion is that the reduction in quality-adjusted prices in the last years was largely caused by competition between established operators and by entry of fourth low cost operator. Our results are also robust in comparison to other constructed price indices. When we compare the results from our hedonic price regressions with the alternative OECD and ARCEP basket approach, we can draw similar conclusions, despite that OECD and ARCEP baskets do not capture the impact of 4G network launch, what is however well assessed by our hedonic price regressions.

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A Appendix: Estimation Results

A.1 All Tariffs

Table A.1: Results from hedonic price regressions

	(1)	(2)	(1)	(2)
	OLS		WLS	
Data allowance				
data=0.5GB	7.31***	(0.62)	4.09***	(0.67)
data=1GB	13.25***	(1.10)	9.71***	(0.81)
data=2GB	24.03***	(0.85)	15.13***	(0.84)
data=3GB	35.84***	(1.68)	21.09***	(1.67)
data=5GB	43.15***	(1.80)	33.29***	(1.76)
data=6GB	62.83***	(5.03)	40.50***	(1.59)
data=10GB	96.78***	(17.23)	66.30***	(12.28)
data=14GB	150.60***	(1.79)	138.42***	(1.14)
Bundle with fixed line				
Quadruple Play with broadband Internet	22.67***	(0.51)	25.48***	(0.47)
Quadruple Play with fiber Internet	24.85***	(0.71)	28.20***	(0.65)
Voice				
Voice allowance in minute if not unlimited	0.08***	(0.01)	0.11***	(0.00)
Dummy for unlimited national calls	23.84***	(1.62)	24.40***	(0.82)
Dummy for unlimited international calls	35.96***	(5.54)	27.77***	(2.11)
Other attributes				
Handset subsidy dummy	13.53***	(0.45)	11.84***	(0.52)
Commitment period of the mobile plan=12	-3.91***	(0.60)	-2.06	(1.29)
Commitment period of the mobile plan=24	-7.65***	(0.65)	-6.99***	(1.19)
Discount 3G=1	-17.52***	(2.63)	-4.93**	(1.49)
Web-only mobile plan	-21.03***	(1.51)	-18.63***	(1.80)
Dummy for fixed price contract	-6.60***	(0.56)	-5.86***	(0.64)
May 2011	0.00	(.)	0.00	(.)
June 2011	-2.20***	(0.07)	-0.71***	(0.05)
July 2011	-1.34***	(0.09)	-0.52***	(0.06)
Aug 2011	-1.54***	(0.05)	-1.91***	(0.08)
Sep 2011	-0.67***	(0.14)	-1.98***	(0.05)
Oct 2011	-1.25***	(0.20)	-2.47***	(0.11)
Nov 2011	-2.59***	(0.10)	-1.42***	(0.17)
Dec 2011	-1.95***	(0.12)	-1.77***	(0.15)
Jan 2012	-2.50***	(0.16)	-2.47***	(0.19)
Feb 2012	-2.72***	(0.29)	-3.43***	(0.25)
March 2012	-2.45***	(0.34)	-4.62***	(0.25)
Apr 2012	-5.56***	(0.30)	-5.45***	(0.23)
May 2012	-6.00***	(0.36)	-5.36***	(0.20)
June 2012	-6.42***	(0.46)	-5.73***	(0.18)
July 2012	-5.88***	(0.57)	-6.65***	(0.20)
Aug 2012	-7.89***	(0.51)	-7.04***	(0.24)
Sep 2012	-8.45***	(0.48)	-6.79***	(0.20)
Oct 2012	-8.04***	(0.17)	-7.83***	(0.25)
Nov 2012	-8.96***	(0.19)	-8.82***	(0.24)
Dec 2012	-8.05***	(0.20)	-8.78***	(0.24)
Jan 2013	-8.98***	(0.24)	-8.48***	(0.27)
Feb 2013	-9.11***	(0.19)	-10.22***	(0.31)
March 2013	-9.98***	(0.29)	-10.83***	(0.29)

