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# Downstream market structure and the incentive for innovation in telecommunication infrastructure

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## Abstract

This paper addresses the question of how the competitive situation in the downstream market, the services, and the innovative activity in the upstream market, the network infrastructure, interact. The focus is on the vertical structure of the telecommunication market, which is analysed in the framework of a patent licensing model. The paper considers an integrated network provider who can implement a new technology for the network which reduces the costs of offering services over the network. This provider can charge a mark-up above the new lower cost level from the service providers for the use of the new technology. The level of the mark-up is determined by a regulator who aims at promoting innovation. It can be shown that the network provider's incentive to innovate increases with the number of competitors, given that the mark-up is sufficiently high. Hence, there exists a range for the mark-up where increasing competition in the service market and more innovative investment in the network infrastructure can be achieved simultaneously.


JEL Code: L96, O31, L42, L24, L51.
Keywords: Telecommunication, innovation, vertical structure, licensing, regulation.

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## 1. Introduction

The liberalization of the European telecommunication markets has led to a strong increase in competition in the sector. New firms have been allowed access to the incumbent's network infrastructure, so today a variety of firms are offering telecommunication services using the same underlying network infrastructure. This has caused a change in the structure of the market. Whereas, before the liberalisation, the sector was typically characterized by one large integrated firm that offered telephony service via its own infrastructure, today the market is vertically separated: the downstream market, the services, which are offered by many different companies and the upstream market, the network infrastructure, which is provided by one or only very few firms as an input for the services.

The separation between infrastructure and services is reinforced by the ongoing transition from the classic Public Switched Telecom Network (PSTN) to the packet-based Next Generation Network (NGN), which causes a fundamental change in the architecture of telecommunication networks. By using one common protocol (IP) different media, services and applications can use the same infrastructure. Thus, the transition to the IP-based NGN allows the provision of service related functions independently of the technology of the underlying transport function, which further promotes the vertical separation of the two functions (cf. ITU 2004).

The development and implementation of this new technology for the communications networks has raised the question whether it should, like the classic PSTN, be subject to regulation. The focus of the discussion is whether competition drives or hinders innovation and investments in new technologies. On the one hand it is argued that new infrastructure investments need to be regulated, i.e. access should be granted to competitors, in order to stop the investing network provider from gaining again a dominant position and to prevent a concentration of market power in the telecommunications sector. On the other hand it is claimed that investors need to be guaranteed pioneer rents in order to create incentives to invest in the first place, therefore new investments should not be regulated.

These arguments usually only consider cases where innovation and competition take place in the same layer of the market, i.e. they only consider horizontal relations and hardly ever distinguish between horizontal and vertical relations. But another important point is what influence an increase in competition has on the incentive to innovate in another layer of the market. Here, this paper adds to the discussion by analyzing the vertical relationship between network and services and its implications for innovative activities, most especially the effect of an increase in competition in the downstream service market on the innovative activity in the network infrastructure is to be considered. Such an increase may result from different developments. The liberalisation process in the telecommunications industry has allowed new firms to enter the market simply by creating the legal prerequisites for market entry. Today one observes a transformation process towards the IP-based NGN and alongside this a convergence process of different media. New services are offered and formerly separately offered services are now using the same network, thereby increasing competition on one given network.

Although the two layers of the telecommunications sector are becoming more and more independent of each other a connection between the downstream market, the services, and the upstream market, the network infrastructure still exists, since the latter can be regarded as an input for the first. A network provider's incentive to innovate depends on the additional profit it can realise through the innovation, which again depends on the market structure in the downstream market. Thus an interaction between the competitive situation in the downstream market and the innovative activities in the upstream market exists.

