Market power and welfare analysis of the mobile market in Brazil

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Abstract: This paper proposes the application of two different models, linked by interconnection prices in the mobile telephony market in Brazil. The first is an application of the model presented by Bresnahan (1982) to measure the market power of providers of mobile telephony in Brazil and to estimate a function for marginal cost. The second is an application of the model presented by Harbord and Hoering (2010) to analyze the total welfare in Brazil mobile's telephony market, when the mobile interconnection price is reduced. It is expected that a reduction in the price of mobile interconnection leads to an increase in total welfare according to the positive externality of receiving a call. The results are in line with those reported by Harbord and Hoering (2010) for the case of the UK and go against some previous literature on that matter, serving as a new policy orientation regulatory system for the mobile market.

Palavras-Chaves: Poder de mercado; Preço de interconexão; Externalidade positiva; Bem estar; Telecomunicações.

Keywords: Market power; Interconnection price; Positive externalities; Welfare; Telecommunications.

JEL Codes: L13, L96, L98.

1 Introduction

The price charged by mobile phone companies for access to their network, also called interconnection price in the mobile networks, is a problem that has long occupied the agenda of regulators of the telecommunications sector in many countries. Typically the price charged does not match the cost of interconnection and this was supported both by mobile phone service providers and by regulators.

It is noteworthy that currently the mobile market has been understood as two separate markets, namely the originating and terminating call markets. Thus, the existence of competition in the originating market does not denote competition in the termination market.

The existence of market power in the call termination market generates an incentive to apply interconnection monopoly prices by the mobile telephony providers. For this reason, the price of mobile interconnection is always at the forefront of discussions on the economic regulation of the sector and has so long been discussed in telecommunications' literature.

There are various interconnection regulation models in the telecommunication markets worldwide. In Brazil, the interconnection rate for landlines is regulated under the *price-cap* model[1], whereas for mobile, liberalization is the rule[2]. Therefore, while landline interconnection has a maximum value determined by the regulator, the price of mobile interconnection is agreed upon[3], depending on the free negotiation between the companies[4].

Thus, the differences between both interconnection expenses are exaggerated. While fixed network interconnection rates cost around three cents per minute, mobile interconnection rates cost around forty cents per minute (Anatel/2010).

Moreover, since mobile phone companies get paid for every traffic minute in their networks, they have an incentive to subsidize new user entries in order to increase access numbers and expand their networks. And by practicing interconnection prices above marginal cost, their revenues are directly related to the size of their networks. Thus, mobile service providers adopt a strategy that focuses on network size, impairing its use.

Since interconnection expenses are not related to call termination costs, interconnection becomes an important revenue source for the company and hence is seen as a wholesale service rather than being treated as another service cost.

Various regulatory agencies around the world have been systematically recommending a reduction of mobile network interconnection charges. In general, the determination of decreased levels of mobile interconnection aims to curtail the market power of mobile operators and seeks to establish a correlation between price and cost of interconnection. The logic of regulation is that welfare would be maximized at this price point.

In Brazil, sector policy is not far from world practice and there are guidelines determining that the value of mobile interconnection be cost-driven since 2008. However, it is difficult for the regulatory agency to establish such directives.

Despite not using a cost-oriented regulation, the regulator intends to induce the market to a reduction in mobile interconnection fees in the same nominal value (in Reais) to be applied to the reduction in the rate of fixed-mobile, which for the proposal

[1] Type of regulation where the regulator sets a maximum rate for the regulated company.

[2] Article128, item I of Law n.°9.472/97.

[3] Article.13 of Resolution n.° 438/06, from Anatel.

[4] There is no ceiling on the price of mobile interconnection in case of no agreement on a possible resolution of conflict, Anatel arbitrates a value.

in consultation Public, would be 10% (ten percent) per year. This reduction would allow an approximation of the cost incurred for the termination of the call and the amount charged by the provider.

The first part of this study aims to identify the degree of competition in the mobile market. For this purpose, a Bresnahan's oligopoly model (1982) was used to assess the degree of market power in this market.

Bresnnahan (1982) formulated an oligopoly model that allows the identification of market power by using aggregated data from industry. By modeling demand curve and supply, the proposed model allows the measurement of the market power by identifying specific parameters.

Considering the challenge to find a value that would serve as a parameter or approach to the cost of mobile interconnection, the present study estimated the marginal cost. This marginal cost is a secondary result of the model of Bresnahan (1982) used in the calculation of market power.

In the second part, the present study applied a Harbord and Hoering (2010) model which introduces a positive externality due to the incoming call. It is shown that under this assumption a reduction in the price of mobile interconnection increases welfare.

The importance of this result is that in previous works, many authors advocate an interconnection price above marginal cost. For them, the telecommunications market as "a network market", generate positive externalities by the additional users that affect the existing customers (Priest (2007)). Thus, they argue that the existence of these positive externalities in consumption makes the definition of the price of interconnection based on the cost of providing the service not necessarily socially optimal.

Considering this positive externality resulting from the addition of new users of mobile telephony service, Wright *et. al*. (2007) show that the optimal price for interconnection must be greater than the cost, since it is possible to expand the mobile network and there is competition between mobile operators.

However, Wright *et. al*. (2007) and Wright (2000) demonstrated that there is a case in which the correlation between price and cost of interconnection would be socially optimal: when there is no possibility of expansion of mobile telephony.

