Chapter 7
Competition, Concentration, and Competitiveness of the European Manufacturing Industry

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It is a widely held opinion that the European telecommunications industry is too fragmented, due to regulation and the protection of "national champion." This chapter tries to investigate the consequences of this protection on the competitiveness of European firms, in particular the way they conduct R&D in the essential public-switching market. It then becomes apparent how the opening of national markets caused by deregulation may impinge on the competitiveness of the European manufacturing industry.

First, a description of the telecommunications manufacturing industry is made, which shows a clear stability of structures over time. Then second sourcing, a common practice by carriers to improve the competitive supply of equipment, is examined. The impact of second sourcing is shown. Finally, an estimation is made of potential benefits from alliances or mergers. A distinction is made between the end 1970s period, when alliances had a large potential benefit, and 1980s period, when the benefits from partnership are more limited. In conclusion, some indications are put forward on the limits of our model.

THE TELECOMMUNICATIONS MANUFACTURING INDUSTRY

The Situation in 1985

In 1985, the market for telecommunication equipment reached $79 billion. Although not comparable to the telecommunications service market (more than $200 billion), it has a strategic importance for the major manufacturers: AT&T, Alcatel, Siemens, NEC, Ericsson, etc. The geographical structure of the demand is shown in Table 1.

The public switching systems account for 40% of the total market by 1990, with an annual growth rate of only 1.8%. The central importance of public switching in the telecommunications equipment market is due to many factors, including the impact on network architectures and long-standing relationships between the seller and the buyer. With deregulation and technological progress, however, this relationship will be loosened.

The main suppliers of central exchanges in 1984 are shown in Table 2.

That telecommunications manufacturing is too fragmented was a well-admitted opinion in the mid 1980s. The European Commission, in particular, had claimed that the amortization of a current central exchange generation over a life time of 10 years required a market share of 7%. Therefore, by 1990, many experts expected 5 major suppliers to remain in the market, instead of the 10 that existed at the time.

Table 1. Telecommunications Equipment (million $)

	1983	1984	1985
North America	$23,361	24,964	27,014
Europe	22,625	21,945	21,967
Far East	11,433	11,383	11,637
Soviet Union	6,000*	6,400*	6,750*
Pacific area	3,275	2,848	3,870
Middle East	3,487	3,230	3,349
Latin America	2,549	2,595	2,963
Africa	1,963	1,852	1,670

Source: Golschmann (1986)
*Estimation.

Table 2. Telecommunications Manufacturing Industry in 1969 and 1984. ($ million)

1969		1984	
1) Western Electric	4,000	1) AT&T	11,300
2) ITT	820	2) ITT	4,381
3) Siemens	700	3) Siemens	3,600
4) GTE	590	4) Northern Telecom	3,318
5) Ericsson	480	5) Ericsson	3,268
6) Northern Electric	300	6) Alcatel-Thomson	2,794
7) NEC	260	7) NEC	2,564
8) Plessey	192	8) GTE	2,496
9) AEG	190	9) Plessey	807
10) Philips	150		
11) CGE	136		

The simple arithmetic mixes two different things, products and firms. Current figures for R&D expenditures ($600 million for development, and $100 million per year for adapting the system to different national networks and new functionalities such as ISDN) clearly lead to a concentration of the supply, particularly in Europe. But this does not necessarily lead to mergers. Several firms have joined their efforts to develop a public exchange: GEC, Plessey, and STC for System X, GTE, and Italtel for the Italian UT/10-3. Conversely some firms have merged but still offer two lines of products: Alcatel NV produces Alcatel's E 10/MT and ITT's System 12.

In general, alliances are unstable, while mergers sooner or later lead to product rationalization. But in the medium term, the structure of the supply is not necessarily given by the number of suppliers: in fact, oligopolization and concentration is parallel to the major customers, the carriers, opening the market. Carriers tend to buy from at least two sources, and the Swiss or Italian PTTs even have three suppliers. But this market opening is not as large as one could claim.

The U.S. market has been the most open since AT&T's divestiture, and this confirms that deregulation has an impact on the opening of carriers purchases. In the U.S. case, this has benefitted Northern Telecom for the central exchange segment. According to Northern Business Information in 1985, the Canadian manufacturer succeeded in selling as many public and private exchanges as AT&T. This became possible as a result of the earlier digitization of the Canadian network and the similarity of U.S. and Canadian network features.[1]

The European network operators have also tried to open their purchasing procedure, while preparing themselves for deregulation.

