# INTERCHANGE FLOWS BETWEEN MOBILE TELEPHONE NETWORKS: ASYMMETRY AND DISCRIMINATION

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**ABSTRACT**

Over the last decade, the development of mobile telecommunications has reached a very high rate of growth in most industrialised countries and, in particular, in Italy. The increasing volume of mobile phone calls and the relative growing number of carriers are transforming mobile telecommunications from that of a traditional monopoly and instead into a market with growing competitive pressures. The older scenario of telecommunication mobile services formed by a state monopoly carrier is changing into one in which there are different competitive companies that offer mobile telecommunication services.
In this paper we will analyse, through our simulation modelling, the relationship between market share and profit resulting from a strategy of price discrimination. In particular, the policy of price discrimination in the mobile telephone market is based on the possibility for the carriers to set different retail prices with regard to calls made on net or off net.

## INTRODUCTION

In the course of the last years, the sector of mobile telephones has been characterized by many changes that have revolutionised its structure and physiognomy.
The current scenario in the Italian mobile phone sector is represented by the presence of diverse competitors that operate in competition with the traditional ex monopolist carrier, offering a multitude of services to an increasingly articulated clientele.
The Italian mobile phone market is characterized by a more elevated growth rate of demand in the European context and by the presence of the dominate operator TIM that despite the entrance of Omnitel in 1996, Wind in 1999, and Blu in 2000 (even if the latter did not succeed to reach economic and financial self-sufficiency due to a serious crisis within the market), has consolidated its continental leadership in terms of its market share.
In reality, the liberalization of the Italian sector has come about quite late with respect to other European countries, where the regulators of the sector were a major force of impulse for innovation and market liberalization. The abolishment of the monopoly regime and the progressive opening of the competition had conferred great importance to the role of the regulator, increasing its range of intervention within the sector. Competitiveness produced socially efficient markets that required the definition of body of rules and regulations in order to eliminate possible barriers to entry, such as the conditions of interconnection and the rebalancing of telephone rates.
The crucial factor for the development of competition is the possibility of interconnection between distinct networks. The carriers can strategically use the possibility of customers to chose between on net or off net calls. This has been the subject of present works undertaken by Michael Carter and Julian Wright, who have analysed the interconnection phenomenon between networks.
The main aim of our paper is to analyse the competition in the Italian mobile phone market under the following conditions:

- Asymmetry in market shares.
- Price discrimination's strategy carrie out by carriers between phone calls which, having originating on the carrier's own network, finish on the same network (on net) or on the network of another carrier (off net).

Both of these conditions are representative of the Italian competitive scenario in which there is a dominant carrier in terms of market share and where retail prices diverge depending on the type of call, depending on whether it is on net or off net.

The starting hypothesis is that of a competitive model made up of only two networks which chose a strategy of price discrimination and which is characterised by market symmetry. This last hypothesis will be substituted with that of market asymmetry. The aim of the present paper is that of analysing how when market shares vary it also changes the economic convenience of chosing a strategy of price discrimination. In particular, we will analys how a strategy of price discrimination provokes positive effects for the network that holds the greatest market share both in terms of variations in profits and in market share. The analysis will be limited to the hypothesise of only two carriers since its been demonstrated that the effects provoked by price discrimination in a model in which three carriers compete are not significantly different from the ones represented by the current model.

## A MODEL OF NETWORK COMPETITION

To set up our framework we start from the model of Carter and Wright (1999) proposing an extension in order to analyse the particular competitive situation.

Carter and Wright, (1999) consider a two carriers model whereby both providing full local coverage.

This assumption is not very far from the Italian reality where only four carriers operate and in which one of them is suffering from a grave economic and financial crisis and subsequently, considering to abandon the sector altogether. In addition, it demonstrates how the effects of a price discrimination strategy are not noticeably divergent in the case in which the market is composed of three respective carriers or that of two carriers.

The essential characteristics of such a model are the following:

- Companies are horizontally and symmetrically differentiated and will be indicated from this point onwards as network "*a*" and "*b*";
- Companies bear a cost "*c*" for starting and terminating calls;
- Companies bear the costs for interconnection equal to "*d*", presumably constant and equal at the same time;
- Consumers draw upon the utility of calls carried out. The utility of the generic consumer to be connected to a generic carrier "*i*" is given by:

$$u(q^i) + \theta^i + v_0 \qquad (1)$$

Where:

- $q^i$ represents the total quantity of telephone calls originated from carrier "*i*" and direct to subscribers of another carrier;
- $\theta^i$ measures the additional benefits of the customer to be connected to one of the two networks;
- $v_o$ represents the fixed surplus for the connection with the networks.