Baigorri and Maldonado (2011), adapting the model of Wright *et al* (2007) to the Brazilian case, found optimal values for the price of mobile interconnection above cost of interconnection and points out that the optimum value of the price of interconnection would vary with measure of welfare used. Therefore, the authors calculated the optimal price of interconnection for each objective function that the regulator can choose.

However, Harbord and Hoering (2010) presented a critique of Wright *et al* (2007), since the result presented by the latter was counter-intuitive proposing an interconnection value greater than the costs of interconnection. Thus, the present study proposes a model in which the main difference *vis-à-vis* the Wright *et. al.* (2007) model is the introduction of positive externality due to incoming calls. Furthermore, the authors consider the possibility of charging two values for interconnection by mobile operators, one for calls on-net[5] e other for calls off-net[6].

The results presented by Hoernig and Harbord (2010) contradict the assertions made in the recent literature and confirm the recommendation of the Commission[7]. Thus, they demonstrate that a reduction in price of mobile interconnection increases social

[5] Call originated and terminated within the network of one provider.

[6] Call involving more than one provider when payment is due to network.

[7] *Draft Common Position on Next Generation Networks Future Charging Mechanisms / Long term Termination Issues,* European Regulators Group.

welfare, consumer surplus and profit of the fixed telephony operator in the UK, which supports the thesis of a value-oriented interconnection costs.

Considering the result presented by Hoernig and Harbord (2010), the present work intends to apply that model adapting it to the reality of the Brazilian market in order to verify the thesis that a price policy of cost-oriented mobile interconnection brings an increase of welfare. So, making the necessary adjustments to the model, it is provided a comparative static exercise by changing the price of mobile interconnection using some values decreasing to a scenario where the price of interconnection is equal to marginal cost estimates.

The result allows confirming the assertion that a cost-based policy in the interconnection price increases well-being. The comparative static exercise found that there is an increase of well-being that ranges from about R$ 12 billion to R$ 40 billion, depending on the positive externality of an incoming call and the price of interconnection that is considered.

This article is organized as follows. Section 2 presents the proposed model to measure the power of the mobile telephony market and estimates the marginal cost of mobile telephony. Section 3 presents the model proposed by Hoernig and Harbord (2010) and the corresponding results obtained in Brazil, where we found similar results to those obtained by these authors. In its final part, the paper concludes that the regulation of the interconnection price based on the costs increases the total social welfare.

2 Market power of mobile phone

1.1 Description of the Model

The model aims to identify the degree of market power in this industry, using econometric methods. Thus, we can identify the parameter of oligopoly even when no information about the costs or profits of the firms and when the demand curve and supply of the firm need to be estimated.

However, wider relations as the existence of some market power by suppliers may appear. When you have competition, price equals marginal cost (MC = P). When the marginal cost is less than the price (MC < P) for some market power.

Based on the article by Bresnahan (1982), we use the following econometric model to calculate the mobile phone market power λ.

We start with a linear demand for mobile telephony:

$$Q_m = \alpha_0 + \alpha_1 P_m + \alpha_2 Y + \epsilon \qquad (1)$$

with:

Q_m = Quantity Mobile Minutes;

P_m = Price of Mobile Minutes;

αi = parameter;

Y = Income; e

ϵ = errors uncorrelated with the explanatory variables of the models.

Then add the price of fixed telephony, the good substitute. From this equation we can identify the parameters α that will allow the estimation of market power and the marginal cost.

$$Q_m = \alpha_0 + \alpha_1 P_m + \alpha_2 Y + \alpha_3 P_m P_f + \alpha_4 P_f + \epsilon \quad (2)$$

With:

P_f = Price of LandLine Minutes.

So, to find the α's that allow the identification of $Q_{mt}^{\star}$, as the model of Bresnahan (1982), we use the following econometric model for regression of demand for mobile minutes:

$$\Delta^2 Q_{mt} = \alpha_0 + \alpha_1 \Delta^2 P_{mt} + \alpha_2 \Delta^2 P_{mt-1} + \alpha_3 \Delta^2 Y_t + \alpha_4 \Delta^2 P_{mt} P_{ft} + \alpha_5 \Delta^2 P_{ft} + \epsilon \quad (3)$$

where:

$\Delta^2 Q_{mt}$=*Second difference of Mobile Minutes;*

$\Delta^2 P_{mt}$= *Second difference of the Mobile Minute Price;*

$\Delta^2 P_{mt} P_{ft}$=*Second difference of the cross product of prices;*

$\Delta^2 Pft$= *Second difference of landline prices;*

$\Delta^2 Y_t$=*Second difference of GDP;*

α_i=*parameter;* and

ϵ = *errors uncorrelated with the explanatory variables of the models*

The econometric model incorporates a lagged variable given the best fit. After defining the model for demand, we will structure the regression to identify market power.

We started the model to the market power, set the price per minute for mobile supplier company. Given a demand P = P(Q), if we take the example of a market with "N" firms at Cournot competitors, each company produces q_i, and the total amount of minutes of traffic is $Q = \sum_{i=1}^{N} q_i$. Thus, each firm maximizes:

$$P(Q)q_i - c(q_i) \quad (4)$$

Differentiating and equating to zero, we have:

$$P'(Q)q_i + P(Q) - c'(q_i) = 0 \quad (5)$$

Rewriting the equation and isolating the price of mobile minutes:

$$P(Q) = CMg(q_i) - P'(Q)q_i \quad (6)$$

$$= CMg(q_i) - \left(\frac{dP}{dQ} \times Q\right) \times \frac{q_i}{Q} = CMg - h(Q) \times \lambda \quad (7)$$

Where $\lambda = \frac{q_i}{Q}$ is the amount that firm *i* offers, so we have have 0≤λ≤1. If this λ is constant or varies very slowly, as is the case of the mobile market as shown in the table below, we can consider as the one parameter.

