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**DISCUSSION PAPERS
DISKUSSIONSBEITRÄGE**

No. 61

**PRICE STRUCTURES IN THE
MARKET FOR LONG-DISTANCE
VOICE TELEPHONY IN GERMANY**

BY

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Price Structures in the Market for Long-Distance Voice Telephony in Germany

Gert Brunekreeft & Wolfgang Gross¹

Abstract: This paper analyses price structures in the liberalized German market for long-distance telecommunications services. Theoretically deduced patterns are backed-up by empirical observations. The market is exceptionally competitive; entry is taking place on a large scale and prices are falling sharply. The product is strongly homogeneous and search costs are extremely low. Propositions included in the assessment concern the necessary absence of systematic price discrimination, the probability of cut-throat competition, and the necessary presence of a demand-compatible peak-load structure. With respect to the latter there is an observable move of the price structure, which can be explained by regulatory failure.

JEL-classification: D41, L43, L96

Keywords: telecommunications, price discrimination, peak-load pricing

1. Introduction

Even if perfect competition as the textbooks define it does not exist in reality, the market for long-distance voice telephony in Germany comes very close to it. Market entry is free and takes place on a large scale, the product is strongly homogeneous, and switching costs (after the initial set-up costs of getting familiar with the system) are extremely low. From the first day of fully opened markets on January 1st 1998, competition has been amazingly vigorous. Until the end of 1998 51 firms had entered the market and had taken over 30% of the market volume from the incumbent.² In 1999, the number of entrants is still growing and it seems that every inch of competitive potential is being exploited. There is a small number of providers with nation-wide long-distance networks of their own, while the number of resellers and providers which are developing

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² For details see Regulierungsbehörde für Telekommunikation und Post [1998].

strategically laid out networks is vast. Tariffs for national long-distance calls have seen dramatic drops in only one year; they fell by 37.9%.³ Not only does the average level of tariffs decrease rapidly, the tariff *structure* is undergoing substantial changes as well. A theoretical and empirical examination of the effects on the price level, but in particular on the price structure, are the subject of this paper. After only 16 months of competition the data on price development is not sufficient to test hypotheses about long-run trends in the market but it is ample to indicate developments which follow directly from theoretical reflections.

In section 2 we characterize the market in some detail. Sections 3 and 4 provide 4 propositions; while section 3 deduces them theoretically, the plausibility of these propositions is assessed empirically in section 4. The underlying assumption is always an extreme extent of price competition, such that the firms are price-takers. Although frictions remain, our empirical analysis indeed suggests that the market comes close to being perfectly competitive. First, we argue that persistent price discrimination is simply not sustainable; after only somewhat more than a year of experience, the dominant tariff-structure is largely flat. Nevertheless, as yet, the incumbent, Deutsche Telekom, shows a stronger tendency for price discrimination than its competitors. In our second proposition we argue that this can be explained from (currently) non-switching consumers for whom the set-up costs to get acquainted with the new system are apparently too high. It is important to realize that this phenomenon is self-destructive and transitory. Third, the competitive pressure and the cost-structure of the network operators (mainly fixed costs) may, with current excess capacity, induce cut-throat competition. In the short run tariffs may reach levels below average costs. Even so, there is no need for regulatory intervention. In the longer run, the market will solve this transitory problem. Fourth, a peak-load tariff structure will push through, which necessarily reflects demand correctly. A curious shift in peak-load pricing can be observed in Spring 1999. This shift will be explained from (incorrect) regulation of the structure of interconnection charges, which revealed itself with the increasing competitive pressure.

³ This is the figure the Statistisches Bundesamt [1999] reports for March 1998 to March 1999.

2. Market characteristics

The regulatory framework

The legal basis for market liberalization in Germany, apart from EU-legislation, is the Telecommunications Act of 1996 (TKG) and its accompanying implementing ordinances. Together with the decisions of the newly founded national regulatory authority the rules with regard to interconnection, equal access and the prices of services for consumers are of special importance for the development of a competitive market for long-distance voice telephony.⁴

The TKG obliges dominant carriers to grant network access and to allow its competitors to interconnect to its network on non-discriminatory terms. The interconnection tariffs Deutsche Telekom is allowed to charge are supposed to be cost-based in principle. They have been determined by international benchmarking in 1997;⁵ in April 1999 they were settled at and partially above the upper bound of the charges recommended by the European Commission as ‘best current practice’ [European Commission, 1999].⁶ In the first months of competition the right to interconnect to the incumbent’s network was granted on equal terms irrespective of the size of the entrant’s network.⁷ No substantial infrastructure investment was needed in order to gain full coverage of the market. After having negotiated an interconnection agreement with the incumbent, an entrant was able to deliver services to all customers connected to

⁴ A more detailed description of the regulatory framework in Germany is provided by e.g. Büchner et al. [1997].

⁵ See table 5 in section 4 for the interconnection charges in Germany.

⁶ See European Commission [1998] on interconnection pricing regulation in Europe. An economic evaluation of the interconnection regulation in Europe is given by Knieps [1998].

⁷ This has changed in the meantime. Deutsche Telekom can charge higher interconnection tariffs if it can prove additional costs caused by an insufficiently dimensioned network. In effect, this will make entry of switch-based service providers somewhat more difficult. The respective decision of RegTP and the preceding review process are documented in Regulierungsbehörde für Telekommunikation und Post [1999].

the incumbent's network. It seems plausible to assume that interconnection was non-discriminatory.⁸

Equal access regulation implied that pre-selection and call-by-call services were possible in the long-distance segment for every customer immediately from the start of liberalization. A customer can choose to pre-select an alternative long-distance provider for a time period and/or can pick a more convenient long-distance provider on a call-by-call basis by dialling the respective 5digit carrier selection code. The decision of the regulator that number portability had to be free of charge helped keeping switching costs low for consumers.

All services of carriers that are classified to be dominant are subject to some kind of price regulation. The prices of Deutsche Telekom for voice telephony are regulated by a price-cap mechanism. Deutsche Telekom is obliged to reduce the price level for each of two separate baskets (one containing local and long-distance services for private customers and one for business customers) by 4.3% in the two-year span from 1998 to 1999. By the end of 1998 the price level for private customers and for business customers had already gone down by more than that due to price cuts in the long-distance market. This indicates that the actual price cap does not influence Deutsche Telekom's pricing decisions in this segment so that there is no need to incorporate the price-cap mechanism in our model in section 3.

Entry strategies

Initially, most firms entering the German market for telecommunications services focused on providing homogeneous basic long-distance voice telephony.⁹ In terms of infrastructure investment their entry strategies were very different, though. Entrants are distributed along a scale that reaches from the one extreme of network operators with extensive infrastructure of their own to the

⁸ A comprehensive analysis of access to and competition in local networks can be found in Merkt [1998].

⁹ Today, operators expand their service portfolios, so that mobile, internet and local services gain importance.

other extreme of resellers of services that do not invest in infrastructure at all. Some operators laid out nation-wide networks, others restricted their investment to a certain region or city, while still others invest in a limited number of transmission facilities.¹⁰ Out of the multitude of entry strategies in the German market, alternative network providers with national scope and switch-based service providers gained most prominence.