The Bundespost opened to second sourcing in 1981, but the second manufacturer, SEL, has long been present in Germany, and this firm is accustomed to working in cooperation with Siemens, its main competitor. One could say that the situation evolved from a recognized cartel to a more competitive duopoly. In the UK, Ericsson has become a second source to British Telecom, to swap their national champion (GEC/Plessy and Alcatel, respectively) as second sources. In the British case also, two sources of the former generation of exchanges, the analog TXE2 and TXE4 already existed; hence, second sourcing is not a novelty. In France, Ericsson recently bought the French second source, CGCT, after a strong competition with Siemens and AT&T. But second sourcing had also been introduced in 1975–76, when Thomson supplied Ericsson's CP 400 and ITT's Metaconta to the French PTT, in addition to Alcatel's E 10.

Although the "duopolization" of the major public switching markets is not as impressive as is sometimes claimed, it is nonetheless present. The major difference is that the second is now a true "foreigner" (Ericsson in the UK, the Netherlands and France, Alcatel in Germany), while in the past, the second source was a national company, or a long established subsidiary of a multinational, which behaved as a local manufacturer.

Additionally, the telecom manufacturing industry evolves along "long cycles," making its structure more stable than often perceived.

The Manufacturing Industry in the 1960s

At that time, national markets were more protected than now; the share of world trade was less than 10% of world production, compared to 15% more recently. Also, public switching was not yet digital. However the industry structure was not very different, as we see from the comparison of Table 2.

In the public switching segment this similarity also holds while the breakthroughs of Alcatel, Ericsson, and Northern Telecom are noticeable: These three companies have been innovators in the transition from analogue to digital technology, and this explains their breakthrough. The stagnation of other manufacturers' production is explained by the investment cycles of their main customer: NTT's program culminated in 1974, while this happened in France in 1982 only.

Long-Term Determination of Market Structure

Although the market structure of the public switching segment has not evolved radically since the 1960s, current technology may lead to major changes, with the lifetime reduction of market positions evolv-

ing more quickly; for example, the implementation of the ISDN in European networks requires the adaptation of existing exchanges, with new development costs. The issue is thus the following: Could the firms have anticipated this market evolution (concentration and increased competition)? Has the national market protection prevented the firm's adaptation? Will deregulation and the practice of second sourcing in Europe lead to a better competitiveness? We will try to answer these questions in the remainder of this chapter.

THE EUROPEAN INDUSTRY: MARKET POWER AND CONCENTRATION

Purchasing Policies of the Main European PTTs

With digital exchanges, the purchasing policy of European PTTs has evolved. In Germany, after the expiration of Siemens' patent life for the EMD electromechanical exchange, the Bundespost redesigned its purchasing policy. From 1975 onwards public tenders have been set up each year, which are limited to the four German suppliers (Siemens, De Tewe, SEL, Telefonbau): An incentive mechanism gives an increase in market share of 2% to the best offer each year. Since 1979, after having discarded Philips' PRX, the Bundespost has competitively selected two new digital exchanges, Siemens' EWSD and SEL's System 12. Now, the two systems compete annually.

In Italy, the purchasing policy of SIP, the Italian main carrier, is biased since it is owned by STET, the State holding company which also owns Italy's major manufacturer, Italtel. According to Pontarollo (1983), SIP writes a "Memorandum" in which the amount of orders and prices are defined. The latter are determined from investigations into manufacturer costs. Pontarollo claims that prices are aligned with the most expensive proposal, since it is generally the one of Italtel. Digitization has led to the delivery of three systems to SIP: Ericsson's AXE, Alcatel's System 12, and Italtel's UT 10/3 Proteo.

In the UK, the privatization of British Telecom was followed by a change of the relationship of BT with the "Ring" of suppliers. In March 1985 the "System Y" of Ericsson was selected as a second source, with the first shippings at the end of 1986. The aim of BT is to bring the share of System Y to 25–30% of its orders at the beginning of the 1990s. In France, the merger of telecom activities of Alcatel and Thomson in 1983-1984 upset France Telecom's purchasing policy. The latter has strived for competition between suppliers since 1976, and suddenly faced a monopoly, Alcatel-Thomson. The arrival of Matra/Ericsson as second source has enabled France Telecom to restore the competition between suppliers.