Table 1 – Evolution of market share in mobile telephony

	Vivo	Claro	Tim	Oi	Other
Dec/2007	27.68%	24.99%	25.85%	21.13%	0.35%
Dec/2008	29.81%	25.73%	24.06%	20.03%	0.37%
Dec/2009	29.63%	25.61%	23.71%	20.46%	0.59%

Source: Anatel

For the function h(Q) using the set in (7) in equation (1), we have:

$$h(Q) = Q\frac{dp}{dQ} = \frac{Q}{\alpha_1 + \alpha_3 P_i} \tag{8}$$

To apply the proposed model to the mobile market, we start with a quadratic cost function and therefore a linear marginal cost.

$$C_m = k + \beta_0 Q_m + \beta_1 \frac{Q_m^2}{2} + \beta_2 \frac{CT_t}{M_t} Q_m \tag{9}$$

$$CMg_m = \beta_0 + \beta_1 Q_m + \beta_2 \frac{CT_t}{M_t} \tag{10}$$

where:

k=Constant;

Q_m=Quantity of Mobile Minutes;

$\frac{CT_t}{M_t}$ =wages per access; e

β_i=parameter.

And so, substituting the results in (8) and (10) the equation (7) results in:

$$P_m = -\lambda\left(\frac{Q_m}{\alpha_1 + \alpha_3 P_f}\right) + \beta_0 + \beta_1 Q_m + \beta_2 \frac{CT_t}{M_t} \tag{11}$$

And finally, we define the regression to measure the market power, using lagged variables, as shown below:

$$\Delta P_{mt} = \beta_0 - \lambda \Delta Q_{mt}^{*} + \beta_1 \Delta Q_{mt-1}^{*} + \beta_2 \Delta Q_{mt} + \beta_3 \Delta \frac{CT_t}{M_t} + \beta_4 Dummy + \eta \tag{12}$$

with:

$$Q_{mt}^{*} = \frac{-Q_{mt}}{(\alpha_1 + \alpha_4 P_{ft})} \tag{13}$$

where:

ΔQ_{mt}=First difference of Mobile Minute;

$\Delta Q_{mt}^{\star}$=First difference of the transformed Mobile Minutes;

ΔP_{mt}= First difference of mobile Minute Price;

λ=Degree of Market Power;

$\Delta \frac{CT_t}{M_t}$ =First difference in wages per access;

Dummy = Dummy for technology change;

β_i=parameter;

α_i=parameter;

η =errors uncorrelated with the explanatory variables of the models; and

$Q_{mt}^{\star}$= Transformed Mobile Minutes

In regression (13), the λ is a parameter that measures the market power ranging from zero to one. When $\lambda = 0$, we have $P_m = CM_{gm}$ and therefore there is no market power. When $\lambda = 1$, it is assumed that the firm serves the entire market which leads to a monopoly price. Other solution λ between 0 (zero) and 1 (um) characterizes oligopoly´s solutions. A justification for that interpretation is given in the Appendix.

2.2 Description of the Data

In order to estimate the parameters used in the regressions presented above the following information for each period is required: total minutes of calls originated on mobile telephony, the average rate of fixed telephony minutes, the average price (APM) of the minutes of mobile telephony, the consumers' income and a proxy of the cost of providing the mobile service.

The data used are quarterly information for the period between the first quarter of 2004 and the last quarter of 2009 (24 observations) from operators of fixed telephony and mobile telephony in the Brazil aggregate level.

The size of the sample is relatively short due to data availability. The mobile phones market is recent, therefore, structured data are available just from 2004.

The short sample period can produce some undesirable consequences to the OLS estimator, used in the regression, such as multicollinearity and loss of asymptotic efficiency. However, the results and statistics of the model are satisfactory. This is why we use the available data set.

The data were obtained from the following sources: (i) for fixed telephony, ANATEL was used as the main source, since all prices and quantities are published on the regulator's website, (ii) for mobile phones, consolidated quarterly statements published by the investment bank Merrill Lynch (2010) in its database *Interactive Global Wireless* Matrix were used. All monetary values are available in Reais (the Brazilian currency R$) at current values.

Given that all prices are expressed in current values, these values were deflated by the National Consumer Price Index (IPCA), calculated by the Brazilian Institute of Geography and Statistics (IBGE), the National Consumer Price Index (IBGE / SNIPC) and released by the Institute of Applied Economic Research (IPEA). Thus, all monetary values are expressed in constant prices of March 2004.

The data for the total minutes of calls originating in the operators' networks were computed based on the amount of minutes of use (MOU) and divided by the number of access terminals, thus arriving at a number of trafficked minutes per access.