The market shares are determined on the basis of Hotelling's model, according to which consumers are uniformally distributed throughout a unitary interval [0,1]. A consumer with value "*x*" receives extra benefits:

$$\theta^a = \frac{\beta}{2\sigma} + \frac{1-x}{2\sigma} \qquad \theta^b = \frac{x}{2\sigma} \qquad (2)$$

Derived from belonging to carriers *a* and *b* respectively.

The variable $\sigma$ represents the degree of substituability between carriers while the reverse measures the cost in which consumers incur by changing network. Such variable play a fundamental role in the determination of market share. Parameter $\beta$ measures the degree of asymmetry between the carriers in terms of brand loyalty and this also influences their market share. Until $\beta=0$ and $\sigma=0$, carrier *a* divides the market equally with carrier *b*, if instead $\beta>0$, carrier *a* finds itself in an initially more advantageous position, detonating a greater market share.

The generic customer *i* presents the utility function given by:

$$v^i = \max_q \{u(q) - pq\} \qquad (3)$$

A consumer, localised in *x* will be indifferent between the two networks if:

$$V^a + \frac{\beta}{4\sigma} + \frac{1-x}{2\sigma} = V^b + \frac{x}{2\sigma} \qquad (4)$$

By solving for *x*, we obtain that the market shares of carrier *a* is:

$$s^a = \frac{1}{2} + \frac{\beta}{2} + \sigma\left(V^a - V^b\right) \qquad (5)$$

Consequently, the market shares of the second carrier will be:

$$s^b = 1 - s^a = \frac{1}{2} - \frac{\beta}{2} + \sigma\left(V^b - V^a\right) \qquad (6)$$

In the present work the following hypotheses are added in order to analyse the Italian competitive situation:

- Asymmetry in market shares.
- Price discrimination strategy practiced by both carriers.

This last hypothesis is based on the possibility of operators to implement different retail prices in relation to calls that are directed on their networks (on net) or those on competitor's networks (off net). This strategy has already been working for some time now by all Italian mobile telephone operators. Such price discrimination strategy has as its goal that of introducing user migration towards their own networks. This goal assumes a relevant role with regard to the Italian mobile telecommunications sector, where the penetration rate is very high and not so far from being very close to a context of full participation on the behalf of users. In addition, it has passed from a phase in which the market was in full expansion and whereby carrier's had the goal of attracting customers that still had not decided to participate in the market to a phase in which the market is saturated and the competitive strategy is based on attracting customers from competing networks. The possibility of changing operators has been favoured by the Italian Communications Authority that has laid out the portability number of carriers, or rather systems that consent the change of mobile carriers whereby conserving their old number. Portability has greatly increased the migration phenomenon of customers between carriers: it was allowed to come into force on 1 May 2002 and has provoked 25 thousand transfer requests within 15 days, as many as those gathered in the United Kingdom within a year.

The decision by customers to migrate on other carriers is based on two considerations. The first is related to the effective price discrimination strategy being practiced: customers search to migrate towards those carriers that have adopted a system of lower prices. The second refers to the relative dimensions of market shares. For example, even if a carrier fixes their internal prices relatively low, but have a market share of small dimensions, migration would not therefore be convenient for customers that would have a very low probability of carrying out calls on net.

The focus of the present work is based, therefore, on the analysis of the convenience by mobile telephone carriers to practice a price discrimination strategy in function with the relative dimensions of their market shares. The goal of such analysis is that of assessing if the price discrimination strategy provokes a different impact in terms of profits and market shares according to relative dimensions. The fact that price discrimination can provoke competitive advantages for an operator to bring about the necessity for intervention by a Regulatory Authority. In order to assure, in fact, that there are not any barriers to entry and the market remains containable makes the intervention by a Communications Authority fundamentally important.