On the whole, the European PTTs have taken the opportunity of digitization to redesign their purchasing policy. The aim is now to focus on functional compatibility between different systems, and to put pressure on prices, through a yearly competitive bidding between several (generally two) recognized bidders.

The Competitive Behavior of Firms

It is generally admitted that manufacturers benefit from "rents" in their protected markets where prices and margins are higher than in the world market. According to an OECD study (1983), the prices of equipment in Europe were 20% to 30% higher than in the U.S. On the other hand, carriers are eager to reduce these margins: With the introduction of a second source, some incentives for competition are set up, with limited results.

First, as in the case of Italtel and SIP, or Bell Canada and Northern Telecom, vertical integration between a supplier and the customer leads to internal transfers: some lucrative market segments (telephone services) pay for risky projects (R&D in public switching). Second, the customer is in most cases a monopoly and can pass the burden of excessive prices to the end user, the telephone subscribers; it can thus put a mild pressure on pricing behavior by the suppliers. Third, industrial policy considerations are still present that require supporting national champions. In any case, it is not yet proven that the "rents" mentioned above are socially wasteful, since they permit the financing of R&D. Several theoretical papers have shown that in some cases, monopoly rents may be more efficiently employed as R&D subsidies (see, in particular, Dasgupta & Stiglitz, 1980).

A Theoretical Model

Consider a carrier who buys a quantity q of equipment from 2 suppliers. In order to stimulate competition, he organizes public tenders between them each year. The final price is the lowest proposal and market shares are function of the proposals. Mathematically

$$p = Inf\,(p1, p2)$$
$$q1 = f\,(p1, p2)$$
$$q2 = q - q1$$

where $p1$ is the price of the first bidder, $p2$ the other proposal, $q1$ and $q2$ the market shares. The strategy of the firms is to maximize their profits. A usual solution to this problem is the concept of Nash

equilibrium. It can be shown (see Appendix 1), that, in case of repeated tenders (each year), and, provided market share do not change very much, collusion between the suppliers may be the outcome. This is a variation on the well known "prisoner's dilemma" problem, where the fear of retaliation leads to cooperative behavior (see Axelrod, 1984).

We can expect that suppliers will propose the highest price that the customer is ready to pay (Pareto optimal Nash equilibrium). So what is the purpose of the second source?

First, the incumbent has its market share reduced, even if its profit rate remains the same. It has to export if it wants to maintain its benefits. Second, a second source with a different technology may provide a better information to the buyer, and this will lower its maximum acceptable price. Third, in the medium term, production capacities will be better adjusted to demand evolution, particularly when fixed costs are high.

To summarize, the margin of the manufacturers, and the capability to finance R&D with profits earned from their protected markets, will be computed from the maximum acceptable price, p^*, that the buyer is ready to pay.

Market Power and the Financing of R&D

We assume that R&D costs for the next generation of public exchanges is $\$K$ billion, with K near to 1. The manufacturers will use the margin derived from their market power to finance this R&D. We suppose that the costs are linear, and fixed costs are mainly R&D costs:

$$c_i(q) = K_i + a_i^* q_i$$

We suppose that all manufacturers have the same R&D costs, $K_i = K$. Let p^* be the maximum acceptable price. A carrier will successfully introduce a second source, if it can pay for a fair share of R&D costs to this second source. Typically, if m is the proportion of its orders compared to world orders, it will pay mK to its suppliers. Then for a second source with a marginal cost a_i and market share q_i:

$$(p^* - a_i) \cdot q = q_i.m.$$

which determines p^*.

If marginal costs are negatively proportional to market shares (something that is related to economies of scale in production), then the national champion, with a larger market share, will earn "super-profits," or rents, beyond the mere payment of a fair share of R&D

Table 3. Manuafacturers market shares in Europe

	Siem.	Eric.	ITT	Alca.	Ital.	Ples/ GEC	ATT/ Phil.
Germany	.70	0	.30	0	0	0	0
France	0	.15	0	.85	0	0	0
UK	0	.20	0	0	0	.80	0
Italy	.2	.2	.2	0	.6	0	0
Spain	0	.3	.7	0	0	0	0
Belgium	.2	0	.8	0	0	0	0
Netherlands	0	.25	0	0	0	0	.75
Denmark	0	.80	.20	0	0	0	0
Portugal	.5	0	.5	0	0	0	0
Greece	.4	0	.4	0	0	0	.2
Ireland	0	.4	.2	.4	0	0	0

Source: Quatrepoint (1984), with later estimations

costs. Also, the more equally the market is divided between the two sources, the lesser are these rents. With fair division (50/50) the rents are nil (see Appendix 2 for computation).