Alternative network operators with national scope aim at becoming full-range suppliers of services. They intend to offer perfect substitutes to the incumbent's bundle of services. For this purpose these initially three firms build up substantial long-distance networks of their own. Typically this is done by exploiting economies of scope with other network industries (electricity-transmission in the case of o.tel.o and Viag Interkom and railway-infrastructure in the case of Arcor).¹¹ The size of these networks has been chosen in anticipation of a strongly increasing demand. As a consequence, the strategy of these entrants led to substantial excess capacity in the short run.

In contrast, the switch-based service providers' strategy is to enter the market quickly while keeping fixed costs as low as possible. They invest in minimum network configurations: typically a limited number of switches which they connect via leased lines. In order to overcome the distance between their points of presence and customers these entrants rely heavily on interconnection services. Examples for providers belonging to this group are Interoute, Mobilcom and Teldafax. In the following we do not explicitly distinguish between switch-based service providers and resellers but consider them as one type of providers which we label a bit loosely as "service providers".

¹⁰ The boundaries between the categories of providers are not clear-cut and firms might change their strategies over time: e. g. regional and city carriers expand their scope by connecting local networks in different cities. Resellers and switch-based service providers develop towards full-scale network operators by augmenting their number of switches and increasing the size of their network.

¹¹ Arcor bought o.tel.o in April 1999 so that there are de facto only two alternative network operators with extensive nation-wide facilities of their own left.

The costs of providing long-distance services are mainly costs of the network infrastructure. Costs per call and costs of marketing, billing and customer care are neglected in the theoretical model in section 3. For simplification, we assume that the network operators have built up complete parallel networks with identical cost-structures. Call origination and termination in the local networks are not specified explicitly so that all costs of network operators are fixed costs of network capacity. In contrast, the service providers are assumed to have no transmission capacity of their own at all. They completely rely on interconnection so that all their costs are costs of interconnection which accrue on a call-by-call basis. This means that for switch-based service providers we neglect the fixed costs of switches, points of presence, receiving a licence and negotiating interconnection contracts. We also do not specify further that depending on the contracts for leased-lines, other cost characteristics could occur in reality.

Demand characteristics

Consumers can select their long-distance providers via call-by-call or via pre-selection contracts.¹² By the end of 1998 only 17 % of all German households were actively using long-distance services from other providers than the incumbent, while 32% claimed that they would be going to do so in the following months.¹³ This suggests a considerable group of consumers who are not (sufficiently) informed about the new institutional setting. In order to include this phenomenon in our model we explicitly consider switching costs.

With respect to switching costs, two different issues have to be distinguished. First, getting informed about the institutional setting and second, given being informed, switching between different providers. The unfamiliarity with the institutional setting of the market is likely to be a reason why a non-negligible group of consumers does not (yet) switch at all. For this group, the initial set-up

¹² Of all customers using services from other providers than the incumbent at the end of 1998 80% used call-by-call services, the acceptance of pre-selection is growing, though, according to Hochköpper & Plica [1999].

¹³ See Hochköpper & Plica [1999]. A survey by Forsa-Institut cited in Connect-online [1999] states that 55% of the population in Germany does not intend to buy services from alternative providers in the near future.

costs to get familiar with the institutional setting are simply too high, as compared to the expected savings they could make on their telephone bills. These consumers by definition solely purchase from the incumbent, who has some market power over them. It must be stressed, that this market power may be very limited, because it depends on the expected savings on the telephone bills, which increase with increased price differences.

For consumers who are familiar with the institutional setting, switching costs are extremely low. The only "burden" to be taken in using call-by-call, compared with using the incumbent provider, is dialling the 5digit carrier selection code. If even this is too much, technical help may be used. Most telephones allow programming of selected numbers and leased-cost routers can be bought which find the cheapest provider on a call-by-call basis automatically. For consumers, costs of switching to pre-selection services are normally restricted to filling in a registration form. The costs of adjustments in the local switch are carried by the pre-selection provider, number portability is granted by regulation. Complementary to low switching costs are low search costs; the latter means finding the cheapest provider. The internet and printed media are full of price information, and brokers and agencies provide information, much like insurance brokers. Last but not least, the providers themselves advertise aggressively with one dominant variable: price.

Given technical standards and full interconnection, there is only limited scope for product differentiation between firms, especially concerning call-by-call services and services for residential customers. Billing is mostly outsourced to Deutsche Telekom so that the call-specific bill is integrated (though specified) in the incumbent's bill. The product ("a telephone call") has no taste or colour or otherwise brand-specific dimensions. What remains are possibilities of product differentiation in terms of customer care. It can readily be assumed that the entrants' long-distance services are perceived by consumers as largely homogeneous products. In empirical surveys consumers claim that the price is by far the most important criterion for them to choose between providers

[Connect-online, 1999; FAZ, 1999]. Thus brand- or firm-loyalty does not seem to play an important role empirically.

3. Theory

By means of a highly stylized model we will now put forward four propositions which result from the assumption of an extreme degree of price competition. This assumption is plausible for two reasons: first, extremely low switching costs and second, nearly perfect product homogeneity as argued in section 2. The theoretically deduced conclusions are not new in themselves, but the application to the long-distance telephony market in the German institutional setting is the contribution of this paper. The model below characterizes the polar case. To emphasize price competition, the firms' individual demand curves are assumed to be horizontal (except the demand of non-switchers). This section contains two parts. The first part concentrates on (the non-existence of) price discrimination, while the second part explains a phenomenon concerning peak-load pricing.

Price discriminatory tariffs

We will adopt the definition of price discrimination of Philips [1983, p.6; italics in original]:

"[P]rice discrimination should be defined as implying that two varieties of a commodity are sold (by the same seller) to two buyers at different *net* prices, the net price being the price (paid by the buyer) corrected for the cost associated with the product differentiation."

The main conclusions will be derived with a simple Lagrange-formulation. Below, three types of firms are indicated with the index i : $i=1$ is the incumbent Deutsche Telekom, $i=2$ are the alternative network operators and $i=3$ are the service providers. There are four types of demand. First, the demand of the non-switchers, x_N . By definition, this demand is only available for the incumbent. The other three demands are x_B , x_L and x_R respectively. x_B and x_L are the

demands which might potentially allow for price discrimination; the indices B and L may e.g. indicate the user groups "big" and "little". x_R is the derived demand for interconnection. This type of demand is relevant for the producer types $i=1,2$ only; i.e. for the network operators. x_R is demanded by the service providers ($i=3$) who by assumption do not own networks and thus need interconnection. It is an intermediate demand, which derives revenue for the network operators and is a cost factor for the service providers.¹⁴ The prices set for the different demands are p_N , p_B , p_L and r , respectively. The network operators only have fixed costs, βK_i , where β expresses marginal network expansion costs. The service operators only have variable costs, $r(x_B + x_L)$, the costs of interconnection. x_N is not relevant for the service providers and x_R is input rather than output for the service providers.¹⁵

There are two dummy variables, which values (1 or 0) depend on the type of producer. α_i activates the non-switching demand for $i=1$; i.e. $\alpha_i=1$ for $i=1$ and $\alpha_i=0$ for $i=2,3$. The other dummy, γ_i , activates the different cost-structures between network operators and service providers. That is, $\gamma_i=1$ for $i=1,2$ and $\gamma_i=0$ for $i=3$.

$$\begin{aligned} L(x_N, x_B, x_L, x_R, K_i) = & (\alpha_i \cdot p_N(x_N) \cdot x_N) + (p_B \cdot x_B) + (p_L \cdot x_L) + (\gamma_i \cdot r \cdot x_R) \\ & - \gamma_i \cdot \beta \cdot K_i - (1 - \gamma_i) \cdot [r \cdot (x_B + x_L)] \\ & - \lambda \cdot \gamma_i \cdot (\alpha_i \cdot x_N + x_B + x_L + x_R - K_i). \end{aligned} \quad (1)$$

The first line represents revenues, with a falling demand curve x_N for the incumbent ($\alpha_i = 1$); the other demand curves are horizontal, representing price-taking behaviour. The second line describes the costs; the dummy γ_i activates between the fixed costs for the network operators ($i=1,2$) and the variable costs

¹⁴ The specification of this intermediate relation is highly simplified, but suffices for the problem at hand.