To measure income, it uses Gross Domestic Product (GDP) measured quarterly by the Brazilian Institute of Geography and Statistics (IBGE), divided by the population size. As a proxy of the cost of an input of mobile telephony, the present study uses the value of total wages paid by Vivo (one of the leading operators in Brazil), divided by the number of access. We use data from Vivo because it is the market leader, in addition to providing the data. Moreover, there is no reason to assume that the costs of providing mobile telephony have large variance among providers.

Finally, we stress the use of a dummy variable in the regression of market power, since the introduction of third generation technology of mobile telephony (3G), which began in 2008 and lasted until the end of the series, apparently altered costs of mobile telephony.

2.3 Estimation and Discussion

We begin the presentation of the results obtained by the unit root test of the series involved in the regression, to identify whether it is better to work with values in level or difference. We apply the test of Augmented Dickey-Fuller, where the null hypothesis is $a = 1$, ie, the series has a unit root.

The results indicate that some series are stationary in first difference, but all are stationary in second difference. For this reason, we use the variables in the second difference in regression (3) and the first difference in the regression (12). So we have all the regressions with stationary series. Note, too, that due to the small size of the series we can assume the hypothesis of stationary series (appendix II).

After that, the parameters of equations (1) and (3) were estimated and are reported in Tables 1 e 2.

Table 2 – Results from the regression of demand – estimated parameters

	Coefficient	Standard Deviation
Const	-0.0000404803	0,00179535
Δ^2PIB	0.0171322**	0,00643342
Δ^2Pm	-2.65343***	0,878738
Δ^2Pf	-4.46491**	2,04799
Δ^2PmPf	12.7003*	7,04021
Δ^2Pm-1	-0.401168***	0,117636
R2	0.811415	
R2(adj)	0.639909	
F	60.87229***	

observations	21
White test for heteroscedasticity	statistics: 12,7572
Null hypothesis: no heteroscedasticity	p-value: 0,2375
LM Test for Autocorrelation	statistics: 1,06123
Null hypothesis: no Autocorrelation	p-value: 0,420577
Test of normality of residuals	statistics: 2,92602
Null hypothesis: error has a normal distribution	p-value: 0,231538

Obs.: ***, **, * represents levels of significance of 1%, 5% and 10%

Source: Elaborated by the author

From our results we find some market power in the mobile market which corresponds to $\lambda = 0.168$. Whereas λ varies from 0 (zero) to 1 (one), we conclude that the mobile telephony has a low market power, at least in the market for call origination, therefore the retail market of mobile telephony is closer to the competition than to the oligopoly.

The marginal cost function results $Cmg_m = 0 + 0.44Q_m + 1.26\frac{Wages}{Access}$. Calculating the marginal cost for the fourth quarter of 2009 we found approximately $Cmg_m = 0.13$.

Table 3 – Regression results of market power – estimated parameters

	Coefficient	Standard Deviation
Const	0,00859166***	0,00146
ΔQm	0,442633***	0,0823
ΔQm*	-0,168623***	0,0499
ΔQm-1*	-0,043824*	0,02245
ΔS/M	1,26264*	0,66728
ΔDummy	-0,0067981***	0,00171
R2	0,754358	
R2(adj)	0,677595	
F	17,68993***	
observations	22	
White test for heteroscedasticity		statistics: 14,6463
Null hypothesis: no heteroscedasticity		p-value: 0,40294
LM Test for Autocorrelation		statistics: 0,348353
Null hypothesis: no Autocorrelation		p-value: 0,840206
Test of normality of residuals		statistics: 0,493246
Null hypothesis: error has a normal distribution		p-value: 0,781435

Obs.: ***, **, * represents levels of significance of 1%, 5% and 10%

Source: Elaborated by the author

With the estimated cost curve, we can construct series of marginal cost estimates. We made two series: one with observed wages per access and the other with the average wages per access. These series are presented in Table3.

Table 4 – Marginal cost of mobile telephony, using observed wages and the average wage per access

Data	Observed wage	Average wage
2004q1	0.07	0.06
2004q2	0.13	0.12
2004q3	0.13	0.12
2004q4	0.12	0.12
2005q1	0.11	0.11
2005q2	0.11	0.11
2005q3	0.11	0.11
2005q4	0.11	0.10
2006q1	0.09	0.09
2006q2	0.09	0.09
2006q3	0.10	0.11
2006q4	0.11	0.11
2007q1	0.10	0.10
2007q2	0.10	0.10
2007q3	0.11	0.11
2007q4	0.11	0.12
2008q1	0.11	0.11
2008q2	0.12	0.12
2008q3	0.12	0.13
2008q4	0.11	0.12
2009q1	0.10	0.10
2009q2	0.09	0.10
2009q3	0.11	0.12
2009q4	0.13	0.13

Source: Elaborated by the author

It is important to notice that the cost is measured by each call. Therefore, if we assume the factors used to originate a call are the same to those used to finalize it, then the costs of origination and termination are equal. Thus, the cost of completing a call would be a half of the cost of performing an entire call, or something around R$ 0.07 (seven cents) in the fourth quarter of 2009.

With respect to the analysis of the wholesale market, *i.e.*, the termination of calls, we found that the estimated marginal cost for terminating a mobile call (R$ 0.07) *vis-à-vis* the price of mobile interconnection (R$ 0.40) is very small. This fact may indicate that indeed the providers in the mobile telephony have market power in mobile termination and tend to charge a monopoly price for interconnection.

