Strategic behaviours in international telecommunications system

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Abstract

In this paper the international telecommunication market is analysed in order to evaluate the impact of different strategic behaviours of telecommunications carriers. Using the Nash fixed threat bargaining model, we formalize the carriers bargaining behaviour in a growing competitive pressure market. The effect of competition is considered both in the final market and in the intermediate one, in which carriers compete on tariffs to get an appropriate distribution of profits. We show that carriers may have an incentive to a cooperative behaviour in the setting of tariffs and the results of such behaviour in terms of final prices depends upon the competitive pressure degree they are subject. © 2001 Elsevier Science B.V. All rights reserved.

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1. Introduction

Over the last decade, regulatory reforms and technological progress have had strong impacts on the telecommunications sector in most industrialized countries. The globalization process of the international economy, with a rise of telecommunications intensity, induces a growing demand for international telecommunication services [1]. This is changing the functioning of international telecommunication systems, traditionally based upon bilateral trade cartels among the monopolists serving each national market. The increasing volume of international calls and the corresponding growing number of carriers are moving telecommunications from the traditional monopoly to a market with a growing competitive pressure [2]. The other scenario of telecommunication services formed by state monopoly carriers is changing into a single conduit in which there are different exclusive territorially competitive companies interconnected internationally.

In the USA, since 1984 when the regional operating companies were separated from AT&T, deregulation has gone far. In ensuing years, the US telecommunications marketplace became an exceedingly competitive arena and strategic alliances became a core feature of competitive strategy. The recent further deregulation of the USA telecommunications industry through landmark Telecommunications Reform Act of 1996 may accelerate even faster the pace of competitive dynamics in US markets. In particular, the Telecommunications Act
has authorized the Bell Operating Companies (BOCs) and the Local Exchange carriers (LECs) to provide long distance services competing with the existing Interexchange carriers (IXCs) [3].

In the UK in 1984, British Telecom became a private company, and the Government allowed Mercury to operate in the long distance market. Such transition from monopoly to competition induces new problems to determine competition pressure results.

Long-distance is a very important sector in the whole telecommunications market. For example, in 1995 in the USA this sector made up 41% of the telecommunications market (Fig. 1) [4]. The other sectors were local telephony with 51%, and cellular with 8%. Typically in long distance only very big companies operate, but in the last years the scenario is changing and also small companies are entering the market.

In the USA, for example, AT&T had 95% of the market in 1985 and only 59% in 1995 (Fig. 2) [5]. There are also two other big companies, MCI and Sprint, continuously growing and about 4000 other small companies that operate in circumscribed geographical areas. With the Telecommunications Act of the 1996, also the big companies of local telephony can operate in long distance and, probably, the competition in the next years will be rising.

Many analysts point toward the large difference between the cost of providing international service, which has fallen sharply over recent years due to technological development and the relatively high prices charged by international carriers. The growing margin between the two elements has attracted an increasing range of competitors. In fully liberal markets incumbent carriers face competition from new market entrance with their own infrastructure; in other countries the conventional international service is under pressure from various alternative service provision. This includes the services of resellers which are companies that purchase facilities and resell services to business and residential users. Between 1991 and 1996 the average charge for a one minute international telephone call, from one OECD member country to all others, decreased from US$ 1.34 to US$ 0.95 in peak times and from US$ 1.07 to US$ 0.74 in off-peak time [4]. Although these are important reductions, 23% and 24% in local currency respectively, they still remain modest given the degree to which the costs of providing international infrastructure have fallen.

As shown by Baumol and Sidak [3] for the local telephony, the local exchange carriers services constitute inputs for the activities of the rivals of these firms in other markets, inputs without which the rivals cannot hope to operate. The same competitive problem is in international telecommunications system, in which an international call utilizes the services of a telephone company at each end (final market) where the revenue is collected by the originating telephone company from the party who initiates the call. The company then compensates the other one by the tariffs (intermediate market) for the costs it incurs in handling the call. Therefore, the interconnection services in intermediate market are deemed “bottlenecks” or “essential
facilities” [6], since an international carrier could use such essential facilities to achieve monopolistic rents inducing final price distortions.

In this framework, telephone services can be represented by a form of production in which each producer has the following characteristics:

- each producer has a different competitive power in its own market;
- each producer operates both in the intermediate and in the final market;
- each producer must purchase the intermediate good from the other producers.

This market form has some parallels with the standard vertical integration model and can be seen as an extension in which the production links stretch out in both directions. This is the fundamental complicating phenomenon that besets the deregulation of telephone services. This framework can be considered a symbiotic production form in which suppliers trade essential inputs with one another [7].