¹⁵ This notation simplifies considerably. First, strict complementarity is assumed; one unit of output of the service providers is one unit of input, which in turn is one unit of output for the network operators. This assumption is plausible. In addition, by identity the sum of outputs of the service providers must equal the output x_R of the network operators. However, x_R should not be substituted for x_B and x_L for the output for the service providers, because the option of price discrimination would be lost. Furthermore, for other purposes one would probably like to divide and specify total demand over the different firms. Integrating all this would increase notational effort considerably, without providing additional insight.

for the service providers ($i=3$). These are mutually exclusive. The third line is the Lagrange-constraint, with multiplier λ . It says that -for the network operators- the sum of outputs must be equal to or less than network capacity K_i . This constraint applies to the network operators only ($i=1,2$). The service providers do not have a capacity problem, except for the underlying capacity constraint of the network operators, which is implicitly included in the maximization problem.

The general solution is straightforward derivation w.r.t. the variables.

$$\frac{\partial L_i}{\partial x_N} = \alpha_i \cdot MR_N(x_N) - \gamma_i \cdot \alpha_i \cdot \lambda = 0, \quad (2)$$

$$\frac{\partial L_i}{\partial x_B} = p_B - (1 - \gamma_i) \cdot r - \gamma_i \cdot \lambda = 0, \quad (3)$$

$$\frac{\partial L_i}{\partial x_L} = p_L - (1 - \gamma_i) \cdot r - \gamma_i \cdot \lambda = 0, \quad (4)$$

$$\frac{\partial L_i}{\partial x_R} = \gamma_i \cdot r - \gamma_i \cdot \lambda = 0, \quad (5)$$

$$\frac{\partial L_i}{\partial K_i} = -\gamma_i \cdot \beta + \gamma_i \cdot \lambda = 0, \quad (6)$$

For completeness, $\gamma_i(\alpha_i x_N + x_B + x_L + x_R) \leq K_i$, $\lambda \geq 0$ and $\lambda \gamma_i(\alpha_i x_N + x_B + x_L + x_R - K_i) = 0$. From the general solution, using the appropriate i , the propositions follow directly.

Proposition 1: The dominant tariff-structure on the long-distance market will be a flat rate, expressing absence of systematic and persistent price discrimination. This will be the case for all three types of providers.¹⁶

¹⁶ It does, however, not apply to the difference between switchers and non-switchers as stated in proposition 2.

Solving the general solution above for the different types of producers gives the following solutions.¹⁷ First, for Deutsche Telekom ($i=1$) as mentioned already above, $p_B = p_L = MR_N = r = \beta = \lambda$. For the alternative network operators ($i=2$), $p_B = p_L = r = \beta$ and for the service providers $p_B = p_L = r$. It follows directly that the end-user prices (except for the non-switchers) are always equivalent; i.e. (persistent) price discrimination is not sustainable. The reason is well known: perfect price competition does not allow systematic price discrimination. Given a discriminating tariff-structure, there are always firms which will undercut prices in the high-priced market and serve only these consumers. This will force prices down in this market and simultaneously force prices up in the other market (for cost-recovery) until prices are equal in both markets.^{18, 19} This proposition contrasts somewhat to the finding of OECD [1999, p. 162], which states: “The difference between standard listed prices and what subscribers to discount schemes pay is largely proportional to the amount of competition in a given market.” Supposedly, what OECD observes here is the *process* of prices coming down (rather than the equilibrium): first, prices for more elastic (larger) users, then prices for the relatively inelastic (smaller) users. This is deceiving. It is clearly a mistake to conclude from the OECD observation that the steady-state competitive equilibrium will be characterized by a strong degree of price discrimination. Proposition 1 states quite the opposite.

Proposition 2: [$i=1, \alpha_i=1, \gamma_i=1$] The incumbent will attempt to price discriminate between switchers and non-switchers.

Solving the general solution for $i=1$ gives $p_B = p_L = MR_N = r = \beta$. Since $p_N > MR_N$ by definition, it follows that $p_N > p_B = p_L = r$. Thus, the incumbent will set

¹⁷ Here, it is still assumed that capacity is variable.

¹⁸ The issue has been settled in a famous controversy between Taussig and Pigou at the beginning of the 20th century. The interested reader may be referred to Ekelund & Hulett [1973] for a discussion of the dispute. Moreover, the reader may be referred to Philips [1983, p. 16] or Varian [1989, p. 599] for more on the necessary conditions for price discrimination.

¹⁹ A related issue is whether the same applies to distance-related pricing. It is beyond the scope of this paper to be extensive on this. Current empirical evidence suggests -for the moment- that distance-related tariff differentiation is unstable price discrimination. This may not apply for the future, however (see section 4).

a differentiated structure, in which the non-switchers are discriminated against. Proposition 2 indicates that a somewhat more differentiated tariff-structure of Deutsche Telekom compared to the others can be explained from the relative stickiness of non-switchers, rather than from systematic and persistent price discrimination. Nevertheless, even if there is a potential for Deutsche Telekom to discriminate between switchers and non-switchers, practical implementation may be weak. There is no obvious distinction mark; one cannot label consumers as non-switchers. Therefore criteria are needed which are correlated to consumers' tendency for switching.

Another problem is that this type of price discrimination is self-destroying. The non-switching argument rests on the assumption that the potential savings on the telephone bill do not compensate the set-up costs to be informed about the institutional setting. Obviously, the stronger the price difference is, the stronger is the tendency for switching. The group of non-switchers is in itself a heterogeneous continuum of consumers; with every given price difference, a proportion of consumers are switchers. The larger the price difference, the larger this proportion of switchers. This implies in particular that if -as happened- the prices for switchers fall sharply, that the price for non-switchers should somehow fall as well. Moreover, there is a self-enforcing effect in the reduction in the size of the group of non-switchers. Information of the institutional setting has a spill-over effect from one consumer to another, simply because people communicate. If more consumers are informed, the spill-over effect will be larger, which will inform more consumers and so on.

As an overall consideration, one may expect the following to happen. At first, the group of switchers is relatively small compared to the non-switchers. In this case it may be best to set one (relatively high) price only; that is, the distinction of two different demands is overrun by transaction costs. As the group of switchers gets larger, price discrimination may be temporarily profitable, until the group of switchers is relatively large. Then again one (relatively low) price will prevail. Straightforward plausibility considerations thus suggest that this type of discrimination will soon vanish completely, reducing prices *overall*.

Proposition 3: Among the network operators ($i=1,2$) there exists a *short-run*, but nevertheless real threat of cut-throat competition, driving prices down to marginal costs. In the *longer run*, capacity will adjust to demand, and prices will be adjusted to marginal capacity-expansion costs, β (which exactly covers cost).

