National Roaming - An Incomplete Contracts Approach

Preliminary Version

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Abstract

National roaming is a form of infrastructure sharing in mobile communication networks, where an operator opens his network for a competitor's customers and is compensated by a usage based charge. Arguments in favour of national roaming include the reduction of network investments or faster network rollout. This paper examines the effects of national roaming on competition, network investments and welfare. Using an oligopoly setup with ex-ante capacity investments and incomplete contracts, it is shown that cooperation might increase production efficiency but does not affect total network capacity.

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1 *Introduction*

Third generation telephony services are currently being launched across Europe. But high license costs, uncertain demand and increased cautiousness of investors had a significant impact on pace and level of network investments. As a possibility to achieve a fast and far reaching network rollout despite these problems, network operators have envisaged network infrastructure sharing and national roaming as means to reduce necessary investments. Network infrastructure sharing describes the joint use of network infrastructure, and may reach from mast/antenna sharing to the joint use of spectrum. National roaming in contrast, is an agreement between network operators granting each other usage rights on their networks, but keeping ownership completely separated. It is the aim of this paper to analyse potential implications for investments and competition, when these control rights are being used strategically. It will be shown in a framework of simultaneous and sequential investment that national roaming might lead to a more efficient production without a reduction of consumer welfare thus improving total welfare. But it may also prevent further investments by the "weaker" operator, resulting in insufficient competition, even when the "weak" operator improves his competitiveness.

The paper will be structured as follows: First a cooperation agreement between T-Mobile and O2 will be presented in the context of European competition policy. Then after discussing the assumptions of the model, a benchmark case without capacity wholesale will be considered. Finally after analysing the wholesale case, welfare conclusions will be drawn.

2 *Infrastructure Sharing in Europe*

Different forms of infrastructure sharing can now be observed across Europe. In Sweden, Vodafone and "3" compete in urban areas with separate networks, while coverage in rural areas is provided by a jointly owned company 3GIS, which is building and operating a single network for both operators. In the UK, T-Mobile and O2 have closed a similar agreement, with the difference that coverage of less populated areas will be split between the two operators, who will grant each other roaming rights on these parts of their networks (Gabathuler and Sauter, 2003). In Germany another type of cooperation can be observed, which will be presented in greater detail:

In a recent European Commissions decision (2004/207/EC) a cooperation agreement between T-Mobile Germany and O2 Germany has been permitted. The cooperation agreement consists of three parts: An extended site sharing agreement, radio access network (RAN) sharing and a national roaming agreement. This paper will focus on the national roaming agreement, as the other two agreements are of a more technological nature and are mainly undisputed or even regarded as necessary from a regulatory point of view (eg. Directive 2002/21/EC, recital 23).

The national roaming agreement allows O2 to widen its network coverage by using T-Mobile's network. In return T-Mobile receives a time based charge for voice telephony and a transmission based charge for data traffic[1]. The time based charge is based on the parties termination charges and the transmission based charge depends on some other factors, including retail prices and demand. Geographically, the area where national roaming may be used is subject to certain constraints. Roaming in areas with a high population density has to be ceased by December 2005, while it may be continued in rural areas and areas not covered by the minimum coverage requirements set out in the UMTS license.

The parties are not only allowed to use the other network's capacity to offer it to their own customers, but also to resell it to service providers or virtual mobile network operators(MVNO)[2]. The critical aspect of this agreement is that the resale of network capacity to MVNOs, which has been obtained through the national roaming agreement, is subject to the consent of the network operator producing this capacity. Furthermore the reselling party is obliged to allow the other party to directly offer this

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[1] The national roaming agreement is formally a reciprocal agreement, but it is generally perceived that it will be used only in the direction described.

[2] Service providers or "resellers" are undertakings that offer mobile services to customers using their own brands and billing processes. MVNOs do not own neither a network operator license, nor an network, but who have an own mobile network code, so that from the end-users perspective they appear to operate an own network.

capacity to the service provider or MVNO(2004/207/EC rec. 40-42). In other words, this means that whenever O2 is reselling capacity obtained from T-Mobile to service providers or MVNOs, T-Mobile might intervene and sell its capacity directly to the third party.