In order to compute the "rents," we need some information about markets and market shares. Table 3 shows the current market shares in most European countries.

Finally, Table 4 is an estimation of market sizes of the European countries for the period 1985–1994.

It is possible, then to compute the margins given by the carriers to the European manufacturers, in Europe, to recoup their R&D costs. Table 5 summarizes the computations.

Table 4. Size of European markets (1985–1994) for digital exchanges (% of World market)

Germany	5.85
France	6.67
UK	6.84
Italy	5.34
Spain	2.78
Belgium	.77
Netherlands	1.62
Denmark	.86
Ireland	.43
Portugal	.43
Greece	.21

Source: Northern Business Information (1985)

Table 5. R & D financed on European market by European firms ($ milions)

ALCATEL	$649
PLESSEY/GEC	565
ITT	488
ERICSSON	408
SIEMENS	388
ITALTEL	192
ATT/PHILIPS	120

Noticeably, Alcatel has, after its merger with Thomson but before merger with ITT, the higher European financing, because of the size of its market (France) and its dominant position in this market. Siemens, on the other hand, is handicapped by a delayed digitization of the German network and a lower market share (70%, against 85% for Alcatel in France). However, Alcatel has to maintain two digital systems—E 10 of Alcatel and MT 20 of Thomson—and this costs probably around 1.5 times the price of a single system. Therefore, the financing of R&D by system in Europe can be calculated and is shown in Table 6.

European markets alone are not sufficient for European firms to recoup their R&D costs, if the latter are as high as $1 billion. Also, Ericsson and ITT, although installed in most European countries, do not benefit fully from this situation, compared to national champions, because they cannot earn extra margins from dominant positions. After the ITT/Alcatel merger, the new Alcatel NV entity has an R&D financing of $1,143 million, for approximately 2.5 systems; that is, $457 million per system. This does not give a leading position to this firm, unless it can streamline its product image.

Table 6. R & D financed by digital system ($ million)

PLESSEY/GEC	$565
ITT	488
ALCATEL NV	457
ALCATEL	432
ERICSSON	408
SIEMENS	388
ITALTEL	192

Conclusion

We have tried to evaluate the position of the European industry in public switching. We have shown that deregulation and opening markets to second sourcing does not prevent the survival of "rents" to national champions. The often publicized statement of the European Commission that national markets are insufficient to finance R&D is correct but useless: Even if entry were free, most PTTs would limit their purchase to two sellers, and continue to pay extra profits to incumbent firms. The major impact of second sourcing is to reduce the market size of the national champion, and to force it to get exports to maintain its production. Also, concentration has nothing to do with market openings, as the ITT/CGE, ATT/Italtel mergers have shown. But are some mergers more efficient than others?

POTENTIAL ALLIANCES BETWEEN EUROPEAN FIRMS

The Situation in the Late 1970s

Digital switching has not emerged in a single stroke. Some firms have been innovators, some followers, but it is recognized that there are too many products in the market. By 1983, 13 digital switches had been announced by as many companies, and, by 1986, all but 3 were in production.

The innovators in the digital market were Alcatel, Northern Telecom, and Ericsson, which had collectively captured 72% of the digital lines installed by 1985 (Chavelet, 1986).

With two European innovators (Ericsson and Alcatel), the question may be raised whether some followers had an interest to merge with one of the two, to avoid R&D expenditure. Since the British firms, although not innovators, had long been involved in digital switching, they were unlikely to abandon a project where their main customer, the Post Office, was involved.[2] Other European firms, Siemens, Italtel, Philips, ITT, and Thomson could have formed alliances with innovators. The results in terms of R&D financing are summarized in Table 7:

ITT was an ideal partner for both innovators, because it offered wide European market coverage. Also, Ericsson would have been a better partner to ITT than Alcatel. So the best alliance, in the late 1970s, was between ITT and Ericsson. A second best would have been a partnership or merger between ITT and Alcatel-Thomson, which happened in 1986. One can say that the merger would have been much more effective in the late 1970s.