This paper addresses the question of how the competitive situation in the downstream market and the innovative activity in the upstream market interact. Moreover, it analyses how a regulatory intervention would affect competition and innovative activity within this vertical structure. This is done in the framework of a patent licensing model. The similarity between the situation of a patent holder and a network provider which has implemented a new technology in its network infrastructure is clear-cut:

The market structure in the telecommunication sector is characterized by few integrated firms, that provide both the network infrastructure and operate in the service market, and many service providers that offer only services. The integrated firm sells the right to use its network infrastructure to the service providers which then offer telecommunication services over the network. If a network provider innovates, for example if it implements a new, cost reducing technology for its network, it can license the use of this new technology to the service providers.

Similarly, the patent licensing literature looks at a patent holder that can sell licenses for the use of its new technology to other firms who then use the technology as an input in their own production process. The patent licensing models focus on the analyses of different licensing mechanisms, that can be used by a patent holder to license its new technology. These mechanisms are then compared with respect to the revenue they generate. For an integrated patent holder the royalty mechanism is found to be optimal. This mechanism also represents the structure of the telecommunication market best. Therefore, it is taken here and analysed with regard to both the innovation potential in the upstream market and the market structure in the downstream market.

The patent holder and the network provider are therefore in a similar situation: both have a new technology, though one is protected by a patent, while the other one by prohibitively high investment costs. Both technologies reduce the production costs of the downstream firms. In order to use the insight of the patent licensing models for the analysis of the telecommunications sector this paper considers an integrated network provider, who developed a new technology. This network provider corresponds to the patent holder in the patent licensing models. The technology can be employed in the network infrastructure and reduces the cost of providing services over the network for the network provider as well as for the service providers. The service providers correspond to the licensees in the patent licensing models, since they use the network as an input to offer services in the way the licensees use the patented technology as an input for their production process. In addition to the actual costs, the network provider can demand a mark-up above the new, lower cost level from the service providers for the use of the new technology. This mark-up corresponds to the licensing fee in the patent licensing literature. As stated above, here a patent is not needed because of the prohibitively high investment costs of copying the infrastructure investment.

In the patent licensing models the patent holding firm sets the level of the licensing fee. In order to adapt the model to the telecommunications sector a regulator is introduced that can restrict the level of the mark-up. The primary aim of this regulator is to promote innovation, i.e. the adoption of new technologies. The relevant extension of the patent licensing models is to analyse how the incumbent's additional profit after the innovation is influenced by the market structure in the service market and how a regulatory intervention affects the outcome.

The assumption that the regulator aims at promoting innovation mirrors the objectives of policy makers, for example in the EU. The European Commission regards innovation in ICT and investment in high speed networks as a crucial prerequisite for the development of Europe's competitiveness. Therefore the encouragement of innovation and investment in ICT is defined as an important goal in the current reform of the EU telecoms rules (European Commission 2007). Hence, the way the regulator is viewed in the model, as a regulator aiming at the creation of a modern telecommunications infrastructure, is closely in line with the current European policy.

The structure of the model is a three stage game. In the first stage the network provider decides whether or not to invest in the new technology. This investment causes fixed costs but allows production with a lower cost level afterwards. In stage two an external regulator determines the level of the access charge, in contrast to the patent licensing models where the fee is determined endogenously and the patent holder can realise the complete rent. In stage three the integrated network provider and the service providers compete in quantities in the service market.

It can be shown that the network provider's profit increases in the number of competitors if the mark-up is sufficiently high. The effect persists even if the mark-up is set at a lower level than the one the network provider would choose if he was to freely set the level which is realised in the patent licensing models. The intuition of this result is that the network provider's profit consists of two parts: the Cournot profit in the service market and the mark-up revenue. While the Cournot profit is higher the less competitive the market, the mark-up revenue is maximized under perfect competition; in this way the double marginalization problem is avoided. If the mark-up is set sufficiently high by the regulator, the revenue from the mark-up outweighs the reduction of the Cournot profit and more competition increases the network provider's profit. Hence, a range of the mark-up exists in which more competition in the downstream service market and innovative investment in the network infrastructure can be achieved simultaneously.