Generally such vertical restraints are interdicted by Article 81(1) of the EU-Treaty, because they might restrict competition within the common market. The involved parties have therefore requested either a negative clearance under Article 81(1) or an exemption under Article 81(3) from the European Commission. An exemption may be given, if an agreement between the undertakings "contributes to improving the production or distribution of goods or to promoting technical or economic progress, while allowing customers a fair share of the resulting benefit". In Article 2 of the commissions decision (2004/207/CE), the Commission has applied Article 81(3) of the Treaty, and thus declared Article 81(1) inapplicable. Whether this view, especially the restrictions on capacity resale to service providers, can be supported from an industrial economics perspective, shall be analysed in the following model.

3 The model

Two network operators will be considered. In order to offer their services, network operators are required to invest in network capacity. Alternatively usage rights on a competitor's network might be purchased through a national roaming agreement. Buying network capacity instead of building up a network might be cost reducing for a less experienced or new operator, but comprises the risk of losing full control over an elementary input which is necessary for the operator's services. This problem will be reflected by an option given to the roaming offering operator to retreat from the agreement, after first irreversible investments have already been made. Irrespective whether the hold-up problem occurs, both operators will be given a second investment round to increase their network capacity.

The analysis is conducted within a two player oligopoly setup. This assumption is derived from the nature of mobile communications markets that are generally considered as „natural oligopolies" (Groebel, 2003:, Valletti, 2003). The reason for this can not only be found in the regulatory framework of the market, where licenses prohibit market entry at the network layer, but also stems from the technical constraint that radio spectrum cannot be divided arbitrarily. In contrast to fixed telephony networks, where each local loop line can theoretically be owned or used by a different operator without any technical externalities, a given radio spectrum only allows a certain maximum number of operators to operate within a geographical region.

Other network operators will be ignored in this model. As will be shown, this does not change the models predictions, because total output will stay constant. The setup with only two actors is therefore equivalent to a situation, where these two operators maximise their profits given the residual demand, resulting from other operators' optimal decisions.

3.1 Coverage, Capacity and Transfer Volumes

Third generation networks can be used to deliver two types of services. Voice services similar to existing 2nd generation circuit-switched networks and packet-based data services. Because voice traffic can be encoded into data using VoIP technologies before leaving the user equipment, operators use technical or contractual provisions to maintain different prices in both segments. In the following analysis only a single product will be considered.

An argument in favour of national roaming is an increased network utilisation efficiency, suggesting unused network capacities or networks build primarily for coverage reasons. While coverage has significant impact in 2nd generation networks and may be used as an aspect of product differentiation (Valletti, 1999), 3rd generation networks are primarily destined for high speed data transfers. Regarding these transfers, UMTS system capacity per network cell decreases rapidly with the transmission speeds offered to its users. For example it is possible to serve approximately 70 users simultaneously at a transfer speed equivalent to 2nd generation services, but only 5 simultaneous users per cell can be accommodated once the data transmission speed per user is increased to 144 kbit/s, twice the ISDN line speed (UMTS Forum, 2000 cited in Heng, 2001). A linear relation between capacity and data transfer is therefore deducted, lumpiness of investments is neglected and as a consequence an operator offering national roaming will have to increase network investments in order to accommodate the competitor's customers.

3.2 Demand

Demand is represented by the inverse demand function $D^{-1}(Q) = a - b * Q$, where $Q = q_1 + q_2$ is the total quantity offered. For strictly positive values of a and b, this is a simple linear demand function.

3.3 Production

Mobile communication networks are characterised by a typically high fixed costs component and relatively low marginal costs (Haucap, 2004). Only the costs of capacity production will be considered in this model. It is produced at constant costs c_i. Without loss of generality, it is assumed that $c_1 \leq c_2$. This cost asymmetry represents the first operators cost advantage and creates a potential efficiency gain by substituting the production with wholesale. The intuition for this asymmetry is the scarcity of good locations and the growing resistance of neighbourhoods against mobile telecommunications transmitters, which gives a strategic advantage to the incumbent operator. This operator is already in possession of numerous locations from 2nd generation mobile telephony services and thus he may enjoy lower costs for network rollout by just upgrading existing base stations.