To check this we analyze the existing mark-up in both markets, comparing the price charged with the estimated marginal cost in each market, for the period. To this end, we define the formula of mark-up as:

$$Mark - up = \left(\frac{P - CMg_m}{CMg_m}\right) \quad (14)$$

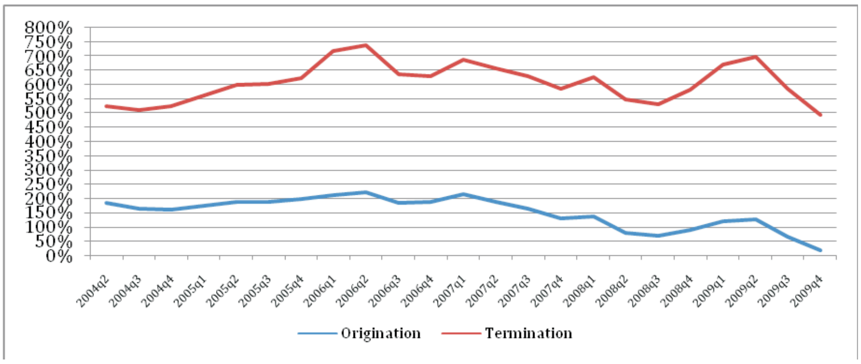
where:

P = Price of mobile on-net and off-net call; and

CMg_m = Marginal cost of mobile telephony.

The results are shown in the Graphic 1 below:

Graphic 1 – Mark-up in the mobile markets



Source: Elaborated by the author

Whereas a *mark-up* of 100% implies that the supplier is selling the service by a price which is twice its marginal cost, the values of the termination (although decreasing) remains high when compared with the origination.

Observing the calculated values, it appears that the mark-up (17%) in the origination market is relatively small *vis-à-vis* the market power in the market for call termination (494%). Thus, we can say that market power in the market for call origination is lower than the market power for call termination.

Another way of analyzing the results is by comparing the average mark-ups of the observed period. In this light, it appears that both are high mark-up, but the average mark-up in the origination market (164%) remains much smaller than the average mark-up in the market for call termination (629%), which does not exclude the hypothesis that market power in both markets occur in isolation.

Since at the current level the mark-up of retail is low, it is expected that the service regulator to act more urgently in the regulation of interconnection prices, which would reduce the market power in call termination, making the difference between mark-ups are reduced.

Therefore, an attempt to maintain or even expand, the price of calls in order to reconstruct the reduced profits due to a price reduction of interconnection rate would not materialize given the low market power in call origination. The competition also encourages the maintenance and expansion of the number of mobile users, even with a decreasing termination price, since each provider would be encouraged to have more access to enhance the number of calls and keep their profits with incoming calls.

Moreover, a reduction in the price of calls does not generate any incentive to reduce the price of termination.

Whereas the difference between the market power of termination and origination is passed onto the competition for access, it identifies a motivation to the implicit subsidy to mobile phone equipments when the price of mobile termination is not regulated, since competition is in the number of users rather than in the mobile phone traffic.

Since providers of mobile telephony services apply very similar prices in their on-net and their off-net calls and the traffic between them is symmetric or close to that, it results that the net payment among them is practically null. However, the landline service has not that benefit, since it cannot replicate the prices charged by mobile provider.

Taking into account the price charged by mobile interconnection, the price of a landline call to a mobile becomes more expensive than the price of a mobile call to a landline, this stimulates the migration of landline users to the mobile provider.

Furthermore, as the price of mobile interconnection is more than 10 times the price of interconnection to landlines (R$ 0.40 vs. R$0.03), the net payment of interconnection services is largely unfavorable to the landline provider, which is the main injured by the lenient regulation of the price of mobile interconnection.

Even the user has to pay the high price of call termination, he can respond to that market failure by using more than one provider of mobile telephony. In that way, he may become a multiple networks user and just perform on-net calls avoiding to pay the interconnection rate.

Such a result is an indication that it is necessary a stronger regulation of mobile interconnection rate, at least from the competitive point of view. The analysis provided in the next section shows that a reduction in the mobile interconnection rate is also beneficial from the welfare point of view.

3 Externalities from received calls

3.1 Description of the Model

According to the model proposed by Harbord and Hoering (2010), a reduction in the mobile interconnection rate does not reduce the consumer surplus and the welfare of the mobile market.

The model that the authors use is a generalization of the competition model of networks of Laffont *et al* (1998) and Carter and Wright (2003) for inclusion of asymmetric networks.

The quantitative analysis is based on Hoernig (2009), which presents an analytically tractable model of competition between various asymmetric mobile networks to determine both the consumer surplus and the profits of each network in equilibrium.

Thus, the consumer surplus is the result of the sum of utilities for the use of the mobile network and the landline services, minus the cost of using these services.

The equations used are from the model Hoering and Harbord (2010). The parameter of the model is the price of mobile interconnection, since the prices of mobile-to-mobile and fixed-to-mobile calls depend on the price of mobile interconnection. It is well-known that the price of network call “A” to network “B” will equal the cost of the network “A “, plus the value of ending the call on the network “B”, plus a *mark-up*, depending on the provider’s market power:

$$P_{a-b} = C_{oa} + P_{tb} + \pi \qquad (15)$$

P_{a-b} = Price of a call from network “A” to network “B”

C_{oa} = Cost of call origination in network “A”

P_{tb} = Price of call termination in network “B”

π = Mark-up

Therefore, for the consumer, the price of interconnection affects the price of the call, which implies the number of calls, and finally determines his utility.