From a design and construction models point of view, price discrimination involves the following considerations, relative to generic carrier *i*:

- The operators must fix two price levels: one with regard to calls on net by following that indicated with $p^i_{int}$ and another with regard to calls off net indicated with $p^i_{est}$;
- there exists two demand function typologies, one with regard to the market of calls on net and the other with regard to the market of calls off net:
  - $q^i_{int} = a - bp^i_{int}$;
  - $q^i_{est} = a - bp^i_{est}$;
  - the total quantity of calls made would therefore be equal to: $q^i = q^i_{int} + q^i_{est}$;
  - a is the linear function parameter presumes equal both for calls on and off net;
  - b is the linear function component in question, concerning the sensibility of customers presumes equal both for calls on and off net;
- the utility function depends on both prices and is given by:

$$V(p^i_{int}, p^i_{est}) = \max[u(q^i_{int} q^i_{est}) - p^i_{int} q^i_{int} - p^a_{est} q^i_{est}] \qquad (7)$$

Based on the hypotheses made the profit function will be structured in the following way:

$$\pi^i = s^i\left(p^i_{int} - 2c\right)q^i_{int} + s^i\left(p^i_{est} - c - d\right)q^i_{est} + s^j(d-c)q^j_{est} \qquad (8)$$

Where the first addendum represented profit shares realised on the market of on net calls, the second corresponds to profit shares deriving from call made off net and therefore, to the net costs of interconnection, whereas the third represents the profit share provoked by the flow of calls originating on another network.

## MODEL UNDER SYMMETRY CONDITIONS

In order to strat the process, we consider the symmetry's condition as regards the relative market shares. Subsequently, we will analyse the effect of the strategy of price discrimination in conditions of asymmetry, in order to show the italian competitive situation.

In the hypothesis of price discrimination with respect to two markets (that of calls made on and off net), it is necessary to optimise the profit made by both markets. The goal of optimisation is, in our specific case, the reaching of Bertand equilibrium.

For carrier *a* the profit in Bertrand competition strategy, is given by:

$$\frac{\partial \pi^a_{int}}{p^a_{int}} = 0 \qquad \frac{\partial \pi^a_{est}}{p^a_{est}} = 0 \qquad (9)$$

Analogous for carrier *b*:

$$\frac{\partial \pi^b_{int}}{p^b_{int}} = 0 \qquad \frac{\partial \pi^b_{est}}{p^b_{est}} = 0 \qquad (10)$$

In conditions of symmetry, or rather when the firms are equally divided in the market, is verified that: $s^a = s^b = ½$.

Therefore, the internal market profit of carrier *a* will be equal to:

$$\pi^a_{int} = 1/2\left(p^a_{int} - 2c\right)\left(a - bp^a_{int}\right) \qquad (11)$$

The profit of on net calls for carrier *a* will instead be equal to:

$$\pi^a_{est} = 1/2\left(p^a_{est} - c - d\right)\left(a - bp^a_{est}\right) + 1/2(d-c)\left(a - bp^b_{est}\right) \qquad (12)$$

Obviously, profits of calls off net and on net for the carrier *b* are symmetrical compared to those of carreir *a*.

For the market of on net calls, from the first order condition follows:

$$p^a_{int} = p^b_{int} = \frac{1}{2}\frac{a + 2bc}{b} \qquad (13)$$

While, for the market of off net calls:

$$p^a_{est} = p^b_{est} = \frac{1}{2}\frac{a + bc + bd}{b} \qquad (14)$$

Analogously, quantity are given by:

$$q^a_{int} = a - b\left(\frac{1}{2}\frac{a + 2bc}{b}\right) \qquad (15)$$

$$q^a_{est} = a - b\left(\frac{1}{2}\frac{a + bc + bd}{b}\right) \qquad (16)$$

Therefore in condition of symmetry, since subscribers have the same demand function, in equilibrium, the prices of off and on net calls are equal for carriers *a* and *b*, as well as the quantity. In the following parts of our paper we will study the profit maximization in condition of asymmetry and we will analyse the effects of a strategy of price discrimination as regards to relatives market shares.