Apr 2013	-11.36***	(0.22)	-11.91***	(0.30)
May 2013	-13.84***	(0.37)	-18.52***	(0.33)
June 2013	-15.45***	(0.36)	-17.13***	(0.37)
July 2013	-15.57***	(0.35)	-18.11***	(0.40)
Aug 2013	-16.89***	(0.32)	-19.61***	(0.53)
Sep 2013	-17.23***	(0.27)	-18.57***	(0.32)
Oct 2013	-17.05***	(0.28)	-18.44***	(0.28)
Nov 2013	-17.87***	(0.31)	-19.00***	(0.30)
Dec 2013	-17.87***	(0.30)	-18.31***	(0.30)
Jan 2014	-16.90***	(0.30)	-18.31***	(0.33)
Feb 2014	-19.92***	(0.60)	-18.70***	(0.37)
March 2014	-20.96***	(0.69)	-19.30***	(0.52)
Apr 2014	-20.01***	(0.52)	-19.91***	(0.70)
May 2014	-19.76***	(0.57)	-18.40***	(0.26)
June 2014	-18.66***	(0.54)	-18.86***	(0.38)
July 2014	-18.87***	(0.63)	-18.74***	(0.39)
Aug 2014	-18.68***	(0.55)	-18.19***	(0.37)
Sep 2014	-19.43***	(0.63)	-18.10***	(0.39)
Oct 2014	-21.48***	(0.80)	-21.11***	(0.38)
Nov 2014	-21.66***	(1.13)	-19.51***	(0.49)
Dec 2014	-21.61***	(0.87)	-19.51***	(0.51)
Constant	19.96***	(0.85)	17.47***	(1.51)
Observations	5995		5995	
R^2	0.75		0.86	

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Data allowance reference group is zero allowance

Data allowances below 0.5 are grouped in data=0.5.

Data allowance of 4GB are grouped with data allowance of 5GB.

Data allowance of 7GB are grouped with allowance of 6GB

Discount for 3G tariffs was introduced when 4G tariffs were launched

A.2 Classic vs. Low Cost Tariffs

Table A.2: Results from hedonic price regressions

	(1)		(2)	
	WLS		WLS	
	Classic tariffs		Low cost tariffs	
Data				
data=0.5GB	7.91***	(0.41)		
data=1GB	12.61***	(0.78)	5.93***	(0.83)
data=2GB	20.39***	(0.57)	7.99***	(0.97)
data=3GB	27.63***	(1.75)	10.36***	(0.18)
data=5GB	38.01***	(1.49)	12.31***	(1.04)
data=6GB	45.60***	(1.57)		
data=10GB	71.12***	(12.16)		
data=14GB	143.74***	(1.06)		
Bundle with fixed line				
Quadruple Play with broadband Internet	24.72***	(0.43)	26.31***	(0.70)
Quadruple Play with fiber Internet	27.31***	(0.63)		
Voice				
Voice allowance in minute if not unlimited	0.11***	(0.00)	0.02**	(0.01)
Dummy for unlimited national calls	25.59***	(0.87)	7.76***	(0.98)
Dummy for unlimited international calls	28.90***	(2.00)		
Other attributes				
Handset subsidy dummy	10.68***	(0.58)		
Commitment period of the mobile plan=12	-3.13*	(1.29)		
Commitment period of the mobile plan=24	-7.87***	(1.20)		
Discount 3G=1	-6.64***	(1.51)	1.62	(0.93)
Dummy for fixed price contract	-5.95***	(0.60)	0.37	(0.23)
May 2011	0.00	(.)		
June 2011	-0.93***	(0.04)		
July 2011	-0.81***	(0.04)		
Aug 2011	-2.32***	(0.07)		
Sep 2011	-2.32***	(0.05)		
Oct 2011	-2.86***	(0.09)	0.00	(.)
Nov 2011	-2.04***	(0.17)	2.27***	(0.44)
Dec 2011	-2.50***	(0.18)	-0.20	(0.29)
Jan 2012	-3.01***	(0.19)	-8.86***	(0.22)
Feb 2012	-4.11***	(0.26)	-8.54***	(0.61)
March 2012	-5.39***	(0.25)	-8.35***	(0.70)
Apr 2012	-6.18***	(0.23)	-8.25***	(0.75)
May 2012	-6.24***	(0.20)	-8.29***	(0.74)
June 2012	-6.64***	(0.18)	-8.44***	(0.68)
July 2012	-7.63***	(0.22)	-8.43***	(0.71)
Aug 2012	-8.10***	(0.25)	-8.53***	(0.65)
Sep 2012	-7.81***	(0.21)	-8.52***	(0.71)
Oct 2012	-7.98***	(0.24)	-11.17***	(0.93)
Nov 2012	-9.07***	(0.23)	-11.01***	(0.91)
Dec 2012	-9.02***	(0.24)	-11.02***	(0.91)
Jan 2013	-8.75***	(0.26)	-11.20***	(0.93)
Feb 2013	-9.29***	(0.22)	-13.53***	(0.78)
March 2013	-10.68***	(0.25)	-13.88***	(0.85)
Apr 2013	-11.91***	(0.27)	-13.06***	(0.83)
May 2013	-19.90***	(0.36)	-13.80***	(0.87)
June 2013	-19.31***	(0.42)	-14.03***	(0.86)