In this paper we analyse an extension of the general model of symbiotic production focalized on the international long-distance telecommunication services where a growing competition level is introduced. In this production model, the effect of competition is analysed both between carriers in the final market and in the intermediate market in which carriers compete on tariffs to get an appropriate distribution of profits. Thus, the corresponding bargaining effect, strictly depends upon the competitive pressure degree the carriers are subjected to. Moreover, moving from the traditional bilateral monopoly analysed in literature, Carter and Wright [7] show that carriers may have an incentive to collude in the setting of tariffs and that such collusion may lower final prices. Here an attempt is made to extend this result in the case of a growing level of competitive pressure among carriers belonging to the same final market. Carriers, can be expected to behave strategically to affect the tariff charged in the intermediate market to get an appropriate distribution of profits. Therefore to capture such effect rigorously, we formalize the carriers bargaining behaviour in a growing competitive pressure market using the Nash-bargaining solution.

The paper is organized as follows. In Section 2 the basic assumptions and the model are set up; in Section 3 results of competitive pressure provided by the model are analysed; in Section 4 the numerical evidence of the model is presented. Finally, conclusions are summarized in Section 5.

2. An analytical model

To analyse the effect of a growing competitive pressure in international telecommunication system, we consider the following two scenarios. Firstly, it is analysed the traditional bilateral monopoly, in which international telephone carriers operate in each national market and sell each other intermediate products (Fig. 3). Secondly, the existence of a second competitive carrier in one of the considered national markets is assumed (Fig. 4). In more formal terms, the monopolist (a) on one side sells intermediate product to carriers A and B; on the other side carriers A and B sell intermediate product to carrier a. These scenarios are considered due to the real evolution of the international telecommunications services sector in which regulators actively encourage entry and competition. Since the changes in the competitive structure of the different countries are not quite similar, it is important to
analyse the effects of such possible asymmetries in terms of carrier profits and final prices.

In order to simplify the analytical model, we assume that the carriers A and B exactly share the market and we do not consider the probable relations between A and B due to, for instance, to the ownership of the network. These assumptions don’t modify significantly the evaluation of the impact of different strategic behaviours of telecommunications carriers on the final market and on the intermediate one.

In this framework, carriers play a two stage non-cooperative game; in the first one they choose profit maximizing tariffs (Bertrand game) and in the second one the profit maximizing output (Cournot game). The outcome is the standard Nash equilibrium.

The firms’ profit functions are as follows:

Bilateral monopoly
\[ P_A = P_A(q_A)q_A - C_A(q_A, d_A) + T_A(d_A) - T_s(d_{sA}), \]
\[ P_s = P_s(q_s)q_s - C_s(q_s, d_{sA}) + T_s(d_{sA}) - T_s(d_A); \]

Duopolistic competition
\[ P_A = P(q_A, q_B)q_A - C_A(q_A, d_A) + T_A(d_A) - T_s(d_{sA}), \]
\[ P_B = P(q_A, q_B)q_B - C_B(q_B, d_B) + T_B(d_B) - T_s(d_{sB}), \]
\[ P_s = P_s(q_s)q_s - C_s(q_s, d_{sA}, d_{sB}) + T_s(d_{sA}, d_{sB}) - T_A(d_A) - T_B(d_B), \]

with
\[ P(q_A, q_B) \] inverse demand function in duopolistic market,
\[ P(q_i) \] inverse demand function in monopolistic market, \( i = A, B, s \),
\[ q_i \] final output of carrier \( i \),
\[ d_j \] intermediate output of carrier \( j \) sold to carrier \( s \), \( j = A, B, \)
\[ d_{sj} \] intermediate output of carrier \( s \) sold to carrier \( j \),
\[ C_i(q_i, d_i) \] cost function of carrier \( i \) twice continuously differentiable with bounded derivatives,
\[ T_i(d_i) \] revenue received by carrier \( i \) for sales of the intermediate connection service.