Capacity wholesale from operator 1 to operator 2 is charged at a constant price r. The price itself is assumed not to be subject to renegotiation. Unlike in the T-Mobile and O2 case, no quantity discounts or interdependencies with termination rates will be considered.

3.4 Incomplete Contracts

Services and applications of the 3rd generation communications technology are still evolving. Especially when national roaming agreements are made before networks are build, it seems plausible that contracts do not consider all possible contingencies.

A hypothetical example shall be considered in order to illustrate the intuition behind this assumption: Consider a simple national roaming agreement which defines separate pricing schemes for voice and data services. In technical literature this differentiation is analogously used by defining different quality-of-service or traffic classes (Wuschke, 2003). Voice is considered to belong to the conversational Class, which ensures real-time data transfer and preserves the time relation between information entities of the stream[5]. Data services in contrast are usually considered to belong to the interactive or background class that does not fulfil these requirements. It seems plausible to assume that the quality of service classes are specified in such a contract. But then a problem would arise when markets reveal a previously unforeseen high demand for video telephony, which belongs to the streaming class and has not been specified in the contract. In such a case the roaming offering operator would enjoy a strong bargaining position and the possibility of opportunistic behaviour, as he could deny the access to these services to the roaming partners receiving operator.

In the following analysis an incomplete contracts approach will be followed. The parties are able to agree upon a national roaming agreement. This agreement grants specific usage rights from the roaming offering operator to the roaming receiving party. In other words the residual control rights of the network are still owned by the roaming offering party. Hart (1995:30) describes these rights as the right "to decide all usages of the asset in any way not inconsistent with a prior contract, custom, or law". This implies a possible hold-up problem for all cases that were not ex-ante specified in the contract. According to Klein, Crawford and Alchian (1978) the resulting possibility of opportunistic

[5] Exact specifications may be found at the 3rd Generation Partnership Projects' website at www.3gpp.org.

behaviour can be internalised by offering a future premium, that will exceed the potential gain from the hold-up option.

4 *Network competition without capacity wholesale*

This is a reference model, when capacity wholesale between network operators is not allowed, or when there are no incentives to make such an agreement. It will be used as a benchmark to verify the players participation constraints and to compare the change in consumer surplus. It is basically a two-stage simultaneous investment game. On the first stage, both players simultaneously set their network capacity and on the second stage prices are chosen. This Bertrand competition with ex-ante capacity decisions is equivalent to a one stage Cournot-quantity competition, as has been shown by Kreps and Scheinkman(1983)[6]. The solution is straightforward: Both parties maximise their profits

$$\pi_i = p(q_i, q_j) \cdot q_i - c_i \cdot q_i \tag{4.1}$$

and the Nash equilibrium is given by the intersection of their best response functions

$$q_{i,NR} = \frac{a - 2 \cdot c_i + c_j}{3b} \tag{4.2}$$

The total quantity is

$$q_{total,NR} = \frac{2a - c_i - c_j}{3b} \tag{4.3}$$

and the resulting price is

$$p_{NR} = \frac{1}{3}(a + c_i + c_j). \tag{4.4}$$

Profits are given by

$$\pi_{i,NR} = \frac{(a - 2 \cdot c_i + c_j)^2}{9b} \tag{4.5}$$

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[6] The Kreps and Scheinkman model is based on stricter assumptions regarding demand and cost curves. Its results remain valid using the linear setup. (see Wolfstetter, E. (1996): 'Oligopoly and Industrial Organization', Discussion Paper 39, Humboldt University Berlin, Sonderforschungsbereich 373.)

The results are as usual, the higher the cost asymmetry, the higher the differences in output. Due to the lack of potential entry, the resulting price is above the marginal costs of capacity investments.