Proposition 3 is the well-known Bertrand-paradox. The costs of network operators are mainly fixed costs; marginal costs are close to (while in the model, exactly) zero. As described in section 2, substantial entry on the network level has taken place, exploiting the potential of economies of scope with e.g. electricity-transmission and railway-infrastructure. Due to large indivisibilities, in the short run there will exist substantial excess capacity. The latter plus price competition may induce cut-throat competition. Assume -for the short run- that capacity is fixed and generally not exhausted. In the general solution above, (6) will be empty, because K is not a variable. This implies the following solutions. For $i=1$: $p_B = p_L = MR_N = r$. For $i=2$: $p_B = p_L = r$. And for $i=3$ as well: $p_B = p_L = r$. Note first that for $i=3$ (the service providers) it is completely irrelevant and the solution is determinate. Service providers simply set p_B and p_L equal to r (which for them is an input-price). Consequently, they will not be hurt by cut-throat competition. They do neither have fixed costs, nor an (excess) capacity problem. The problem is for the network-operators. Prices are equalized (except for the non-switchers), but the solution as it stands is undeterminate. To come to a solution, the formulation should be reinterpreted. The marginal capital-expansion costs, β , can be interpreted as opportunity costs; i.e. the shadow price. In case of excess capacity, these opportunity costs are zero and are $\beta > 0$ if output is at the capacity constraint. Thus, given excess capacity, pricing according the marginal capacity-expansion costs implies that prices are equal to the short-run marginal costs, which are zero by assumption.²⁰ In other words, it is not unlikely to happen that the prices of (long-distance) telephone services will be close to zero for some time. This will, of course, imply losses for the network operators, but as they compete severely, they hardly have a choice.

²⁰ Since the Lagrange-multiplier λ expresses the capacity constraint, it is equal to zero in case of excess capacity.

Consequences may be that aggregate capacity is reduced (e.g. by merger and take-overs or by mothballing) and that the incumbent may be accused of predation. In the light of cut-throat competition, it appears that such mergers and "predation" are mere expressions of firms struggling to survive rather than an exposition of market power. We would like to stress that we do not recommend legal entry barriers to forestall such "destructive competition". Proposition 3 is an observation, not a plea for intervention. Two arguments may tone down proposition 3. First, cut-throat competition is indeed only a temporary phenomenon, which relies critically on excess capacity. In the longer run, capacity will adjust to demand, after which the solutions of propositions 1 and 2 will apply and prices will adjust to the real marginal capacity-expansion costs, β . If β is constant in the long run, the long-run prices will be exactly cost-recovering. Rapidly growing demand weakens the cut-throat argument considerably. Second, obviously the firms will have a strong incentive not to engage in cut-throat competition; they will hesitate to "spoil the market". It seems plausible that they compete vigorously as long as prices are above average costs, but that there is a rigidity for prices to fall below average costs. Average costs may serve as an (unstable) focal point.

The peak-load structure

In section 4 it will be shown that the firms tend to converge to one and the same peak-load structure. However, a rather special effect appears momentarily: the peak-load structure shifts. Whereas the peak-period lasted predominantly from 9.00 to 18.00 in 1998, it seems to widen from 9.00 to 21.00 in 1999. Figure 1 - relying heavily on Steiner [1957]- will illustrate that this is not the result of changes in demand, but rather the result of increased competitive pressure.²¹ Moreover, it will be argued that the resulting peak-load structure reflects incorrect regulation, rather than correctly reflecting demand conditions.

²¹ The figure gives the market solution, but this will be stable in perfect competition (see Officer [1966] and Brunekreeft [1998]).

Proposition 4: Regulating (setting) the peak-load *structure* of the interconnection charges is either superfluous (high-profit case) or is likely to be harmful (low-profit case).

Two cases are distinguished; the difference is in β and β' respectively. Whereas above, β has been interpreted as the marginal capital-expansion costs, here it also includes an (excessive) profit margin, which is allowed by the market during the period of transition. Early 1998, shortly after the opening of the market, the profit margin was high. This invited new entry, competing away the profit margin. With time, new entry suppressed prices and thereby the profit margin, which in the figure is reflected by a shift from β (high profits) to β' (low profits). This seems plausible in the light of empirical observation (see figure 2). To be sure, in both cases individual firm demand is horizontal, reflecting price competition, but in time the general price level, to which the firms adjust, is reduced.

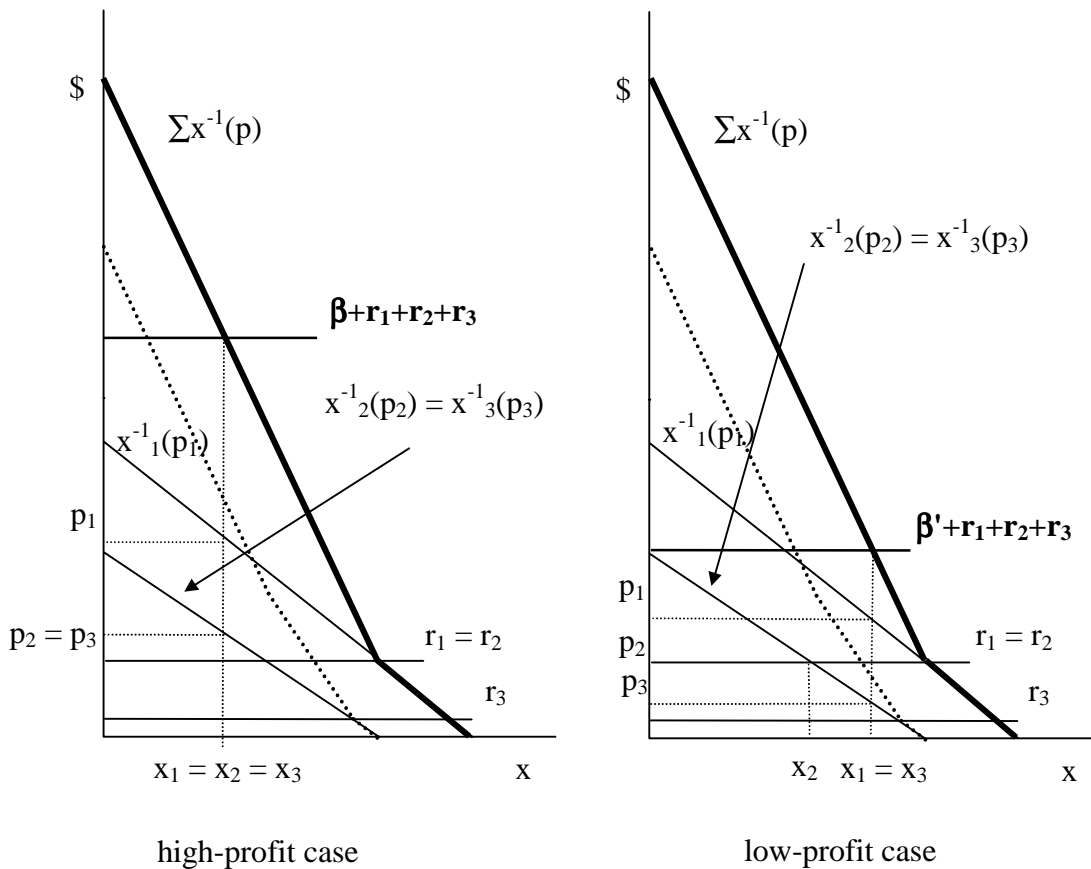


Figure 1: Graphical illustration of proposition 4.