By applying a patent licensing model to the telecommunication sector, this paper adds two aspects to the existing literature. Firstly, it considers the costs a potential innovator has to incur to implement a new technology. Secondly, it drops the assumption that the innovator can freely chose the level of the license fee (mark-up), this fee is set by an exogenous agent.

The remainder of the paper is organized as follows. An overview of the related literature is given in section 2. Section 3 introduces the model and analyzes its equilibrium outcome. Section 4 contains a summary and draws some conclusions.

## 2. Related literature

The first publications in the area of patent licensing are from the 1980s (Katz and Shapiro 1985, 1986, Kamien und Tauman 1986)[1]. They analyse different licensing mechanisms a patent holder can employ to sell licenses for the use of its new, cost reducing innovation with regard to the profit they generate. Two main mechanisms can be distinguished: the fixed fee- and the royalty-mechanism. When the fixed fee-mechanism is applied the licensee pays a single, once off fixed fee for the use of the technology, independent of the amount of output produced. With the royalty-mechanism, in contrast, the licensee pays a fee per output unit produced with the new technology.

Kamien and Tauman (1986) compare the fixed fee licensing mechanism to the royalty licensing mechanism and come to the result that the fixed fee mechanism generates a higher profit for the patent holder, as well as leads to a higher consumer surplus than the royalty mechanism. However, this result is derived under the assumption that the patent holder does not produce anything himself but only licenses the new production technology. So, if the innovator is not vertically integrated the theoretical model concludes that the fixed fee mechanism generates a higher profit for the innovator than the royalty mechanism. However, empirically there is strong evidence that the royalty mechanism is more frequently employed than the fixed fee mechanism (Rostoker 1983).

One explanation of this phenomenon is uncertainty about the development of the market and the demand. This makes it difficult to determine the adequate level of the fixed upfront fee and therefore makes firms reluctant to opt for the fixed fee mechanism. In recent contributions this contradiction between theoretical and empirical results could also be dissolved theoretically. The crucial aspect is that the results are reversed for the case when the innovator is an integrated firm. Wang (1998) showed that if the innovator is also a producer in the downstream market it is indeed optimal for him to use the royalty mechanism to license his

[1] For an excellent survey of the patent licensing literature see Kamien (1992).

cost reducing innovation. The reason for this inversed result is that the patent holder's profit consists of two parts: the licensing revenue and the Cournot profit from its own production in the downstream market. The royalty licensing mechanism gives the patent holder a relative cost advantage over his competitors. This weakens competition in the downstream market and thereby increases the Cournot profit. Kamien und Tauman (2002) extended the duopoly case considered by Wang to an oligopoly with n firms.

Following in Kamien und Tauman's footsteps, this paper is an extension to their model, to represent the structure of the telecommunication market and to analyse the influence of its structure on innovation. However, only the case of royalty licensing is considered since this represents the telecommunications sector best. Usage fees for network infrastructure are typically fees per amount of capacity used and therefore rather per unit, i.e. royalty, fees.

## 3. The Model

### 3.1. Structure

Following Kamien and Tauman (2002), the analyzed model is characterized by an innovator who licenses his new technology via a royalty scheme, i.e. the licensees pay a fee per unit produced with the new technology. The structure of this model is well suited to represent the structure of the telecommunications market, in which service providers use the network to offer their services and pay the network provider for the amount of capacity they use. The cost structure only has to be adapted slightly, i.e. the traditional production costs from the patent licensing models are, here, in the case of the telecommunications market, usage fees for the input network infrastructure. The patent holder, from the patent licensing models, corresponds to a network provider which has developed a new technology for its network. The network provider has the possibility to implement the new technology which reduces the costs of providing services over the network. The licensees correspond to the service providers. They use the network to offer the services, like the licensees use the patented technology as an input for their production process. The implementation of the new technology leads to lower costs of providing services but the network provider can charge a mark-up in addition to the new lower cost level. This mark-up corresponds to the licensing fee. In contrast to the patent licensing models, where the patent holder sets the level of the licence fee, here, to adopt the model to the telecommunications sector, a regulator is introduced that can restrict the level of the mark-up. This regulator primarily aims at promoting innovation i.e. setting the mark-up in order to create incentives for the network provider to invest in new technologies. The regulator's secondary aim is to create competition in the service market and thereby reduce prices and increase consumer welfare.