5 Network competition with capacity wholesale

Capacity wholesale will now be introduced by adding a layer to the preceding model. It is assumed that resale capacity is produced before the quantity competition on the last stage. In other words, the investment stage from the first model is duplicated and an intervention option is introduced. The intervention option reflects the first operators right (see recital 40-42 in the previously cited Commissions decision), either to decline his consent to the resale or to decide to offer his services directly to the service provider, once resale capacity has been produced. In case that the usage right is declined, the second operator does not have to bear any costs.

Without the option to intervene, this model is similar to the sequential investment model by Dixit (1980) and Spence (1977), who have argued that a production of excess capacity might prevent market entry or at least lead to a Stackelberg outcome. The Dixit model has been criticised by Ware (1984), who noted that Dixits two stage game ignored that the followers investments were possible without incurring fixed costs. He therefore added another stage between the first movers investment decision and the competition, where the follower produces his capacity, after observing the leaders investments.

The timing can now be depicted in the following table:

Stage	**Actor**	**Strategy space**
1.	Both	Produces q_w, q_{1E} and q_{2E}, his own ex-ante capacity
2.	Operator 1	Option to break the contract and use q_w himself
3.	Both	Choice of ex-post capacity q_{1p}, q_{2p}

The second operators ex-ante (1st stage) investment is incorporated only for reasons of symmetry, but it has no strategic relevance, as long as it is observable by the first operator, before the intervention option can be exercised.

Solving the model by backwards induction, requires a distinction between two cases, depending whether or not the intervention option is exercised. The results will then be used to derive the second operators optimal choice of wholesale capacity q_w, based on the first players participation constraint.

5.1 Resale of Capacity – No Intervention

The resale case is denoted by the subscript *R*. Solving the last stage, for any given level of wholesale capacity and ex-ante (1st stage) investments, profit functions can be written as

$$\begin{aligned}\pi_{1,R} &= p_R \cdot (q_{1E} + q_{1P,R}) + q_w \cdot r - c_1(q_{1E} + q_{1P,R} + q_w) \\ \pi_{2,R} &= p_R \cdot (q_w + q_{2E} + q_{2P,R}) - q_w \cdot r - c_2 \cdot (q_{2E} + q_{2P,R})\end{aligned} \tag{5.1}$$

and the Nash equilibrium with respect to ex-post (3rd stage) investments is[7]

$$q_{1P,R} = \frac{a - 2c_1 + c_2}{3b} - q_{1E} \text{ and } q_{2P,R} = \frac{a + c_1 - 2c_2}{3b} - (q_w + q_{2E}) \tag{5.2}$$

The equilibrium quantities are in a direct inverse relation to the ex-ante investments. The duplication of the investment game therefore has no strategic effect in this subgame and the total quantity produced is independent of the timing of the investments

$$q_{total,R} = \frac{2a - c_1 - c_2}{3b} \tag{5.3}$$

This quantity is equal to the quantity produced in the benchmark case. The resulting price is therefore the same and the profits are given by

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[7] It is assumed that $a > 2 \cdot c_2 - c_1$, this means that the second operator would participate in a market without capacity resale. Furthermore the second operator may not produce more ex-ante capacity than he would in the benchmark case: $q_{2E} \leq \dfrac{a + c_1 - 2 \cdot c_2}{3 \cdot b}$.

$$\pi_{1,R} = \frac{(a+c_2)^2 + 4\cdot c_1(c_1 - a - c_2)}{9b} + (r - c_1)q_w$$
$$\pi_{2,R} = \frac{(a-2c_2)^2 + c_1(2a + c_1 - 4c_2)}{9b} + (c_2 - r)q_w \qquad (5.4)$$

The efficiency gain sharing can nicely be seen from the above profit equations. For a given total capacity and as long as the wholesale price is above the costs of production, the first operator's profits increase with the wholesale capacity. Analogously the second operator is interested in substituting self-produced capacity by wholesale capacity, when the wholesale price is below his costs of production.