To calculate the economic welfare, we calculate the welfare of the representative consumer of each mobile operator and then summing up these terms we obtain the welfare of mobile consumers.

Below, we present the methodology to calculate the mobile consumer surplus.

$$w_i = \rho M \sum_{j=1}^{n} \propto_j \left(v_{ij} + \phi u_{ji}\right) + \rho N \left(v_{if} + \frac{\rho_f}{\rho} \phi u_{fi}\right) - F_i \tag{16}$$

where:

ρ = probability of making a mobile call;

ρ_f = probability of making a landline call;

M = Number mobile users;

N = Number of landline users;

$\propto_j$ = Market share of mobile operator j;

v_{ij} = utility of making a call from network i to network j;

u_{ji} = utility of receiving a call from network j on network i;

φ = externality to receive a call; and

F_i =Annual subscription charged by the firm i.

The utilities v_{ij} and u_{ji} depend on the number of calls made and received and can be written as follows:

$$v_{ij}\left(q_{ij}\right) = a_i \times q_{ij}^{\frac{\varepsilon-1}{\varepsilon}} - p_{ij} \times q_{ij} \tag{17}$$

and

$$u_{ji}\left(q_{ji}\right) = a_i \times q_{ji}^{\frac{\varepsilon-1}{\varepsilon}} \tag{18}$$

where:

a_i =Parameter of the demand for mobile provider i;

q_{ij} =Number of calls made from de the provider i to provider j;

p_{ij} =Price of calls made from provider i to provider j;

q_{ji} =Number of calls received by the provider j of the provider i; and

ε =Price-Elasticity.

To calculate the total welfare of consumers of mobile telephony (S), we have to multiply the surplus of each representative consumer by the market share of each provider and the amount of accesses:

$$S = M \propto' w \tag{19}$$

To calculate the consumer surplus of the landline telephony (S^f), we consider the utility of fixed-mobile calls for each mobile provider and the total access to the landline:

$$S^f = N \rho_f M \sum_{i=1}^{n} \propto_i \left(v_{fi} + \frac{\rho}{\rho_f} \phi u_{if}\right) \tag{20}$$

For the welfare of mobile providers, we calculate the profit of each one of them. Thus, we consider the profit arising from originated calls plus the revenue from the interconnection service plus each access annuity, minus the cost of maintaining each access.

Regarding the mobile telephony provider, the price of a call is affected by the interconnection rate and so the revenue of originating calls. That revenue also depends on the number of calls. The same happens with the revenue from incoming calls, if by one side the reduction in the price of interconnection reduces revenue, by other the increase of incoming calls can lead to an increase in revenues.

Thus, we model the profit of each provider as follows:

$$\pi_i = M \propto_i \left(\rho M \sum_{j-1}^{n} \propto_j R_{ij} + \rho N Q_i + F_i - f_i\right) \quad (21)$$

with:

R_{ij}=Revenue from calls i to j;

Q_i=Revenues from incoming calls from provider i and landline provider; and

f_i=annual fixed cost of provider i.

The total surplus of producers mobile (Π) is the sum of the profits of each provider weighted by the market share and the total number of accesses:

$$\Pi = M \propto' \left(\rho M R \propto + \rho N Q + F - f\right) \quad (22)$$

Finally, the landline provider surplus (π^f) is given by the revenue of originated fixed-mobile calls:

$$\pi^f = N \rho_f M \sum_{i-1}^{n} \propto_i r_f q_f = N \rho_f M r_f q_f \quad (23)$$

where:

r_f=Revenue from fixed-to-mobile calls; and

q_f=Number of fixed-to- mobile calls.

The total welfare is given by:

$$W = S + S^f + \Pi + \pi^f \quad (24)$$

3.2 Calibrating the Model

Calibrating the model is to define the parameters such that the data, when introduced in the model, produces results that are adherent to the reality.

For the demand of mobile phone it was used a linear demand function, which was calibrated using data from the *Interactive Global Wireless Matrix*. That data provides the number of minutes demanded from each mobile service provider and the average prices charged.

Since the mobile service offered in Brazil exhibits the particularity of having approximately 90% (ninety percent) of pre-paid mobile phones, where there is no a monthly subscription, we consider F_i being equal to zero.

The data of prices per minute where collected from the website of each provider, the on-net and off-net prices for the pre-paid plans.

The data of the landline provider is available from ANATEL. The minutes of use for fixed-to-mobile calls and its average price per minute for each mobile operator were the information obtained from that agency.

The elasticity price of the demand is equal to -1.62, as calculated by Baigorri and Maldonado (2011). For the fixed-mobile we consider a value of -0.5, according to the weighted average values reported by Barrionuevo and Lucinda (2005) and obtained from a survey performed by the Getulio Vargas Foundation in 2003.

The parameter ϕ, which measures the intensity of the externality varies among three levels: zero (*i. e.* no externality), 0.5 and 1(*i. e.*, the receiver has the same utility as the user who originates the call). In fact, a value around 0.5 seems to be realistic, however, we consider three levels of externality for comparison purposes.

To calculate the market share it was used the amount of access of the four largest mobile phone service providers in December 2009 (ANATEL).

The fixed costs of mobile telephony are assumed to be R$ 7.00 per month, leading to an annual fixed cost of R$ 84.00, according to estimates reported by Ellery (2006).