For proposition 4, the polar case has to be left. For the case at hand, we concentrate on intermediate providers. These providers do have an incomplete network (and thus have fixed costs and a capacity problem), but do also rely on interconnection. They generally cannot terminate telephone calls relying exclusively on their own network. Consequently, they also incur interconnection costs. This is actually more realistic than the polar case used above which is an abstraction. It suffices to distinguish three periods (1, 2 and 3), with (regulated) interconnection charges, $r_1 = r_2 > r_3$. There are three periods of demand ($x_i(p_i)$); however, demands in periods 2 and 3 are equivalent. For the analysis in the figure, the demands have to be summed vertically.²² For the high-profit case it follows that output is equal in all periods,²³ and prices are adjusted to period-specific demand, *irrespective of the interconnection charges*. The essential feature is $p_1 + p_2 + p_3 = \beta + r_1 + r_2 + r_3$; i.e. the *sum* of the prices equals the *sum* of the interconnection charges plus the mark-up. Individual prices are determined by the respective demand, given the output level. It follows that although the regulated interconnection charges r_2 and r_3 differ, prices p_2 and p_3 do not differ, due to equivalent demand curves. In the low-profit case, the profit margin has decreased to β' . If output would now be set equal in all three periods, the end-user price in period 2 would fall below the interconnection charge r_2 . This is not rational. Instead, as soon as $p_2 = r_2$, the firm will stick to this price. The other two periods still allow a mark-up on the interconnection charges, and thus output will be equal in periods 1 and 3. The result is that now $p_1 > p_2 > p_3$. As may be noted, this is not caused by a shift in demand, but by a decrease of the profit margin induced by increased competition. It must be concluded, that since in the high-profit case, the firms simply ignored the structure of the (regulated) interconnection charges, the price structure of the high-profit case reflects the correct demand conditions. Consequently, the price structure in the low-profit case, which to some extent reflects the (regulated) structure of the interconnection charges does not reflect demand conditions. Of course, the regulator might

²² In the figure the dotted line illustrates net aggregate demand which is gross aggregate demand net of the interconnection charges.

²³ The reader may consult Steiner [1957] for a more extensive explanation of the same principle.

set the correct peak-load structure, but one is tempted to question the purpose of regulating the peak-load structure at all.

4. Empirical observations

Our sample of firms comprises all active providers of nation-wide call-by-call telecommunications services in Germany between January 1998 and April 1999.²⁴ Carriers which concentrate explicitly on business customers, regional and city carriers, and providers who only offer pre-selection services are neglected. In accordance with the previous sections the empirical data distinguish between the incumbent, Deutsche Telekom, the three major alternative network operators, Arcor, o.tel.o, and Viag Interkom, and the group of service providers. The latter group comprises between four (in January 1998) and 21 (in April 1999) network operators with large-meshed networks, switch-based service providers, and resellers. To keep the observation traceable we chose to look at five distinct points in time rather than to document continuous developments. The five points are the starting point of competition in January 1998, the end point of the initial wave of market entry in June 1998, and the end points of the major three subsequent waves of price change, namely October 1998, February 1999 and April 1999.

The development of the overall price level indicates that there indeed is strong price competition. Figure 2 and table 1 compare the average prices during a day for the three types of providers. Between January 1998 and April 1999, Deutsche Telekom lowered its average price by 62%, the alternative network operators by 66% and the service providers by 52%. In April 1999 the service providers charged on average only 32% of what consumers had to pay to Deutsche Telekom for comparable services at the start of competition. Not only did the price level decrease for each group but they also converged. In June 1998, the alternative network operators set their average price only slightly (6%) below the average price of Deutsche Telekom whereas the service providers positioned themselves 34% below Deutsche Telekom. This indicates that

²⁴ The detailed data is available from the authors upon request.

network operators were more reluctant to engage in price competition than service providers at market entry.

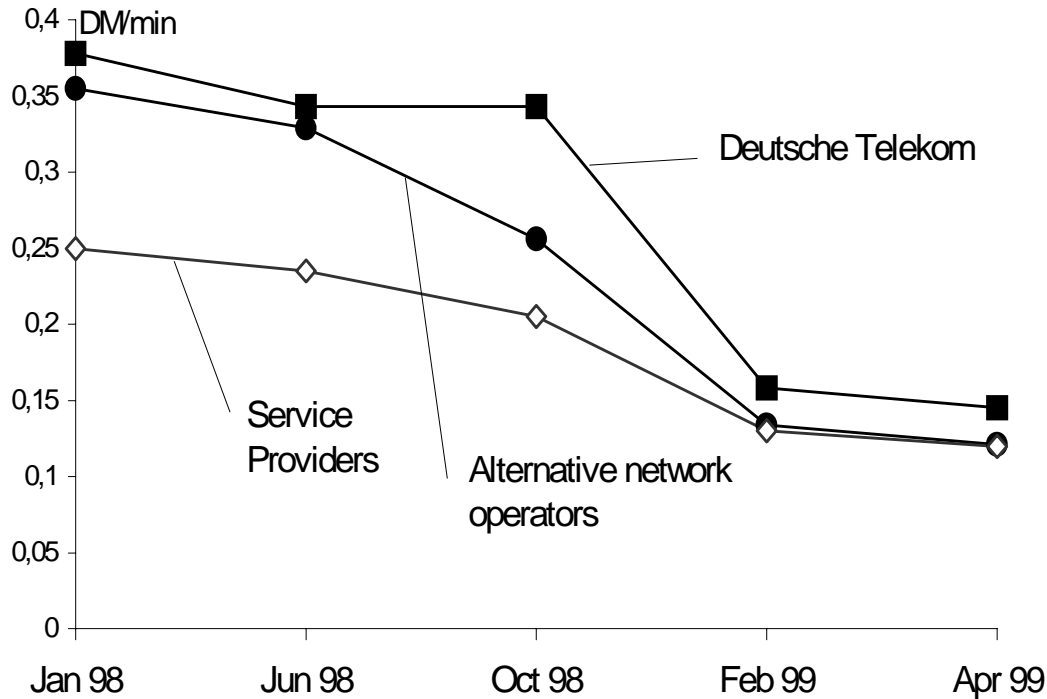


Figure 2: Average prices for the three types of providers (in DM)²⁵

	Jan 98	Jun 98	Oct 98	Feb 99	Apr 99
Deutsche Telekom	0.378	0.343	0.343	0.158	0.145
Alternative Network Operators	0.355	0.329	0.256	0.134	0.121
Service Providers	0.250	0.235	0.205	0.130	0.120

Table 1: Development of average prices (in DM) for the three types of providers

In April 1999 the gap between the average price of the service providers and Deutsche Telekom had narrowed from 34% to 19% and the alternative network operators' prices were close to the ones of the service providers. This indicates

²⁵ We state standard call-by-call prices without discounts. No adjustments are made for different measuring schemes. The average price during a day is defined as the unweighted sum of the prices per minute at every full hour of a working day divided by 24. 1 DM = 0.51 euro.

that none of the groups of providers can persistently charge higher prices than the others, irrespective of the entry strategy.

Proposition 1 suggests that there is no scope for price discrimination in the market for long-distance services.