International telecommunications system characterized by linear tariffs and fixed proportion technology is considered (a fixed price \( t_A \) per unit of intermediate good with no lump sum transfer); moreover, cost functions depending on volume of output with constant per unit cost \( c \) are assumed for each carrier. Hence, it follows:
\[ T_A(d_A) = t_A d_A, \]
\[ T_s(d_{sj}) = t_s d_{sj}, \]
\[ T_s(d_{sA}, d_{sB}) = t_s d_{sA} + t_s d_{sB}, \]
\[ d_{sj} = q_j, \]
\[ d_A + d_B = q_s, \]
\[ C_A(q_j, d_j) = c q_j + c d_j, \]
\[ C_A(q_s, d_{sA}, d_{sB}) = C_A(q_s, q_A, q_B) = c q_s + c q_A + c q_B. \]

Given these assumptions, the carriers profit functions can be written as follows:

Bilateral monopoly
\[ \Pi_A = [P_A(q_A) - c - t_A]q_A + (t_A - c)d_A, \]
\[ \Pi_s = [P_s(q_s) - c - t_s]q_s + (t_s - c)d_A; \]

Duopolistic competition
\[ \Pi_A = [P(q_A, q_B) - c - t_A]q_A + (t_A - c)d_A, \]
\[ \Pi_B = [P(q_A, q_B) - c - t_A]q_B + (t_B - c)d_B, \]
\[ \Pi_s = [P_s(q_s) - c]q_s + (t_s - c)q_A + (t_s - c)q_B - t_A d_A - t_B d_B. \]

In the above relations inverse demand functions are assumed to be linear:
\[ P_A(q_A) = e - f q_A, \]
\[ P_A(q_A) = a - b q_A, \]
\[ P(q_A, q_B) = a - b(q_A + q_B), \]

with \( a, b, e \) and \( f \) positive constants with \( a > c \) and \( e > c \) (these assumptions will be useful for further demonstrations).

International telecommunications system is characterized by bilateral relationships among final
market carriers in which volume of output strictly depends on tariffs. Therefore, the Bertrand game in intermediate market is characterized by a simultaneous tariff choice performed by carriers \( A \) and \( z \) (in the bilateral monopolies), \( A, B \) and \( z \) (in duopolistic competition).

In the two stage non-cooperative game, the optimal quantities (profit maximizing output) are functions of the tariffs levels. As tariffs vary, this function, denoted by \( q^*_i(t) \) and called the Nash equilibrium quantity mapping, describes a set of possible Nash equilibrium quantities. In the first stage, carriers set tariffs levels assuming that profit maximizing outputs are given by \( q^*_i(t) \) function. The non-cooperative equilibrium tariffs and the corresponding quantities constitute the Nash equilibrium of the two stage game.

The evolution of the game is based on the standard technical assumptions [8]. The game outcome, obtained by backward induction [9], provides the profit maximizing output \( q^*_i(t) \) and tariffs \( t^*_i \). In particular, in the second stage, the following proposition holds:

**Proposition 1.** Quantities \( q^*_i(t) \) and \( q^*_j(t) \) are negative related respectively with \( t^*_z \) and \( t^*_j \):

**Bilateral monopoly**

\[
q^*_A(t) = \frac{1}{2b}(a - c - t_A),
\]

\[
q^*_A(t) = \frac{1}{2f}(e - c - t_A);
\]

**Duopolistic competition**

\[
q^*_A(t) = q^*_B(t) = \frac{1}{2b}(a - c - t_A),
\]

\[
q^*_A(t) = \frac{1}{2f}(e - c - t_A).
\]

**Proof.** See Appendix.

Solving the Bertrand first stage game, the following proposition holds:

**Proposition 2.** Optimal tariffs \( t^*_A \) and \( t^*_a \) are respectively:

**Bilateral monopoly**

\[
t^*_A = \frac{e}{2}; \quad t^*_a = \frac{a}{2};
\]

**Competitive market**

\[
t^*_A = t^*_a = \frac{e}{2}; \quad t^*_z = \frac{a}{2}.
\]

**Proof.** See Appendix.

Proposition 2 points out that there are equal non cooperative equilibrium tariffs both in the case of bilateral monopoly and duopolistic market. The intuition arising from the above propositions is that the competition level increase induces a final price decrease due only to an aggregate final supply growth, whereas the intermediate market competition increase is ineffective in terms of final price change.

Moreover, the tariffs invariance has important implications in terms of carriers profit. More specifically:

**Proposition 3.** The Nash equilibrium is always Pareto inefficient.

**Proof.** See Appendix.

The intuition for this result is similar to the double marginalization externality in vertically related firms; a reduction in one carrier tariff causes only a second order loss of its own profits but a first order increase in the other carriers profits. The main implication in the “two way” network [6] considered here is that the double marginalization principle continues to hold in the case of complementarity of reciprocal carriers interconnection services [10].

As a consequence, carriers can attempt to achieve higher profit levels by suitable choice of tariffs. It follows that carriers may have an incentive to cooperate in tariffs choices. Therefore in order to analyse the effects of bargaining behaviour on profits and final prices levels, a cooperative game among carriers is introduced.
3. Bargaining game outcomes

By using Nash bargaining solution both in bilateral monopoly and duopolistic market, we analyse the results of the bargaining behaviour in the intermediate market in terms of carriers profits and final prices. The evolution of the game is based on a cooperative tariffs choice in the intermediate market and a non-cooperative Cournot competition in the final market.