Table 7. Gains from alliances in the '70s in Europe ($ millions)

ERICSSON WITH:	PHILIPS	SIEMENS	ITT	ITALTEL
R & D financed	$404	490	978	445
ALCATEL WITH:	**PHILIPS**	**SIEMENS**	**ITT**	**ITALTEL**
R & D financed	239	356	827	247

Finally, were alliances or mergers made in 1978 instead of 1984 or 1985, higher margins would have been generated and competitiveness would have increased. In a sense, the Commission's statement that market fragmentation has prevented an adaptation of the European industry to new market conditions is correct. There was, at the end of the 1970s, a real potential for improving the competitiveness of the European industry through a series of real concentration and mergers between innovators and followers. The latter, instead, have developed their own system and joined the international competition. But if the followers, Philips, ITT, Italtel, Siemens, and Thomson, could have improved their position through a merger, no innovator/follower team would have been sufficient to reach the $1 billion barrier. Even at the end of the 1970s, exports were necessary to recoup costs.

Possible Configurations in the Mid-1980s

It might be interesting to look at the potential alliances between the remaining firms, once a first series of concentration movements occurred at the beginning of the 1980s: Thomson and Philips dropped out of the public exchange market, ITT has merged with CGE.

However, the situation is now very different from the former one. Previously, some firms offered a digital exchange while others did not. Now, all have a digital exchange. Any merger will permit economization of some costs at the margin, but the gains will be limited and the adaptation costs in social terms will be higher: layoffs and plant closings will be the consequence of streamlining the product range after mergers.

We have tested two configurations of coalitions.

The first one includes Alcatel and Italtel on the one hand, and Siemens and Ericsson the other. The second hypothesis is a coalition of Alcatel and Siemens on the one hand, with a second coalition grouping Ericsson, Italtel, and the British firms on the other. In the latter hypothesis, the German Bundespost would seek a second source, AT&T or Northern Telecom. We suppose that APT (ATT/Philips joint venture) would get the market. Table 8 summarizes the results of our simulation.

Table 8. Gains from alliances in the 1980s ($ millions)

First configuration:	**ALCATEL + ITALTEL**	**SIEMENS + ERICSSON**
R & D financed by systems	$413	394
Second configuration:	**ALCATEL + SIEMENS**	**ERICSSON + ITALTEL + GEC/PLESSEY**
R & D Financed by system *	480	423

*It is assumed that ATT or Northern takes 15% in the German and British markets (second source after mergers).

Although it would be more interesting for Alcatel to team with Siemens rather than Italtel, this coalition is unlikely, given the cultural differences between ITT's subsidiaries and Siemens. Noticeably the "big coalition" Ericsson/Italtel/British companies would have a comparable market share to Alcatel NV. But here again, transaction costs of running this coalition make it unlikely. Hence, the second configuration: Alcatel/Siemens on one side, the other European on the other, is less likely than the Siemens/Ericsson and Alcatel/Italtel configuration.

Generally speaking, our computations suggest that Alcatel NV is the pivotal element of coalitions. Ericsson also has an equivalent role, but the potential benefits are lower.

CONCLUSIONS

In this chapter we have tried to simulate the functioning of public switching markets in Europe. We have shown that deregulation and market opening have had a minor impact on the industry behavior. More important has been the impact of technology evolution (digitization, soaring R & D costs) on the market structure. We have shown that, at the end of the 1970s, concentration offered great possibility for the improvement of market structures and firms competitiveness in Europe. This opportunity, however, has been missed, probably because of market fragmentation and the defense of national champions.

Some concentration efforts were made at the beginning of the 1980s, but the coalitions were not optimal from our point of view. In the mid-1980s, the markets that remained were as fragmented as in the 1970s, and the second sourcing could not generate overwhelming benefits for the industry as a whole.

In the late 1980s, the concentration game can still be played, but our

optimal configuration (a duopoly of Alcatel with Siemens on the one hand, and Ericsson and British firms and Italtel on the other) is impossible to set up. Instead, Italtel has teamed with ATT, and GEC and Siemens are bidding for Plessey. Four major groups will thus emerge in the 1990s in Europe: Alcatel, Siemens/British Firms, Ericsson, Italtel/Philips/ATT. The reason why our model could not predict the eventual configuration are numerous:

1. The entry of the U.S. firms has been neglected, since we were interested in the improvement of the European industry only.
2. Ericsson and Siemens are competing against one another to penetrate the U.S. market. This makes a coalition between them very unlikely.
3. Our model does not claim to encompass the diversity of production situations, the diversity of the products, or the impact of political factors: In France for example, the choice of a second source, Ericsson, has been mainly a political decision.
4. Innovations are still underway in the public switching business. Broadband switching is investigated at the firm level as well as the cooperative level (the European research program RACE). It may impinge on the firms strategies.
5. We have not investigated the position of the firms outside Europe. There are also protected markets (e.g., ex-colonies, or countries where a firm has long been present) that enable firms to generate extra margins for paying their costs.