Provider	October 1998	February 1999	April 1999
Deutsche Telekom	yes	yes	yes but with limited scope
Arcor	yes	no	no
o.tel.o	no	no	no
Viag Interkom	yes	yes	yes but with limited scope
01051 Telecom	-	no	no
3U	-	-	no
ACC	no	no	no
Alpha Telecom	-	no	no
CS	-	-	no
Drillisch	-	-	no
Interoute	no	no	no
Mistral	-	no	no
Mobilcom	no	no	no
Mox Telecom	no	no	no
Nikoma	-	no	no
Pronet	-	no	no
RSL Com	-	no	no
Super24	-	-	no
Talkline	no	no	no
Teldafax	no	no	no
TeleBridge²⁶	no	no	no
Telepassport	no	no	no
Tele2	yes	no	no
Viatel	yes	no	no
Westcom	no	no	no

Table 2: Volume Discounts for residential customers (monthly bills < 250 DM)

²⁶ TeleBridge offers more favourable metering depending on an agreed monthly minimum volume. This could be interpreted as a volume discount.

Table 2 illustrates the tendency towards flat tariffs for residential customers. Only two of the 21 service providers active in April 1999 offered volume discounts for private customers when entering the market and abolished these schemes soon afterwards. Tele2 abandoned its block-declining tariff (granting a 2–4% discount for monthly bills of more than 50 DM) when reducing its average standard price substantially from 0.169 DM to 0.103 DM in February 1999 and Viatel replaced its 5% discount on international calls for all customers by a volume discount for business customers (starting at monthly bills of 1,700 DM).

Network operators were in a greater need to earn consumer rents in order to cover their fixed costs, as discussed in section 3. Accordingly, three out of the four network operators offered discounts for private customers initially, but they soon cut back these schemes. When announcing substantial price reductions for April 1999, Mr. Sommer, CEO of Deutsche Telekom, declared that these reduced rates would be “net prices” [Handelsblatt, 1999]. And indeed, since April 1999, the volume discount “10plus” does no longer apply in the evening period in which prices have been halved.²⁷ Arcor abandoned its generous 1998 pre-selection discount of 5–10% for monthly bills of more than 150 DM in December 1998 and Viag Interkom reduced its initial offer to grant a 15% discount to 15 selected numbers to a 10% discount to 5 numbers in March 1999.

A related issue, which cannot be examined in depth here, is distance-related pricing. It turns out that, except for the difference between local versus long-distance calls, distance-related pricing vanishes momentarily. It is obvious that competitive pressure is the reason, but it is far from obvious whether this is necessary end-state or rather a transitory sub-state. Theoretically, assuming unconstrained technology and neglecting all transaction costs, a high degree of distance-related pricing (or rather component pricing) should actually be expected. We are tempted to conjecture that the current state is a “vacuum” between former distance-related pricing and future component pricing.

²⁷ Deutsche Telekom grants volume discounts to residential customers in the market for local services (CityPlus, CityWeekend). The basic characteristics of this market have very different implications on the viability of price discrimination compared to the long-distance market, though.

There are reasons why some extent of price differentiation can be observed (possibly persistently). First, discounts for business customers can be viable in competition if they have a cost justification. Business customers typically cause smaller marketing or transaction costs per service minute. Higher contract volumes reduce uncertainty costs which is especially relevant in a market with high fixed costs.²⁸ Second, frictions remain, however "perfect" competition may be. To by-pass the price competition, product differentiation will play a role to some limited extent, although it is quite unlikely that this will be empirically relevant. Moreover, to a limited extent, consumers may be attracted to sticky pre-selection contracts e.g. to save on transaction costs. This inertia retains some scope for price discrimination.

Proposition 2 explores price discrimination with respect to switching. To recall, with non-switchers we mean those who have not (yet) invested in set-up costs to get familiar with the new institutional setting and thus tend to stick to the incumbent. To price discriminate between switchers and non-switchers a criterion is needed which allows the firm to separate consumers. As the individual's probability to switch is not directly observable, the firm must use criteria which are correlated to the switching probability.

Criteria correlated to the switching probability are the willingness to adopt new technology and the need for an increased access bandwidth. Consequently, Deutsche Telekom discriminates between long-distance calls originating from customers with ISDN access-lines and those with only analogue access. Optional calling plans with mandatory prior registration can be interpreted as another method to discriminate between switchers and non-switchers. Only customers who are willing to inform themselves about prices have the chance to self-select such discount options whereas non-switchers end up paying higher

²⁸ There are numerous examples of explicit discounts for business customers in April 1999: volume discounts on monthly bills (e.g. Teldafax, Viatel), reduced prices per minute (Mistral) or more favourable measuring (TeleBridge) depending on a minimum monthly volume, discounts for customers who agree to install a router (Tele2), reduced peak prices in combination with a fixed monthly charge (e.g. CS, Interoute) and probably there are also individually negotiated prices for service packages which are not externally observable.

standard prices. The corresponding optional two-part tariff of Deutsche Telekom aiming at private customers is called “Select5”.²⁹ In October 1998, 6 out of 8 discount schemes of competitors were granted without an explicit registration to the calling plan (table 3). These automatic schemes are not well suited to differentiate between switchers and non-switchers.

Provider	discounts without prior registration	discounts with prior registration
Deutsche Telekom	for calls longer than 10 minutes (10plus)	for calls to 5 numbers, business discounts
Arcor	block-declining tariff above 100 DM	none
o.tel.o	block-declining tariff above 500 DM	none
Viag Interkom	for calls longer than 15 minutes	15 % for calls to 15 numbers
ACC	block-declining tariff above 250 DM	none
Interoute	none	none
Mobilcom	none	none
Mox Telecom	none	none
Talkline	none	none
Teldafax	block-declining tariff above 5000 DM	none
Telepassport	none	none
Tele2	block-declining tariff above 50 DM	none
Viatel	none	5 % for calls to 5 foreign countries
Westcom	none	none

Table 3: Volume Discounts in October 1998

²⁹ For a monthly recurring fee of 5 DM a 10% discount is granted on calls to five selected numbers. This scheme was introduced in October 1998.

Yet another criterion may be call duration. The longer the expected call the more likely it is that efforts are made to search for a suitable provider for this particular call. In line with these considerations, Deutsche Telekom introduced price discrimination according to call duration via its scheme “10plus” in March 1998.³⁰ Only one of the 24 competitors (Viag Interkom) introduced a similar discount but removed it soon afterwards.³¹ This observation is in line with the assumption that the price difference these competitors (as compared to the tariff of Deutsche Telekom) should set to reach these non-switching customers is so large that it is not rewarding.

It is quite problematic to assess proposition 3 empirically. As with the phenomenon predatory pricing, it is not entirely clear when exactly competition is supposed to be "cut-throat". As an indication, we have compared profit-data.

	traffic volume (mill. mins/day)	turnover 1998 (mill. DM)	profit 1998 (mill. DM)
Arcor	19	1,800	-297
o.tel.o	11	300	-2,200
Viag Interkom	10	380	-1,170
Teldafax	14	240	+18
Mobilcom ³²	20	1,470	+140

Table 4: Performance of alternative network operators and service providers in 1998

Source: annual reports and companies' press releases

Table 4 indicates that the network operators are indeed in a very difficult position, whereas the switch-based service providers tend to make positive profits. Although at first glance this looks rather convincing, it is indeed nothing more than a mere indication. After all, it is considered good business practice to have relatively high depreciation rates on investment in the first few years. It may mean close to nothing that losses over 1998 are rather high. On the other hand, although opinions differ, sector observers seem to have their doubts on

³⁰ “10plus” is a non-linear tariff granting a 10% (30% for ISDN customers) discount on the price of the interval after the first 10 minutes of a call.