Overall the market consists of n+1 firms. The firms 1, 2, …, n are the service providers who only offer telecommunication services in the downstream market. They do not have their own network but use the network provider's network. Firm n+1 is the integrated network provider that provides the network infrastructure, which is used by itself and by the service providers as an input for the services. But the integrated network provider also offers services in the downstream market so it competes in quantities with the n service providers in the downstream service market. To produce one unit of the downstream good services, one unit of the upstream good network capacity is needed. Each unit of network capacity causes costs $c_1$, so all n+1 firms produce with the same cost structure, i.e. with constant production costs $c_1$. Initially these costs arise for the network provider, but it can claim back these costs from the service providers for using its network.[2] So, effectively, each firms has to bear costs $c_1$ per unit offered in the downstream service market. Therefore before a cost reducing innovation takes place the downstream market is characterized by a classic Cournot situation with n agents and cost level $c_1$.

The network provider has the opportunity to invest in a new technology, that reduces the production costs to $c_2$. However, to carry out this investment it has to incur fixed investment

[2] It is assumed that a cost based regulation of the old technology is in place. Therefore the service providers have access to the technology at costs $c_1$.

costs I. Such an investment would be the setting up of new, more efficient servers and switches that need less space, energy and maintenance. Also the investments cost can be interpreted as R&D costs for the improvement of the currently used network technology. The resulting profit functions for the integrated firm and the service providers will be described in detail in section 3.2.

The demand for the services is assumed to be linear, where p denotes price and Q industry output

$$Q = a - p\,. \tag{1}$$

Also, only the case of a non drastic innovation will be considered. This means the new technology is not too superior to the old one. If the firms still used the old technology they would not drop out of the market but could still compete with the innovator who uses the cheaper new technology. The analogy of this situation in the telecommunications sector is that the old network technology is not shut down but can still be used parallel to the new technology. If this was not possible, one could alternatively suppose that the service providers could switch to another network provider which still used the old technology. Technically the assumption of a non drastic innovation implies that the monopoly price after the innovation exceeds the marginal production costs before the innovation

$$p_m(c_2) = \frac{a + c_2}{2} > c_1\,. \tag{2}$$

This leads to the following condition

$$a > 2c_1 - c_2\,. \tag{3}$$

The structure of the model is a three stage game. In stage one the integrated network provider decides whether or not to invest in the new technology, i.e. whether to incur the fixed cost that allow production at a lower cost level $c_2$. In stage two the licensing decision for the new technology and the optimal level of the mark-up r is analysed. The regulator decides to warrant access to the new technology by the actual costs $c_2$ plus a mark-up r, in order to achieve the aim to promote innovation. In stage three the Cournot quantity competition in the service market between the network provider and the n service providers determines equilibrium quantities and profits. The model is solved via backward induction.

### 3.2 Stage three: quantity competition in the service market

The network provider's incentive to innovate is determined by the additional profit which can be realised via the new technology, i.e. by the difference between the profit before and after the new technology is adopted. In stage three these profits are determined. The n+1 firms engage in Cournot quantity competition, where their profits depend on demand, cost level, number of competitors and the level of the mark-up.