July 2013	-20.56***	(0.46)	-13.83***	(0.87)
Aug 2013	-21.96***	(0.56)	-13.85***	(0.87)
Sep 2013	-21.07***	(0.34)	-13.72***	(0.87)
Oct 2013	-20.85***	(0.32)	-13.57***	(0.87)
Nov 2013	-21.20***	(0.37)	-13.76***	(0.87)
Dec 2013	-20.91***	(0.32)	-13.65***	(0.87)
Jan 2014	-20.78***	(0.34)	-13.55***	(0.87)
Feb 2014	-21.18***	(0.37)	-14.05***	(0.87)
March 2014	-21.81***	(0.55)	-14.15***	(0.86)
Apr 2014	-21.82***	(0.70)	-14.14***	(0.87)
May 2014	-19.96***	(0.25)	-14.11***	(0.87)
June 2014	-20.78***	(0.38)	-14.18***	(0.88)
July 2014	-20.53***	(0.38)	-14.06***	(0.87)
Aug 2014	-20.16***	(0.34)	-14.83***	(0.97)
Sep 2014	-20.24***	(0.35)	-14.91***	(0.96)
Oct 2014	-23.74***	(0.38)	-14.30***	(0.88)
Nov 2014	-21.92***	(0.51)	-14.27***	(0.89)
Dec 2014	-22.06***	(0.52)	-14.31***	(0.89)
Constant	17.31***	(1.54)	16.33***	(1.20)
Observations	5774		221	
R^2	0.86		0.98	

There are only 39 periods of observation for low costs tariffs as there were introduced in October 2011
Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Data allowance reference group is zero allowance

Data allowances below 0.5 are grouped in data=0.5.

Data allowance of 4GB are grouped with data allowance of 5GB.

Data allowance of 7GB are grouped with allowance of 6GB

Data allowance of 0.5GB are grouped with allowance of 1GB for low cost data allowance

Discount for 3G tariffs was introduced when 4G tariffs were launched

B Evolution of MTRS and Roaming

Table B.1: Correlations of regulation variables

	M2M rates	Wholesale price cap voice	Wholesale price cap data
M2M rates	1.00		
Wholesale price cap voice	0.79	1.00	
Wholesale price cap data	0.93	0.95	1.00

C Comparison with ARCEP and OECD Baskets

Table C.1: Mobile services baskets

	2011		2012		2013		2014	
	Voice	Data	Voice	Data	Voice	Data	Voice	Data
National Regulator (ARCEP)								
Basket 1	421	137	400	236	382	418	480	695
Basket 2	421	27	400	67	382	100	480	179
Basket 3	421	32	400	24	382	37	480	66
Basket 4	84	137	98	236	114	418	123	695
Basket 5	84	27	98	67	114	100	123	179
Basket 6	84	32	98	24	114	37	123	66
Basket 7	24	137	22	236	28	418	33	695
Basket 8	24	27	22	67	28	100	33	179
Basket 9	24	32	22	24	28	37	33	66
OECD								
Basket 1	50	100	50	100	50	100	50	100
Basket 2	188	500	188	500	188	500	188	500
Basket 3	569	1000	569	1000	569	1000	569	1000
Basket 4	1787	2000	1787	2000	1787	2000	1787	2000
Basket 5	75	2000	75	2000	75	2000	75	2000