Without intervention the solution provided is similar to the benchmark case, with the only difference that production is now shifted from the inefficient operator 2 to the efficient operator 1.

5.2 Operator 1 intervenes

Now it will be assumed that the first operator exercises his intervention option (denoted by the subscript *I*), after the ex-ante capacity and the wholesale capacity have been produced. In the preceding case, the distinction between ex-ante (1st stage) and ex-post (3rd stage) investments was irrelevant. The first operator can now use this degree of freedom to choose his ex-ante capacity in such a way that he maximises his profits in the case of intervention. This does not reduce the generality, as long as the operators 1 ex-ante capacity is below the equilibrium capacity in the non-intervention case. Furthermore it is assumed, that the wholesale capacity that had been ordered by the second operator is irreversible in the second investment round. The profit functions can now be written as:

$$\pi_{1,I} = p_I \cdot (q_{1E} + q_{1P,I} + q_w) - c_1(q_{1E} + q_{1P,I} + q_w)$$
$$\pi_{2,I} = p_I \cdot (q_{2E} + q_{2P,I}) - c_2 \cdot (q_{2E} + q_{2P,I}) \qquad (5.5)$$

The first operator can anticipate the second operators reaction function from the final investment subgame

$$q_{2,I} = \frac{a - c_2}{2b} - \frac{q_{1E} + q_{1P,I} + q_w}{2} - q_{2E} \qquad (5.6)$$

and use this information to choose the profit maximising capacity in the first round of investments. This gives a first mover advantage to the first operator, because although the ex-post and ex-ante capacity decision have the same impact on operators 2 capacity investment choice, building up capacity in the first investment round creates a credible commitment. Now the profit maximising capacity investment on the first stage can be calculated

$$q_{1,E} = \frac{a - 2c_1 + c_2}{2b} - (q_w + q_{1P,I}) \tag{5.7}$$

Given these optimal reaction functions, the market equilibrium is revealed. The second operator builds

$$q_{2,I} = \frac{a + 2c_1 - 3c_2}{4b} - q_{2E} \tag{5.8}$$

and operators 1 total capacity is

$$q_{1total,I} = q_{1E} + q_{1P,I} + q_w = \frac{a - 2c_1 + c_2}{2b} \tag{5.9}$$

The total capacity is higher than in the preceding cases

$$q_{total,I} = \frac{3a - 2c_1 + c_2}{4b} \tag{5.10}$$

The profits are given by

$$\pi_{1,I} = \frac{(a - 2c_1 + c_2)^2}{8b} \text{ and } \pi_{2,I} = \frac{(a + 2c_1 - 3c_2)^2}{16b} \tag{5.11}$$

This solution corresponds to a Stackelberg-Leader and Stackelberg-Follower competition. The first operator, knowing the second operators wholesale capacity order, chooses his ex-ante capacity in such a way that the sum of these two capacities corresponds to the amount that would be produced by a Stackelberg leader. Because the first operators capacity is produced before the second operator can build his ex-post capacity, the second operator can only maximise his profits given the residual demand and take the followers position.

5.3 Operators 2 optimal choice of wholesale capacity

It has been shown in chapter 5.1 that the second operator can enhance his profits by substituting own network capacity by wholesale capacity as long as the price r is below his costs c_2. The first operators incentives are not directly visible, but the idea can deducted from the profit functions. Considering the non-intervention case q_w has two effects. On the one hand it increases the first operator's profits, through additional income from capacity resale, but on the other hand, it lowers the price through the increase in second operator's quantity.