If the network provider chooses to implement the new technology, then this will enable the provision of services over the network incurring only the lower costs $c_2$. This cost reduction is passed on to the service providers, who then only have to pay the lower cost level $c_2$. However the regulator allows a mark-up r above the actual costs $c_2$ for the new technology so the service providers' costs sum up to $c_2$+r. This gives the profit functions of the n competing service providers $\Pi_i$ and the profit function of the network provider $\Pi_I$ as

$$\Pi_I = (a-Q)q_I - c_2 Q + (q_1 + .... + q_n)(c_2 + r)$$

$$= (a-Q)q_I - c_2 q_I + (q_1 + .... + q_n)r \tag{4}$$

$$\Pi_i = (a-Q)q_i - (c_2 + r)q_i \,. \tag{5}$$

While the service providers' profits equal their Cournot profits in the service market, the network provider's profit consists of the Cournot profit plus the revenue from the mark-up.

The industry output equals the sum of the service providers' and the network provider's output

$$Q = q_1 + q_2 + ... + q_i + ... + q_n + q_I \,. \tag{6}$$

Maximizing the profit functions gives the following equilibrium quantities

$$q_I^* = \frac{a - c_2 + nr}{n+2} \qquad q_i^* = \frac{a - c_2 - 2r}{n+2}. \tag{7}$$

The network provider's equilibrium profit using the new technology is therefore given by the following expression

$$\Pi_I^* = \underbrace{\frac{(a - c_2 + nr)^2}{(n+2)^2}}_{\text{Cournot Profit}} + \underbrace{nr\frac{(a - c_2 - 2r)}{n+2}}_{\text{Mark-up Revenue}}. \tag{8}$$

The first part of the expression is the Cournot profit from the downstream service market. Since the service providers have to pay the additional mark-up above the cost level $c_2$, the network provider has a cost advantage compared to the service providers. Therefore the equilibrium quantities are not symmetric but the network provider offers a higher quantity. The second part of the expression is the revenue that is generated through the mark-up.

To determine the network provider's incentive to innovate, the additional profit from the innovation has to be considered. Before the innovation took place, i.e. when the old network technology was used, the profit equalled the standard Cournot profit with n+1 competing firms and identical costs $c_1$ for all n+1 firms

$$\Pi_{old\ tech} = \left(\frac{a - c_1}{n+2}\right)^2. \tag{9}$$

The network provider's additional profit from the innovation is therefore given by the difference between the profit using the new technology $\Pi_I$ and the profit using the old technology $\Pi_{\text{old tech}}$.

The question of interest is, how does the network provider's incentive to innovate change if new service providers enter the market thereby increasing the competitiveness in the downstream service market. In the framework of the model this means how does the difference between the network provider's profit after and before the innovation change with the intensity of competition, represented by n, the number of competitors in the service market. To see this, the first derivative of this difference with respect to n is taken. It can be shown that this expression is positive as long as the mark up r, granted by the regulator, is above a certain cut off rate r'

$$\frac{\partial\left(\Pi_I - \Pi_{old\ tech}\right)}{\partial n} > 0 \Leftrightarrow r' > \frac{c_1 - c_2}{2}. \tag{10}$$

This means that the network provider's incentive to innovate, given by the difference of its profit with and without the new technology, increases when new service providers enter the downstream market given that the mark-up is set sufficiently high by the regulator. The cut off rate of half the cost reduction is less than the mark-up the network provider would choose, i.e. the complete cost reduction $c_1$-$c_2$, if it was to freely set the mark-up.[3] This means the regulator has some scope: He can set a lower mark-up, and thereby decrease the costs of the service providers and encourage market entry, which leads to more competition in the service market. Still, as long as the regulator sets the mark-up above r' more competition in the service market increases the network provider's profit and thereby results in the incentive to innovate.

The intuition behind this result is that the network provider's profit consists of two parts: the Cournot profit in the service market and the mark-up revenue. On the one hand the Cournot part of the integrated network provider's profit decreases, if the service market becomes more competitive. On the other hand the mark-up part increases with the number of competitors and is maximized under perfect competition, since, in this way the double marginalization problem is avoided. The more competitive the market the less price distortion takes place and therefore the smaller the externality on the upstream market (cf. Tirole 1993, Spengler 1950). If the mark-up is set sufficiently high the increase of the revenue from the mark-up outweighs

[3] For the proof that the incumbent would indeed choose r= $c_1$-$c_2$ see the appendix.

the reduction of the Cournot profit and therefore more competition increases the innovating network provider's overall profit.