Voice is in minutes, Data in MB

Source: ARCEP website and BEREC Report on mobile broadband prices

Figure C.1: Price of cost-minimizing tariff for ARCEP baskets

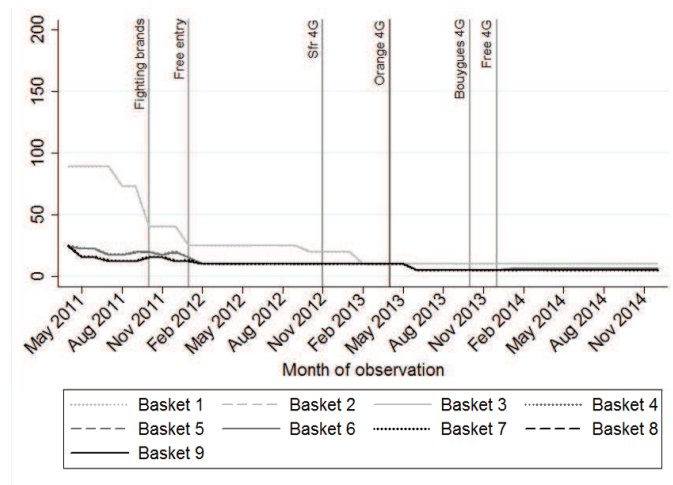


Figure C.2: Price of cost-minimizing tariff with handset subsidy for ARCEP baskets

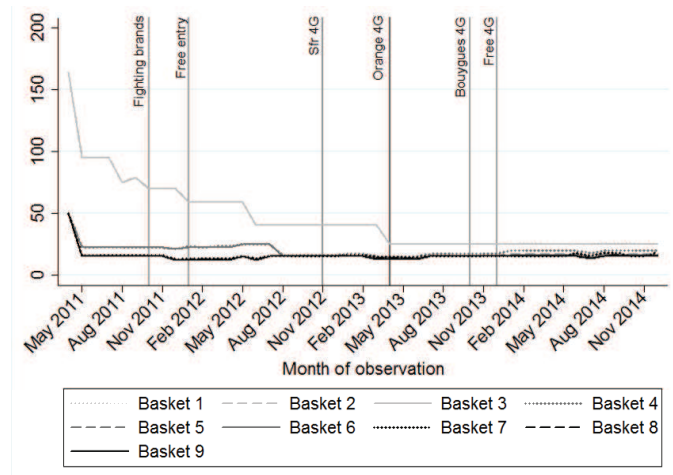


Figure C.3: Price of cost-minimizing tariff for OECD baskets

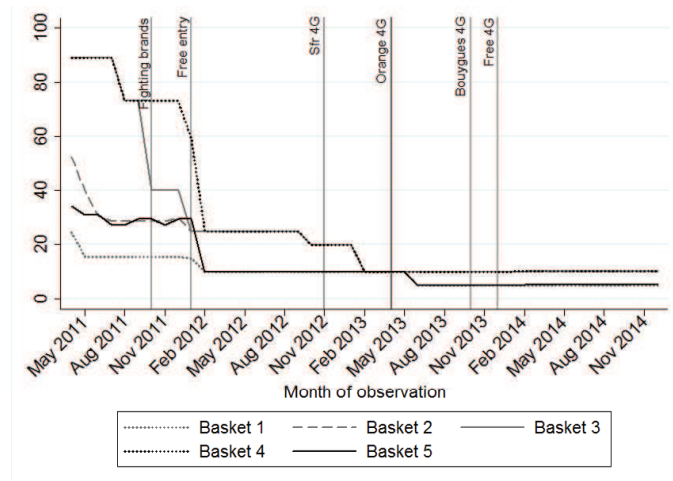


Figure C.4: Price of cost-minimizing tariff with handset subsidy for OECD baskets