The aim of this chapter was to link market structure, market behavior and technological evolution in a market where the hypothesis of perfect competition, or even Cournot or Bertrand oligopoly, do not apply. The rather theoretical exercise undertaken here may help to understand firms' decisions, and to show the boundaries in which these decisions are made. We could easily generalize our method to the world market, in order to answer the question: what is the optimal number of digital exchange systems in the world market?

APPENDIX 1: SOLUTION OF THE REPEATED PUBLIC TENDER GAME

The carrier, each year, raises an amount, q, of orders from its two suppliers. It pays the price of the lowest bidder and has an incentive scheme, where the market shares are function of the bids. Hence, the profits can be written:

$$Max\ (Inf\,(p_1,p_2) \cdot f\,(p_1,p_2) - c_1\,(\mathrm{f}\,(p_1,p_2))$$

$$p_1$$

$$Max\ (Inf\,(p_1,p_2) \cdot (q - f\,(p_1,p_2) - c_2\,(q - f\,(p_1,p_2))$$

$$p_2$$

with linear functions

$$f\,(p_1,p_2) = \bar{q}_1 + a\,(p_2 - p_1)$$

$$c_1\,(f\,(p_1,p_2)) = k_1 + c_1 \cdot (\bar{q}_1 + a\,(p_2 - p_1))$$

$$c_2\,(\bar{q} - f\,(p_1,p_2)) = k_2 + c_2 \cdot (\bar{q}_2 - a\,(p_2 - p_1))$$

It is obvious that the strategies (p_{t^*}, p_{t^*}) at every time, where p^* is the maximum acceptable price by the carrier, are Pareto optimal. We will show that they are Nash solutions for some values of the parameters.

Suppose that a supplier (say number one) begins a price war at $t=0$. Then, its maximum profits will be:

$$Max\ \pi\,(p_1,p^*) = p_1\,(\bar{q}_1 + a\,(p^* - p_1)) - k_1 - c_1\,(\bar{q}_1 + a(p^* - p_1))$$

It can be computed that $\bar{p}_1$ which achieves the maximum profit is:

$$\bar{p}_1 = 1/2\,(\bar{q}_1/a + c_1 + p^*)$$

And the potential gain, during period 0, of this price war, is:

$$G = \pi_1\,(\bar{p}_1,p^*) - \pi_1\,(p^*,p^*)$$

$$= (p^* - \bar{p}_1)\,(\mathrm{a}(\bar{p}_1 - c_1) - \bar{q}_1)$$

Once the price war is unleashed, the second supplier will have an interest to price also $\bar{p}_1$, since its profits will increase: the new equilibrium will be $(\bar{p}_1,\bar{p}_1)$. The potential loss from period 1 onwards for the first supplier is thus (discounted at $t=0$)

$$\mathrm{L} = \sum_{t=1}^{\infty} \alpha^t\,(\pi_1\,(\bar{p}_1,\bar{p}_1) - \pi_{1^*})$$

by substitution we find that

$$L = \frac{\alpha}{(1 - \alpha)} (\bar{p}_1 - p^*) \bar{q}_1$$

Hence, the price war is not profitable and $(\bar{p}^*, \bar{p}^*)$ is a Nash equilibrium from one's point of view, if:

$G < L$, that is (after computations)

$$p^* < \frac{\bar{q}_1}{a} \left(1 + \frac{2\alpha}{1 - \alpha}\right) + c_1$$

By permutation of one and two, we see that an equivalent relation holds for two. Hence

$$p^* = Min \left(\frac{\bar{q}_1}{a} \left(1 + \frac{2\alpha}{1 - \alpha}\right) + c_1, \quad \frac{\bar{q}_2}{a} \left(1 + \frac{2\alpha}{1 - \alpha}\right) + c_2\right)$$

which can be computed by the carrier, gives a Nash equilibrium Pareto optimal.