It can be concluded then, that it does exist a range of the mark-up within which increasing competition in the downstream service market yields more innovative investment in the upstream network infrastructure.

*Proposition:*

*Given the regulator sets the mark-up, the integrated network provider is allowed to demand on his costs, sufficiently high, then the following holds: The integrated network provider's incentive to innovate, i.e. his incentive to implement a new, cost reducing technology in the network, increases if new service providers enter the downstream market. Hence, the regulator can achieve more competition in the downstream service market and more innovative activity in the upstream network market simultaneously.*

This result is in line with the result Kamien and Tauman (2002) find for a patent holder that is a rival in the downstream market and licenses its technology via a royalty mechanism. They conclude that for such a patent holder the incentive to innovate is maximal when the downstream market is perfectly competitive.

Yet in reality the division of the integrated firm's profit in Cournot profit and mark-up revenue may be different from the prediction of the model. The integrated network provider may put a stronger weight either on the Cournot profit or the mark-up revenue part of its profit for historical or strategic reasons.

Typically the integrated network provider used to be the monopolist before the liberalisation of the telecommunication sector took place. So, often it still has a higher market share than the Cournot model predicts, since consumers may feel a certain attachment to their telephone company, or would have switching costs for getting communication services from another service provider. Therefore, the integrated firm might have a higher Cournot profit resulting from earlier periods when it was the monopolist. In this case the incumbent would put more weight on the Cournot part of its profit. But the Cournot profit is adversely affected by increasing competition. So this case, in which the Cournot profit dominates the network provider's overall profit, leads to the result that relatively less competition in the service market is preferable in order to promote innovation.

Strategic decisions, that are taken today, may also play an important role. Integrated network providers have two strategic options. They can either concentrate on offering a wide array of different services and new products over their network or concentrate on pure data transport (cf. OECD Communication Outlook 2007 S.19). The first option implies that the main part of the overall profit is made in the downstream service market. This leads again to more emphasis on the Cournot part. If the integrated network provider specializes in data transportation, as suggested by option two, then it generates its main revenue from fees for the use of the network by service providers. In this case again the classic argument of double marginalization becomes dominant: a competitive downstream market avoids the negative externality on the upstream market. Thus, more competition increases the network providers' profit and therefore its investment activities in cost reducing technologies.

### 3.3. Stage two: Licensing of the new technology

The regulator's aim to promote innovation consists of two parts: to encourage investments in new technologies by the network provider and to encourage the use of the new technology by the service providers. In stage two it is determined whether a level of the mark-up for which both these goals can be achieved exists and if yes, what is this level.

When determining the level of the mark-up r the regulator has to consider how high he can maximally set the mark-up so that the service providers are still willing to accept the new technology. If the service providers decide to use the new technology, they only have to bear the lower costs $c_2$ but they also have to incur the mark-up r. If the service providers do not buy access to the new technology, they can still compete in the service market since they may still use the old technology, which however results in the higher cost level $c_1$.

Therefore the regulator can set the mark-up within an interval with the upper bound being at $r=(c_1-c_2)$. The complete cost reduction is the maximum the service providers are willing to pay for the new technology because this puts them in the same position as if they were producing with the old technology and therefore the high cost level $c_1$. For $r=(c_1-c_2)$ they are indifferent, whether using the old or the new technology since they effectively have to bear the same costs. So the service providers will choose to use the new technology, that allows them to reduce their production costs to $c_{2,}$ if $r\leq(c_1-c_2)$. If the regulator sets the mark-up higher than the cost reduction, $r \geq (c_1-c_2)$, none of the service providers would be willing to pay the mark-up.