Let $\Pi^*_A, \Pi^*_a$ be optimal profit value outcomes of the non-cooperative game. Such values are assumed like threat point of the cooperative game.

The cooperative bargaining game \cite{[8,11]}, is based on the maximization of the function:

$$ (\Pi_A - \Pi^*_A) \cdot (\Pi_a - \Pi^*_a) $$ \hspace{1cm} (1) 

with respect to $t_A$ and $t_a$, subject to the constraints:

(B1) $\Pi \geq \Pi^*$ with $\Pi \equiv [\Pi_A, \Pi_a]'$ and $\Pi^* \equiv [\Pi^*_A, \Pi^*_a]'$;

(B2) $\Pi$ is convex, closed and bounded above.

The condition (B2) ensures that the Nash bargaining solution is uniquely defined.

The bargaining process outlines that international telecommunication carriers can be made better off by an appropriate choice of tariffs, given that the final quantities are set non-cooperatively. This both in terms of optimal profit values and final prices. More specifically the following proposition holds:

Proposition 4. The Nash bargaining optimal tariffs and the final prices are always lower than that arising from non-cooperative game.

Proof. See Appendix A.

Proposition 4 highlights that starting from non-cooperative Nash equilibrium, carriers would increase their profits by jointly lowering rather than rising tariffs. The effect of bargaining behaviour in the intermediate market has direct implications on the final prices so the cooperation among the carriers in the intermediate market has a benefit impact on telephone subscribers in international long distance calls.

Solving the maximization of Eq. (1) is not easy in this case, so instead, we can use numerical simulation in order to obtain the optimal intermediate tariff values.

4. Numerical evidence

Numerical simulation to solve the maximization problem can be made through an appropriate choice of demand function parameters without any essential loss of solution generality.

Profit possibilities in bilateral monopoly and competitive market are shown in Figs. 5 and 6. Let $F(q^*(t), t)$ denote the profit possibility frontier where the carriers choose any tariffs, while quantities are chosen non cooperatively given the tariffs...
Let $M$ denote the point along $F(q^*(t), t)$ at which joint profits are maximized and $HH'$ the linear profit frontier, whereas $A$ and $B$ represent, respectively, the noncooperative and cooperative equilibrium points. Figs. 5 and 6. show an important feature of the cooperative game solution. We can observe that the point $B$ lies along the Pareto efficient frontier. This means that the Nash bargaining solution constitutes a steady equilibrium.

In order to analyse the bargaining behaviour effect on final prices, we can consider Table 1. It is possible to observe that the Proposition 4 has an empirical evidence. Infact the intermediate tariffs and final prices are lower under cooperative behaviour than that under the non-cooperative one. This is true both in bilateral monopoly and competitive market assumptions. We may also observe an important implication due to the cooperative behaviour in terms of prices and tariffs decreasing rates.

The impact of bargaining behaviour on the decreasing tariffs is greater under bilateral monopoly than under competitive market. This is due to the higher difficulty to reach an agreement with a growing number of competitors. The growing competitive pressure in international telecommunication market has different effects in terms of final prices.

Infact, as shown in Table 1, with the introduction of competition, in the duopolistic market the final price falls from 11.74 to 9.78, while in the monopolistic one the price rises from 10.06 to 10.64. So the reduced possibility to reach an agreement involves a more damaging behaviour of the monopolist in its own final market. The above results may have policy implications; a regulation approach based on price cap could induce a further tariff pressure increase. So, such regulation policy may be ineffective. On the other hand the assumed growing competitive pressure in one market (due to the existence of two carriers) states an incentive to a final price decrease and the efficiency of regulation policy such as price cap may be enhanced by promotion of competition amongst providers nationally. The obtained results shown in Table 1 are independents to the choice of demand functions parameters, as it is possible to verify by iterating the numerical simulation.