## MODEL UNDER ASYMMETRY CONDITIONS

In asymmetrical conditions, or when β and σ assume major values of 0, it is necessary to impose an added hypothesis:

- The utility deriving from calls carried out on carrier *a* is the same as that deriving from calls carries out on carrier *b*:

$$u\left(q^a_{int}, q^a_{est}\right) = u\left(q^b_{int}, q^b_{est}\right) \qquad (17)$$

In reality, to variate is the net surplus of consumers

Therefore:

$$V^a = (-p^a_{int} q^a_{int} - p^a_{est} q^a_{est}) \quad e \quad V^b = (-p^b_{int} q^b_{int} - p^b_{est} q^b_{est}) \qquad (18)$$

By substituting this hypotesy in equations 11 and 12 and by maximazing profits (as well as in equations 9 and 10) in Bertrand equilibrium, we obtain follows prices:

$$p^a_{\text{int}} = \frac{1}{10}\frac{5+\beta+4\sigma c q^b_{est}-4\sigma c q^a_{est}+16\sigma c q^a_{\text{int}}+4\sigma c q^b_{\text{int}}}{\sigma q^a_{\text{int}}} \qquad (19)$$

$$p^a_{est} = \frac{1}{10}\frac{10\sigma dq^a_{est}+5+10\sigma dq^b_{est}-4\sigma c q^a_{\text{int}}+\beta+4\sigma c q^b_{\text{int}}-6\sigma c q^b_{est}+6\sigma c q^a_{est}}{\sigma q^a_{est}} \qquad (20)$$

$$p^b_{\text{int}} = \frac{1}{10}\frac{4\sigma c q^a_{est}-4\sigma c q^b_{est}+4\sigma c q^a_{\text{int}}+5-\beta+16\sigma c q^b_{\text{int}}}{\sigma q^b_{\text{int}}} \qquad (21)$$

$$p^b_{est} = \frac{1}{10}\frac{4\sigma c q^a_{\text{int}}+5-\beta+10\sigma dq^a_{est}-4\sigma c q^b_{\text{int}}+10\sigma dq^b_{est}+6\sigma c q^b_{est}-6\sigma c q^a_{est}}{\sigma q^b_{est}} \qquad (22)$$

**Step I**

We have determined prices, profits and market shares by allotting to the parameters of the model the initialisation values of the process. For example, supposing $\beta$=0.9, $\sigma$=0.01 (a realistic value in Italian mobile telecommunications market where the number of the portability system is in force), *c*=2, *d*=3 (we have supposed that the cost of interconnection is greater than the original cost and that of terminating cost on own network), $q^a_{\text{int}}=q^b_{\text{int}}=39$, $q^a_{est}=q^b_{est}=38.5$ (such quantities have been fixed departing from model symmetric conditions), we have obtained the following results:

Table 1: Example of Bertrand Competition

| | $P_{\text{int}}$ | $P_{est}$ | $S^i$ | $\pi^i$ |
|---|---|---|---|---|
| Carrier a | 5.512 | 7.522 | 0.59 | 108.37 |
| Carrier b | 5.051 | 7.058 | 0.41 | 72.37 |

**Step II**

We have inserted the quantity variation and we have considered a price variation of on net phone calls equal to $\varepsilon$ for both carriers. Such price variation provokes a decrease from maximum profit for both carriers, but at the same time, determines the competitive advantage for the carrier with greater dimensions with respect to the other carrier. This is constituted by a respective carrier's increase in market shares. Such results are observable in figures 1 and 2 where the profit variation can be analysed (respectively for carrier a and for carrier b) to change its internal and external price levels. When we have assigned a variation from optimum price level, the profit, as is obvious, is decreasing to the point of assuming negative values. It must be noted how carrier *a* can obtain maximum profit greater than that of carrier *b*.