The lower limit for the mark-up is at $r = (c_1-c_2)/2$. As seen above in section 3.2, at this point the network provider's incentive to innovate, dependent on the intensity of competition, changes sign. By using a lower mark-up than $r = (c_1-c_2)/2$ the regulator could not achieve both, more competition and more innovation, at the same time but more competition would reduce the incentive to innovate.

This gives the following possible interval for the regulator for the mark-up, within which an increase of the intensity of competition in the service market increases the incentive for innovation in the network infrastructure.

$$\frac{c_1 - c_2}{2} \leq r \leq c_1 - c_2 \tag{14}$$

Considering the structure of the model, one might argue that a commitment problem for the regulator exists: after the network provider has made the investment the regulator's aim to foster innovation is achieved. The argument that a higher mark-up is needed to encourage innovation is therefore no longer valid. This allows the regulator to concentrate on other aims, for example, increasing competition in the service market, thereby decreasing consumer prices. To induce the service providers to offer services at lower prices, the regulator has an incentive to reduce the mark-up, i.e. to decrease the input prices for the service providers. This strategy might also encourage new service providers to enter the market, which further increases competition in the service market. Therefore, the reason for the regulator to set a higher mark-up vanishes ex post. Since the network provider anticipates this, it would not undertake the investment in the first place.

However, this only holds in a short-term perspective. Typically the construction of a new network infrastructure with a modern architecture and technology is an evolutionary process, i.e. new components are consecutively installed in different points of the network thereby improving the network step-by-step. Hence, the decision problem as it is described in this paper occurs repeatedly throughout the development process of the new network. To keep his credibility and thereby his ability to support further technological advancement of the network in the future, the regulator has to stick to his decision about the level of the mark up.

To make sure that the network is regularly updated to the latest technological standard it has to be ensured that the innovator primarily addresses the promotion of innovation. This should be clearly defined as the main aim in the regulator's objective function. To achieve this aim the regulator needs to be able to act independently without influence by political or other interest groups. The institutional setting of ,for example, the European Central Bank (ECB), could provide a model for a similar setting in the telecommunications market. The ECB's main task is clearly defined, namely to maintain price stability in the euro area. To achieve this goal, its independence is regarded to be an essential prerequisite and is therefore laid down in the institutional framework for the European Monetary Union. A similar definition of goals and independence is also needed for a regulator in the telecommunications sector if investments in the network and the promotion of innovation are considered as the regulator's primary task.

Another interesting aspect is whether the network provider has to be forced to license its new technology or whether it would also license it voluntarily. If it does not license it to the service providers they still have the possibility to use the network of another network provider, where access is granted at $c_1$. So, even if the network provider refuses to license the new technology, it is not a monopolist in the downstream market but has to compete with the service providers who, however, have to incur the higher costs $c_1$. Therefore the network provider's profit if it invests in the new technology but does not license it is

$$\Pi_I^{NL} = \left( \frac{a + nc_1 - c_2(n+1)}{n+2} \right)^2 . \tag{15}$$

Given that the network provider were not regulated, it would then have two options: either not to license the new technology at all, or to licenses it and set its optimal mark-up $r=c_1-c_2$, the complete cost reduction. So it has to compare $\Pi_I^{NL}$ and $\Pi_I(r = c_1-c_2)$. It can be shown that licensing is, in this case, the better option, i.e. $\Pi_I(r = c_1-c_2) > \Pi_I^{NL}$.

It is also intuitively easy to see why this is the case: if the network provider can ask for a mark-up in the amount of the complete cost reduction, then the service providers effectively produce with the high cost level $c_1$ as in the case when they buy the input network capacity from another network provider. So the competitive situation is the same in both options. However, with licensing, the network provider makes an additional profit from the mark-up revenue. So as long as it is possible for the network provider to charge $r=c_1-c_2$ it will choose to license the new technology.