The second operator's profits are strictly increasing in q_w, given that the first operator does not intervene. He will therefore choose the optimal level of q_w in such a way that operator 1 is just indifferent between intervention and non-intervention. This quantity is then given by

$$q_{w,indiff} = \frac{(a-2c_1+c_2)^2}{72 \cdot b \cdot (r-c_1)} \tag{5.12}$$

This implicit voluntarily reduction of capacity by the second operator creates the previously mentioned premium (Klein et al.) for the property rights holder for not exercising his outside option. Substituting the indifference quantity into the second investment game and solving the Nash equilibrium again reveals that the total quantities of the operators correspond to the pure oligopoly case with simultaneous investments.

$$\begin{aligned} q_{1E} + q_{1P,R} &= \frac{a-2c_1+c_2}{3b} \\ q_{2E} + q_{2P,R} + q_w &= \frac{a-2c_2+c_1}{3b} \end{aligned} \tag{5.13}$$

This result is quite intuitive. As long as the quantity of wholesale capacity is below the second operators pure oligopoly amount, this operator will increase his capacity at the same marginal costs as in the pure oligopoly case. The same applies to the first operator. The case that q_w was very small, so that his optimal ex-ante capacity exceeded the Cournot outcome is unrealistic, because in that case the operator would probably be better off, exercising the intervention option and taking the Stackelberg leader position. Despite that, operator 1 could simply lower the wholesale price *r* and while profits would not change, the wholesale quantity would increase and his optimal ex-ante investments would decrease.

6 *Welfare Analysis and Conclusions*

It can now easily be shown that that the profits with capacity wholesale are higher than in the pure-oligopoly benchmark case. Both operators offer the same quantities as in the case without any wholesale, but a part of the inefficient production is shifted to the more efficient operator 1, thus producer surplus must increase. This profit gain is shared among the two operators. Given the solution for the optimal wholesale capacity, profits are

$$\pi_{1,R} = \frac{(a-2c_1+c_2)^2}{8\cdot b}$$
$$\pi_{2,R} = \frac{1}{9\cdot b}\left((a+c_1)^2 - 4(a\cdot c_2 - c_1c_2 + c_2^2) + \frac{(c_2-r)(a-2c_1+c_2)^2}{8(r-c_1)}\right) \tag{6.1}$$

Operator 1 always has higher profits with capacity wholesale than in the competition case, because he receives at least the payoffs from the intervention option where he holds the first mover advantage. The second operators profits are higher than in the non-resale case, as long as $\frac{(a-2c_1+c_2)^2\cdot(c_2-r)}{c_1-r} < 0$. Given the assumption $c_1 < r < c_2$ this is always true.

The wholesale price *r* can be chosen in the interval between the two costs of capacity production. This irrelevance of the wholesale-price within the given interval is in line with Reys view of retail and wholesale markets. His conclusion from the analysis of resale markets is “[a] simple wholesale price fails to ensure good coordination between the manufacturer and his distributor(s); various vertical restraints can then be combined to enhance this coordination.”(Rey, 2003:254). The importance of vertical restraints has been demonstrated by using an option to intervene. It is this option that created the incentives for both parties to cooperate, because without this option no uniform wholesale tariff exists that would be compatible with both parties participation constraint.

The interpretation of this outcome depends on the timing context. From a static point of view, the result is a Pareto improvement in welfare. Consumers do not bear higher costs, while producer surplus is increased. This is in line with T-Mobiles and O2s argumentation, that national roaming is needed due to the high license costs and potential costs savings through national roaming. But this interpretation lacks the role of property rights. As long as there is a possibility for the network owner to cancel the wholesale agreement and withdraw the usage rights from the second operator, the second operator might restrain from capacity extension. This could for example be the case, when the second operator becomes more efficient, after ex-ante capacity has been produced. Clearly, the second operator could increase his capacity, but in that case, he would have to fear that the first operator might use the wholesale capacity himself by exercising his option. Total capacity would surely increase, but the second operators profits could possibly be lower, because he would have to adapt to the first operators already sunk capacity investments.

The aim of this model was to introduce some economic theory into the discussion, whether capacity resale between network operators should be allowed or not. It has been shown that the disputed resale restriction might serve as a strategic instrument. Furthermore the results show that competition policy should be aware of property rights. In this case, although the model timing would have suggested a capacity extension similar to Stackelberg models, the option to withdraw the usage rights enabled the operators to keep the output at the levels predicted by the Cournot competition.

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