For the marginal cost of mobile telephony we consider R$ 0.13, estimated in the previous section. For simplicity, in the exercises to be held in this section, we assume that this marginal cost is constant

For the cost of origin and termination of calls, we consider a half of that value, assuming that the costs of origin and termination are equal.

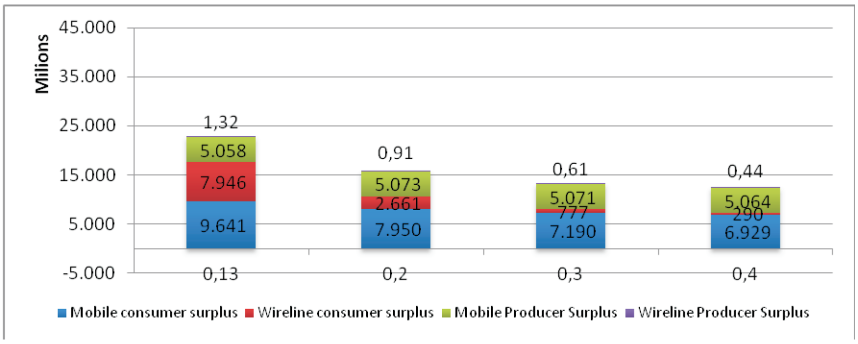
The cost of termination in the landline network was assumed R$ 0.03, which is approximately the average value of the price approved for wireline providers. Therefore, we use the weighted average rates approved for the operators of landlines phones as the price of fixed-to-mobile call.

The base scenario uses the average interconnection rate of the mobile phone companies, R$ 0.40. In alternative scenarios, we use gradual changes in the mobile interconnection price: R$ 0.30, R$ 0.20 and R$ 0.13, which is the marginal cost of mobile telephony, as estimated in this work.

3.3 A comparative statics exercise

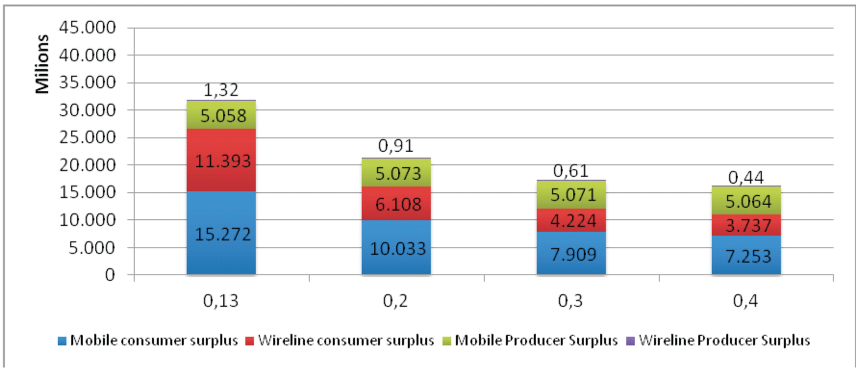
The following Graphics show the results of comparative statics exercises performed using the model when the interconnection rate varies within each scenario of externality intensity of receiving calls.

Graphic 2 – Externality $\phi = 0$ X Possible Interconnection Price



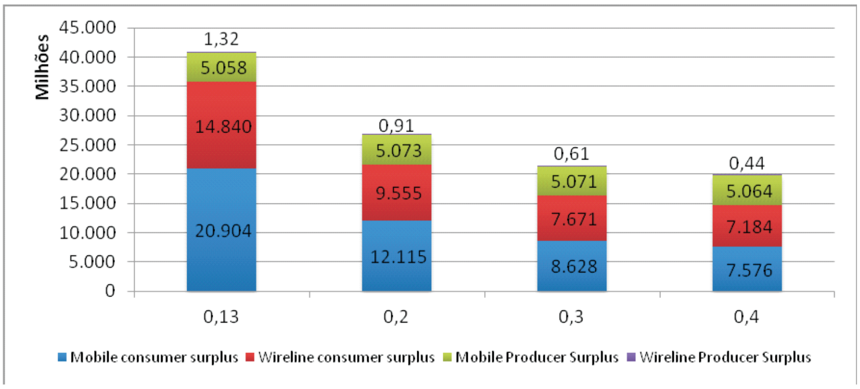
Source: Elaborated by the author

Graphic 3 – Externality ϕ = 0.5 X Possible Interconnection Price



Source: Elaborated by the author

Graphic 4 – Externality ϕ = 1 X Possible Interconnection Price



Source: Elaborated by the author

From the graphics above, we note that the total welfare increases when the interconnection price decreases. The total amount of welfare varies from about R$ 12 billion of Reais when it is considered the current value of the interconnection price and a null externality for receiving calls to R$ 40 billion of Reais approximately in a setting where the mobile interconnection price is R$ 0.13 and the externality is equal to one by receiving calls.

Consider the scenario with externality equal to 0.5. The mobile consumer surplus changes from R$ 7.2 billion of Reais when the interconnection price is R$ 0.40 to R$ 15.2 billion of Reais if that price equals the marginal cost. This represents an increase of R$ 7 billion of Reais or 111% increase in the users welfare of mobile telephony.

The landline consumer surplus departs from R$ 3.7 billion of Reais if the interconnection rate is the current level to R$ 11.3 billion of Reais when the price of interconnection is equal to R$ 0.13. This is an increase of R$ 7.5 billion of Reais, which represents an increase of 205% in the landline consumer welfare.