³¹ Viag Interkom gave a 15% discount after a call duration of 15 minutes between May and December 1998.

³² Mobilcom achieved a substantial part of its turnover (950 mill.) with other than fixed telecommunications services, though.

profitability of the network operators as well (see e.g. Dohmen [1998] or FT [1998]).

We now turn to proposition 4. During the first 16 months of market liberalization competition has reduced the average price of all firms in our sample from 0.30 DM to 0.12 DM. Nevertheless, price competition did not erase peak-load pricing. On the contrary, we observe moves away from undifferentiated price structures towards more explicit peak-load pricing. In February 1999 Mobilcom replaced its famous and initially commercially successful undifferentiated tariff by a tariff with three time zones.³³

The multitude of different price structures depending on the time of the call during a working day can be broadly categorized into four types of price structures:

- **Undifferentiated:** These are price structures without a peak-load element.
- **Peak until 18:** These price structures distinguish between one off-peak period and one peak period lasting until 18.00 and typically beginning at 8.00 or 9.00 in the morning.
- **Peak until 21:** These price structures comprise either two time-periods with the peak period from around 9.00 until 21.00 or three time-periods with an additional period between 18.00 and 21 with prices in between peak and off-peak prices.
- **More than three periods:** These price structures distinguish 4 or 5 time periods, typically with additional distinctions in the morning compared to “Peak until 21”.

Figure 3 illustrates the percentages of firms choosing these price-structures at different points in time. In the first months of liberalization several firms set their price structure in resemblance to Deutsche Telekom: 39% of providers chose to offer more than 3 time periods during a day in June 1998. Up until

³³ Mobilcom charged an undifferentiated price of 0.19 DM/min. to promote its carrier access code (01019).

October 1998 an overall preference for “Peak until 18” can be observed: 54% in June 1998 and 57% in October chose this structure whereas a structure resembling the incumbent's lost popularity, only 14% still relied on more than 3 time zones in October 1998. The situation until October 1998 can be interpreted to have been what we called “high-profit case” in section 3.

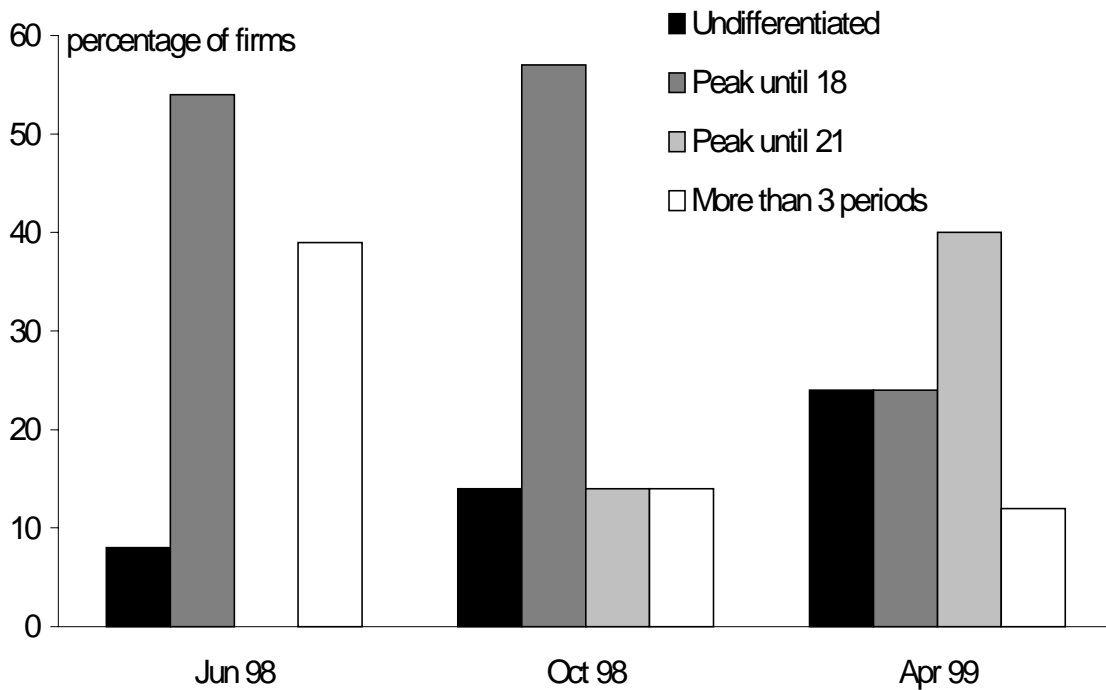


Figure 3: Development of the percentage of firms choosing specific price structures

	9.00 – 21.00	21.00 – 9.00
local	0.0197	0.0124
- 50 km	0.0336	0.0202
- 200 km	0.0425	0.0235
> 200 km	0.0514	0.0316

Table 5: Interconnection charges in Germany in 1998 - 1999 in DM per minute

Table 5 indicates that at least for the service providers a price structure “Peak until 18” was not cost-oriented: A large share of the costs of the group of switch-based service providers are the costs of interconnection and they include a peak-price between 9.00 and 21.00 instead of 9.00 and 18.00. The structure

“Peak until 18” must have been chosen because it reflected demand better than “Peak until 21”.

After October 1998 a move from “Peak until 18” to “Peak until 21” can be observed. The percentage of firms choosing this price structure increased from zero in January 1998 to 40% in April 1999. It is illustrative to have a closer look at the correlation between the price-structure chosen by individual providers and their lowest off-peak price during a day, as depicted in Figure 4. It reveals a correlation between firms with lower prices and price structures "Peak until 21".