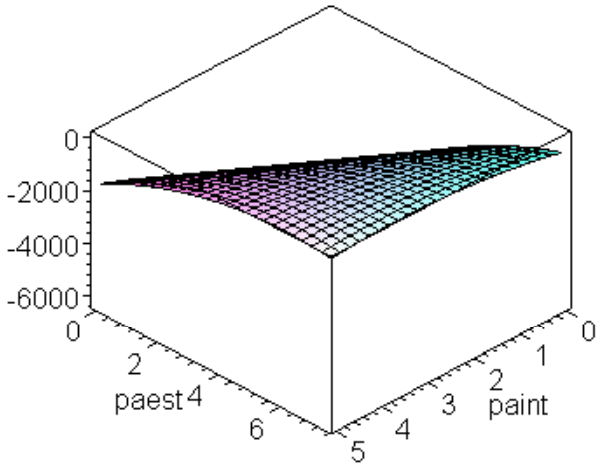


Figure 1: Profit of Carrier A

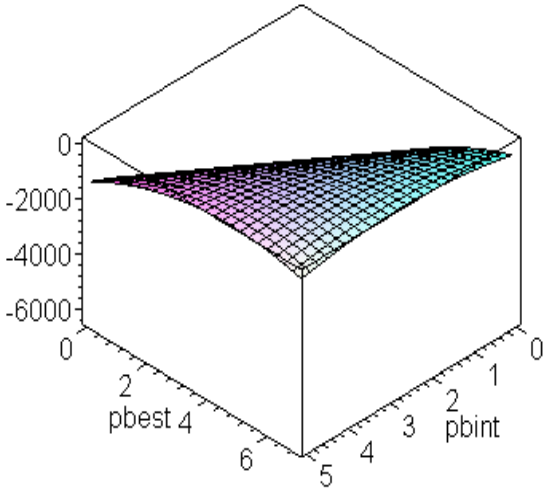


Figure 2: Profit of Carrier B

The relation that elapses between market shares and the level of internal prices are put in evidence by figures 3 and 4. One can see how, as carrier *a*'s market share increases, its internal price decreases, and how such an effect is amplified with the increase in another carrier's internal price. Analogously, one can see how, as carrier *b*'s market share increases its internal price decreases, even more so if carrier *a* increases its internal price. As you can see in the figure, given the range of relative values to optimum prices, carrier *b* is not able (despite even a's elevated prices), of undercutting the carrier with greater dimensions. This result is provoked by the asymmetry between carriers and is represented by parameters $\beta$ and $\sigma$. Consequently, also the hypothesis in which the carrier with lesser dimensions attempts to fix low price levels while the other carrier maintains elevated prices, the high degree of brand loyalty, along with the elevating cost of switching to another one, allow carrier *a* to maintain its own market share.

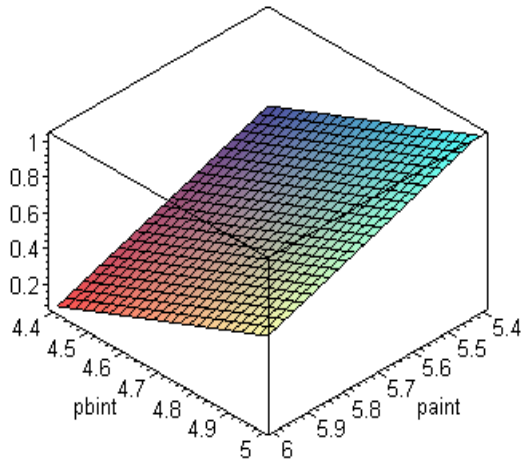


Figure 3: Market Share of Carrier A

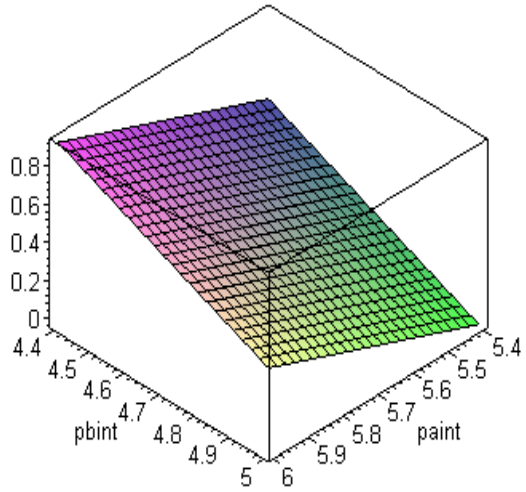


Figure 4: Market Share of Carrier B

## CONCLUSION

In this paper we have analysed the relationship between carriers that have chosen price discrimination policies in the mobile telecommunications market. By using a simulation program called Maple, we have tested the hypotheses of the model. First, we have shown that in conditions of Bertrand equilibrium, the market leader has profits greater than that of their competitor. Then, we have studied the effect of price discrimination with regard to on net telephone calls carried out by both carriers and we have obtained the following results:

- The choice of policies such as price discrimination involves a gap from maximised prices and an increase of market shares for both carriers.
- By applying such an intensive price discrimination strategy, the leader can undercut the competitor.
- On the contrary, the carrier with a smaller market share doesn't succeed in getting all the market, also in the case in which the leader price is very high. Brand loyalty and switching costs (variables $\beta$ and $\sigma$) allow the leader to remain in market.
- Therefore, the policy of price discrimination is more advantageous for the leader.

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