The provider of landline triplicates its profit. Despite the overall increase of welfare when the interconnection price goes from the current value to its marginal cost is approximately R$ 878 thousand of Reais, this represents an increase of 201%, since the welfare of that provider varies from R$ 437 thousand of Reais to R$ 1.3 billion of Reais.

The only sector that has a reduction in its welfare is that of providers of mobile telephony. They have the income reduced by approximately R$ 6 million of Reais. However, the mobile provider profit remains around R$ 5 billion of Reais, so the reduction does not reach 1%.

It is important to notice that there is an increase in the mobile provider profits before its fall. It occurs because of an increase in the traffic resulting from the fall in the interconnection price in the first reductions.

The reduction in the interconnection price provokes a decrease in the revenue of the mobile services provider; however that reduction is partially compensated by the increase in calls because of the price reduction. Since the externality is considered less than 1, the reduction of the profit prevails.

For users the effect is straightforward. Once the interconnection price is reduced, the mobile-to-mobile, mobile-to-landline and landline-to-mobile prices are also reduced. That implies an increase in the amount of calls and the users welfare increase.

The landline provider has the interconnection as its more expensive input when producing a landline-to-mobile call. Thus, if the reduction of the interconnection price is totally transferred to the call price, so the profit per call remains constant, a larger number of calls will arise and that will produce an increase in the landline provider profit.

4 Conclusion

By identifying an indication of low power in the mobile telephony market, with a lambda value around $\lambda = 0{,}168$, we are able to confirm the hypothesis that, in fact, in the mobile market, there exist competition at least when regarding to call origination.

Thus, it is unlikely that any operator can raise the price of minutes of calls significantly without decreasing its market share.

Moreover, the existence of competition in the retail market does not ensure the competitiveness in the wholesale market. That is, despite the market being competitive in the source of calls; it is not a guarantee that the market for call termination will also be.

The value of R$ 0.07 found in this study as the marginal cost estimation of termination calls in the mobile telephony for the fourth quarter of 2009, provides a good indication that in fact the providers of mobile telephony services are charging a price which is much greater than its marginal cost for interconnection, since the average price of mobile interconnection in the same period was R$ 0.40. Thus, we find that the corresponding *mark-up* is approximately 494% in the termination market. On the other hand, the *mark-up* in the market for call origination is 17%.

We also provide a framework which determines whether a reduction in the price of interconnection generates an increase in welfare to society. That framework consists in a model that considers fixed-to-mobile, mobile-to-mobile and mobile-to-fixed calls, four mobile operators, a landline operator and the existence of positive externalities when receiving calls.

The results indicate that a reduction in the mobile interconnection price leads to an increase in total welfare, which would justify a more effective regulation on that mobile interconnection rate.

Thus, we conclude that the price of interconnection - especially in the case of Brazil where the penetration rate has reached 100% - must be equal to the marginal cost of mobile telephony. At that level the welfare of the society is maximized, despite the profits reduction of mobile providers.

APPENDIX I – The parameter λ as the market power of the model

Consider the market demand:

$$p = p(Q) \quad (25)$$

When we have "N" firms competing under the Cournot's style and each one produces q_i, then . $Q = \sum_{i=1}^{N} q_i$ So each one maximizes:

$$p(Q)q_i - c(q_i) \quad (26)$$

The first order conditions results:

$$p'(Q)q_i + p(Q) - c'(q_i) = 0 \quad (27)$$

Then we can write:

$$p(Q) = CMg(q_i) - p'(Q)q_i = CMg(q_i) - \left(\frac{dp}{dQ} \times Q\right) \times \frac{q_i}{Q} = CMg(q_i) - h(Q) \times \lambda \quad (28)$$

Where the function h depends on Q and probably on income and other parameters, and is the market share of firm *i*, hence $0 \leq \lambda \leq 1$.

For this reason, in a monopoly, $q_i = Q$ and results $\lambda = 1$.

Under perfect competition, $q_i \approx 0$ and results $\lambda = 0$.

APPENDIX II – Unit Root test results

Table 5 – Result for ADF test

ADF Test	Ho: Unit Root a=1					
	Qmt	Pft	Pmt	PmtPft	Yt	Ct/M
level						
Estimated value (a-1)	-0,4826	-0,1250	0,0558	-0,0052	-0,0630	-0,3292
t- statistics	-2,2516	-1,2604	0,6838	-0,0830	-0,5058	-2,2853
p-value	0,1881	0,6501	0,9919	0,9495	0,8878	0,1768
1º difference						
Estimated value (a-1)	-0,8586	0,7504	-1,0116	-1,1990	-1,4786	-1,7589
t- statistics	-3,2378	-2,2961	-2,7042	-2,9791	-3,6245	-4,7276
p-value	0,0179	0,1733	0,0732	0,0369	0,0053	0,0001
2º difference						
Estimated value (a-1)	-1,2069	-2,0708	-1,2227	-2,1529	-1,7983	-2,1544
t- statistics	-4,2239	-4,8766	-2,9801	-4,9014	-4,0709	-7,9417
p-value	0,0006	0,0000	0,0368	0,0000	0,0011	0,0000

p-value less than 0.1 means that rejects Ho with this probability, ie, is stationary

Source: Elaborated by the author

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