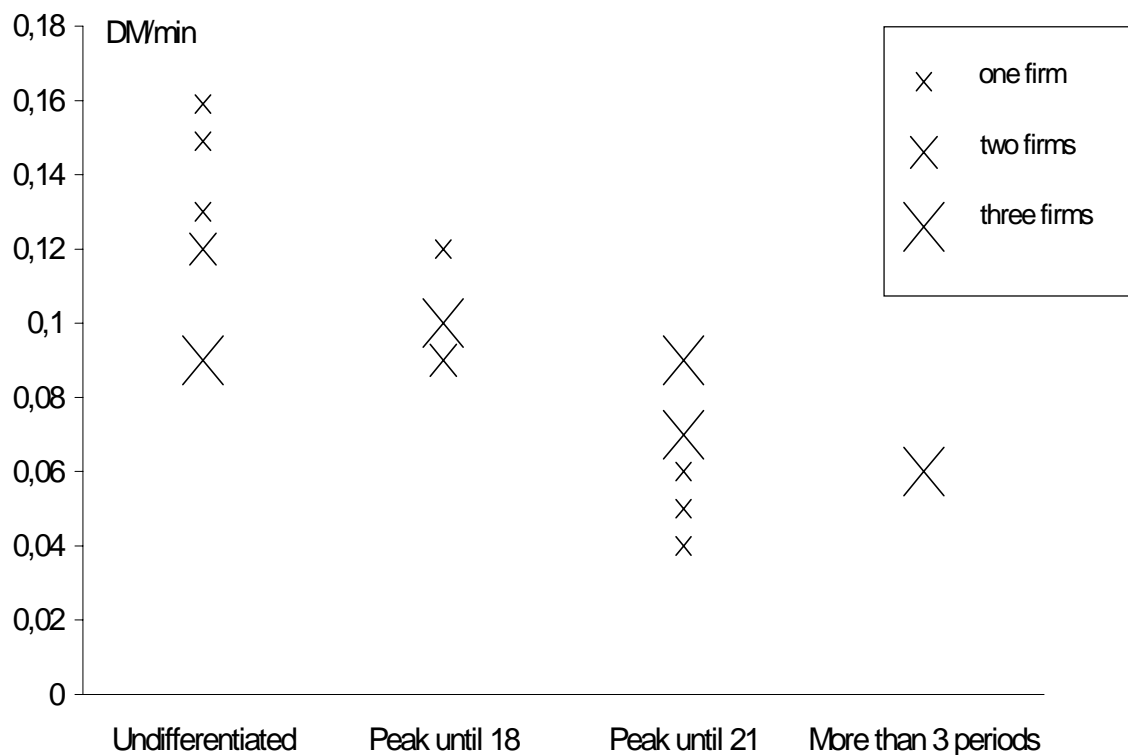


Figure 4: Correlation between off-peak price and price structure in April 1999

None of the firms which decided to reduce their off-peak price below 0.09 DM chose the formerly so popular price structure “Peak until 18.00” anymore. Instead these firms set a higher price between 18.00 and 21.00 than during the night. A look at table 5 shows that firms relying on interconnection have costs per minute of between 0.039 and 0.103 DM depending on the type of call origination and termination they have to purchase. The theoretical result in section 3 (low-profits case) suggests that with decreasing profit margins,

marginal cost (r) sets a natural lower pricing bound. Even if capacity exhaustion requires a further price decrease, it will not take place. This is exactly the situation we are in here. Pressure on off-peak prices has decreased the price level to an extent that charging off-peak prices between 18.00 and 21.00 would no longer cover (interconnection) costs.

As prices go down, the institutionally set interconnection-cost structure seems to reappear in the prices. The analysis above suggest that this regulated structure of the interconnection charges leads to inefficient network usage. Moreover, it can be expected that an efficient peak-load price structure would appear if interconnection charges would be set freely in a competitive environment.

5. Concluding remarks

In this paper, we have analysed the development of the price structure for long-distance voice telephony in Germany. Since January 1st 1998, the market has witnessed an enormous increase in the number of firms of both mere service providers and network operators. Moreover, the average price of long-distance telephone calls has dropped dramatically. This market is of particular interest for both practical and theoretical reasons. At the point of liberalization it was uncertain whether and to what extent competition would work. Now is the time to make empirical examination. Theoretically the German market for long-distance telephone services should be nearly perfectly competitive. The product is highly homogeneous and search costs are extremely low. With these considerations in mind, we have analysed the now available price data and have attempted to back-up observed patterns by theoretical considerations.

The paper puts forward four propositions. First, various attempts to persistent and systematic price discrimination will be fruitless in the long run. In other words, in the long run the dominant tariff structure for long-distance telephone calls will be a flat rate. Despite the obvious incentives to price discriminate, the high degree of price-competition simply makes it unsustainable. Second, for the current period of transition the incumbent's (Deutsche Telekom) somewhat stronger tendency for price discrimination should be explained from the (transitory) existence of non-switchers. Customers have set-up costs to get

informed about the new institutional setting. After they have made this investment, they may switch and will react to price only. Although the incumbent thus has a (transitory and declining) market of non-switchers, it will be quite difficult to actually exploit this potential by lack of an obvious distinction mark. Third, due to large indivisibilities in network investment, capacity is currently likely to be excessive, and since the network costs are fixed, severe price-competition is likely to induce cut-throat competition in the short run. That is, it is not unlikely that tariffs will fall to short-run marginal costs. This does not imply regulatory intervention, however. In the longer run, the market will adjust capacity to demand (or reverse), which implies prices which exactly recover costs. Fourth, we have observed and explained a shift of the peak times from 18.00 to 21.00, which momentarily occurs. In our opinion this reflects incorrect regulation of the underlying peak-load structure of the interconnection charges.

References

- Brunekreeft, G., 1998, 'Peak-load pricing, perfect competition and price discrimination', *Discussion paper*, No. 53, Oct. 1998, University of Freiburg.
- Büchner, W.; Ehmer, J.; Geppert, M.; Kerkhoff, B.; Piepenbrock, H.; Schütz, R. & Schuster, F. (ed.), 1997, *Beck'scher TKG-Kommentar*, C. H. Beck'sche Verlagsbuchhandlung.
- Connect-online, 1999, 'Telekom-Konkurrenten stoßen an Wachstumsgrenzen', *Connect-online*, 23.03.1999.
- Dohmen, F., 1998, 'Kaum noch Luft', *Der Spiegel*, No. 53/1998.
- Ekelund, R.B. & Hulett, J.R., 1973, 'Joint supply, the Taussig-Pigou controversy and the competitive provision of public goods', *Journal of Law and Economics*, Vol. 16, No. 2, pp. 369-387.
- European Commission, 1998, *Commission recommendation on interconnection in a liberalised telecommunications market, Part 1 – Interconnection pricing*. C(98) 50, Brussels.
- European Commission, 1999, *Interconnection tariffs in member states (1st March 1999)*, Brussels.
- FAZ, 1999, 'Die Telefentarife werden in diesem Jahr kaum noch fallen', *Frankfurter Allgemeine Zeitung*, 01.02.1999, p. 23.
- FT, 1998, 'Call pricing trend 'puts telecoms groups at risk'', *Financial Times*, 21.12.1998, p. 3.

- Handelsblatt, 1999, 'Telekom senkt Preise und strebt ins Ausland', *Handelsblatt*, 27.01.1999.
- Hochkötter, M. & Plica, M., 1999, 'Der lange Weg zum treuen Kunden', *Frankfurter Allgemeine Zeitung*, 16.02.1999, p. B1.
- Knieps, G., 1998, 'Costing and pricing of interconnection services in a liberalized European telecommunications market', in: *American Institute for Contemporary Studies, 1998, Telecommunications reform in Germany: lessons and priorities (Conference Report)*, pp. 51-73.
- Merkt, J., 1998, *Wettbewerb im local loop*, Nomos Verlagsgesellschaft.
- OECD, 1999, 'Communications outlook 1999', Paris.
- Officer, L.H., 1966, 'The optimality of pure competition in the capacity problem', *Quarterly Journal of Economics*, Vol. 80, pp. 647-651.
- Phlips, L., 1983, *The economics of price discrimination*, Cambridge University Press.
- Regulierungsbehörde für Telekommunikation und Post, 1998, *Jahresbericht 1998*, Bonn.
- Regulierungsbehörde für Telekommunikation und Post, 1999, Mitteilung Nr. 73/1999, *Amtsblatt der Regulierungsbehörde für Telekommunikation und Post*, 4/99.
- Statistisches Bundesamt, 1999, 'Verbraucherpreise für Telefondienstleistungen im März 1999 um 8,9% niedriger als im Vorjahr', *Press Release*, 31.03.1999.
- Steiner, P.O., 1957, 'Peak loads and efficient pricing', *Quarterly Journal of Economics*, Vol. 71, pp. 585-610.
- Varian, H.R., 1989, 'Price discrimination', in: *Schmalensee, R. & Willig, R.D., 1989, Handbook of Industrial Organization, Vol. I, Elsevier Science Publishers*, Ch. 10, pp. 597-654.