Sensitivity analysis is necessary to determine whether different choices of the demand function parameters produce significant changes in the optimal cooperative tariffs $t_A$, $t_s$ and optimal cooperative final prices $P_A$, $P_s$. Our results about sensitivity is displayed in Table 2 where a sequence

<table>
<thead>
<tr>
<th>Demand functions parameters</th>
<th>a</th>
<th>b</th>
<th>c</th>
<th>f</th>
<th>e</th>
</tr>
</thead>
<tbody>
<tr>
<td>$t_s$</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>$t_A$</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>$P_s$</td>
<td>-</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>$P_A$</td>
<td>+</td>
<td>-</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Table 1
Numerical simulation results

<table>
<thead>
<tr>
<th></th>
<th>Bilateral monopoly</th>
<th></th>
<th>Competitive market</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cooperative</td>
<td>Non-cooperative</td>
<td>Cooperative</td>
<td>Non-cooperative</td>
</tr>
<tr>
<td>$\Pi_s$</td>
<td>15.30</td>
<td>12.25</td>
<td>17.90</td>
<td>15.51</td>
</tr>
<tr>
<td>$\Pi_A$</td>
<td>13.56</td>
<td>9.80</td>
<td>5.72</td>
<td>4.62</td>
</tr>
<tr>
<td>$t_s$</td>
<td>3.38</td>
<td>10.00</td>
<td>4.57</td>
<td>10.00</td>
</tr>
<tr>
<td>$t_A$</td>
<td>0.03</td>
<td>10.00</td>
<td>1.18</td>
<td>10.00</td>
</tr>
<tr>
<td>$P_s$</td>
<td>10.06</td>
<td>15.05</td>
<td>10.64</td>
<td>15.05</td>
</tr>
<tr>
<td>$P_A$</td>
<td>11.74</td>
<td>15.05</td>
<td>9.78</td>
<td>13.40</td>
</tr>
</tbody>
</table>
of the demand function parameter changes are considered. The analysis is summarized into 20 investigations that differ in terms of the changes sign (and + represent, respectively, an opposite and a concordant mutual variation). Moreover, with respect to the profit possibility frontier, it is straightforward to note that an increase in a and e parameters determines a frontier enlargement, whereas an increase in parameters f, b and c, induces a frontier contraction.

5. Conclusions

In this paper we compare two different competitive environments in international telecommunication industry. The results show that the intermediate tariffs and final prices are lower under cooperative behaviour than that under the non-cooperative one. This is true both in bilateral monopoly and competitive market showing that, given the model assumptions, a cooperative behaviour among carriers may not be harmful for telephone subscribers. The entry of new international carriers has an influence not only in their own market but also in the monopolistic one, in which the presence of a monopolistic situation becomes more harmful for consumers in terms of welfare decrease. In fact, giving the assumption of cooperative behaviour among carriers, the monopolistic final market price is rising with the growing competitive pressure in the other market [12].

Acknowledgements

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Appendix A.

Proof of Proposition 1. Given \((q_A^*, q_B^*, q_*^*)\), \(t^* \equiv (t_A^*, t_B^*, t_*^*)\) is determined by first order conditions:

\[
\frac{\partial \Pi_i}{\partial q_i} = 0, \quad i = A, B, z.
\]

Second order conditions \(\partial^2 \Pi_i / \partial q_i^2 < 0\) are always verified.

Proof of Proposition 2. Given \((q_A^*, q_B^*, q_*^*)\), \(t^* \equiv (t_A^*, t_B^*, t_*^*)\) is determined by first order conditions:

\[
\frac{\partial \Pi_i}{\partial t_i} = 0, \quad i = A, B, z.
\]

Second order conditions are always verified.

Proof of Proposition 3. In bilateral monopoly, the following conditions are verified in the point \(t^* \equiv (t_A^*, t_*^*)\):

\[
\frac{\partial \Pi_A}{\partial t_A} = \frac{-2}{4b} (a - c - t_A) < 0, \quad \frac{\partial \Pi_a}{\partial t_A} = \frac{-2}{4f} (e - c - t_A) < 0.
\]

Relations (A.1) and (A.2) show that it is possible to increase the profits of all carriers starting from the Nash non-cooperative equilibrium, by jointly lowering tariffs. The same conclusion holds in competitive market.

Proof of Proposition 4. At the cooperative equilibrium point, we need to verify

\[
(\Pi_A - \Pi_A^*) > 0. \quad (A.3)
\]

In bilateral monopoly, the following relation holds:

\[
\Pi_A^* = \frac{1}{4b} \left( a - c \right)^2 + \frac{1}{2f} \left( e - c \right)^2. \quad (A.4)
\]

Using (A.4), the relation (A.3) becomes

\[
\frac{1}{4b} (a - c - t_A)^2 - \frac{1}{2f} \left( \frac{e}{2} - t_A \right)^2 > 0. \quad (A.5)
\]

The condition (A.5) holds only if \(t_A < t_*^*\). Analogously, it is possible to show that

\[
(\Pi_2 - \Pi_*^*) > 0,
\]

only if \(t_A > t_*^*\) and that such conclusions hold in competitive market too.

References