APPENDIX 2
COMPUTATION OF THE PRICE ACCEPTABLE BY THE CARRIER

As seen in the text, a reasonable assumption is that the network operator will be prepared to contribute to R&D expenditures in the proportion of its size compared to the world market:

Let α be this proportion. Then, for a supplier i

$$(p^* - a_i) \cdot q_i = K_j = (\alpha \cdot K)\, q_i/\mathrm{q}$$

where K is the cost of R&D, a_i the marginal (variable) cost of production, and K_j the amount its R&D paid in the market j.

Then $p^* - a_i = \alpha K/q_j$ since $q_j - \alpha Q$, where Q is the world market size

$$p^* - a_i + \frac{K}{Q}$$

Suppose now that the marginal cost a_i varies with the market share (economies of scale). More precisely let

$$a_i = (n + 1)\, a_{min} / (1 + n.B_i)$$

Where B_i is the market share, a_{min} the "competitive" price, that manufacturers will get in the world market, n the number of "optimal" suppliers in the world market:

when $B_i \to 0$, $a_i \to (1 + n)\, a_{min}$
$B_i \to 1$, $a_i \to a_{min}$

If a national champion is alone in the market ($m_i = 1$), it will be able to have a cost comparable to international standards. If a second source is introduced, the carrier has to guarantee to this second source that the margin obtained from this national market will be comparable to "international standards" therefore

$$(p - a_i)/p = (p^* - a_{min})/p^* = m^*$$

Where m is the "standard" margin. This determines the maximal acceptable price p by the carrier. From this we can deduct the margin of the national champion. It can be shown that this margin m is given by the following relation

$$m = m^* + \frac{a_{min}\,(1 - (n + 1)\, B_i)}{p^*\,(1 - n\, B_i)}$$

Where B_i is the market share of the second source. Clearly $m > m^*$, and national champions get "superprofits." In the numerical application, we have supposed that $n = 10$, that is there are optimally 10 manufacturers in the world market, which is consistent with the assumption that a 10% market share is necessary to recoup costs.

REFERENCES

Aurelle, B. (1966). *Les telecommunications*. Paris: Editions La Decouverte.

Brezzi, P. (1981). *La politica dell'elettronica*. Roma: Editori Riuniti.

Caty, G.F., & Ungerer, H. (1984, December). Les telecommunications: nouvelle frontiere de l'europe *Futuribles*.

Chavelet, E. (1986, December 30). CGE-ITT sur une meme ligne. *Le Figaro*.

Dasgupta, P., & Stiglitz, J. (1980). Industrial structure and the nature of innovative activity *Economic Journal*, pp. 1–28.

Dataquest/Nielsen. (1985, November). The European Telecommunications Industry.

Gilholy, D. (1987, January). The politics of switching. *Telecommunications.*

Golschmann, M. (1986). *L'industrie mondiale des telecommunications.* Publications CESTA, Paris.

Information Dynamics Ltd. (1986). *The European market for public digital telecommunications switching.* Rickmansworth.

Lorenzi, J.H., & Le Boucher, E. (1979). *Memoires volees.* Paris: Ramsay.

Il Mondo Economico. (1982). *Rapporto Mese: Telecommunicazioni.*

Moulin, H. (1981). *Theorie des Jeux pour l'economie et la politique.* Paris: Hermann.

Newstead, T. (1986, March). ISDN: A solution in search of a problem? *Telecommunications Policy.*

Northern Business Information. (1985). *The world public switching market: 1985 edition.* New York: Author.

Quatrepoint, J.M. (1984, May 15). CIT-Alcatel n'a fait qu'une percee limitee. *Le Monde.*

Salaun, J.M., & Sutter, H. (1974, July). L'industrie Quest europeene des telecommunications. *Revue Francaise des Telecommunications.*

Sarrati, L. (1984, February). Lo sviluppo delle reti di telecommunicazioni nel mondo. *Sistemi di Telecommunicazioni,* pp. 18–28.

ENDNOTES

[1] Other innovators in public switching (Ericsson and Cit Alcatel) penetrated the US market in 1982–83 only, when divestiture was announced. There is still skepticism about the variability of a third source to the new regional holding companies (Gilhooly, 1987).

[2] There have been tables, however, between Alcatel and Plessey in 1974 to import, to the UK, Alcatel's E 10, the only digital exchange in the world at that time.