If the regulator sets the mark-up at a lower level, i.e. $r<c_1-c_2$, this leads to a lower revenue from the mark-up and increasing competition via lower effective cost for the service

providers. By setting $r<c_1-c_2$ the regulator redistributes profit from the network provider and increases the service providers profits as well as consumer surplus in the service market.[4]

### 3.4. Stage one: investment decision

In stage one the network provider decides whether or not to invest in the new technology. It will choose to undertake the investment only if the additional profit from this investment is larger than the fixed investment cost I

$$\Pi_I - \Pi_{old\ tech} > I. \tag{16}$$

It can be shown that the left-hand side of this inequality is positive as long as the mark-up r is set within the interval that has been determined in section 3.3., i.e. if $(c_1 - c_2)/2 \le r \le c_1 - c_2$. Whether or not the investment is profitable depends therefore on the amount of the investment cost I. It is assumed that a fixed investment cost I leads to a certain cost reduction $c_1$-$c_2$. During the modernization process of a telecommunications network many consecutive investments have to be made. Each investment decision in this process is characterised by the situation described in this paper; the model of this paper is repeated over time. However it seems reasonable that, with each iteration the same investment costs will yield a lower cost reduction. Hence, there exist a finite number of profitable investment projects. To specify the investment costs as a function of the cost reduction and to find the optimal number of investment projects could be a extension of the model.

## 4. Conclusion

This paper addresses the interdependence of the competitive situation in the downstream service market and the innovative activity in the upstream network infrastructure in the framework of a patent licensing model. The analysed market structure is characterized by one

[4] To determine the complete welfare effects also the investment decision in the upstream network market, which leads to investment cost but decreases production costs, has to be considered.

integrated firm, that provides the network infrastructure and operates in the service market, and many service providers that offer only services. The integrated firm has the possibility to invest in a new, cost reducing technology for its network. It has to warrant access to this new technology to the service providers at a price set by a regulator, who aims at promoting innovation.

It has been shown that the integrated network provider's incentive to innovate increases when new service providers enter the downstream market given that the mark-up is set sufficiently high. The intuition of this result is that the network provider's profit consists of two parts: the Cournot profit in the service market and the mark-up revenue. While the Cournot profit is higher the less competitive the market, the mark-up revenue is maximized under perfect competition. If the mark-up is set sufficiently high, the increase of the revenue from the mark-up outweighs the reduction of the Cournot profit and more competition increases the innovator's profit. And so it could be seen that for a sufficiently high mark-up more competition in the downstream market and innovative investment in the network infrastructure could be achieved simultaneously.

Overall the paper has shown that it is crucial to distinguish between horizontal and vertical relations when analyzing incentives for innovation in the telecommunications market. Often arguments on the interdependence of innovation and competition overlook that innovation and competition frequently take place in different layers of the market and focus on assumed horizontal relations. It is important to take into account what influence an increase of competition in one layer has on the incentive to innovate in another layer of the market, which has been analysed in this paper.

The current model could be extended in various ways. One straightforward extension would be to analyse different types of innovations, for example, a drastic innovation or a product innovation. A drastic innovation corresponds to the case when the old technology is no longer available to the service providers after the investment has been made, i.e. the old technology is shut down or there are no alternative network providers. One would expect the network provider to be more reluctant to license its new technology in this case because it could otherwise make monopoly profits. Another interesting innovation is a product innovation. In this case, a quality improvement allows for the provision of more and new services over the network; therefore, demand is increased. The analyses whether the results from the model considered in this paper also hold in these cases could be a next step.

In the present model, horizontal competition between different network providers, facility-based competition, has not been considered. However, facility-based competition is viewed to have the potential to be a substitute for regulation. Further research could shed light on the question, which influence facility-based competition has on the level of the mark-up, i.e. whether competition for service providers causes the network providers to set the mark-up in the absence of a regulator lower than in the monopoly case and moreover within the optimal interval derived in the model.

**Appendix**

To determine the mark-up r the incumbent would choose to maximize its profit if it was allowed to set it without restraint one has to look at how the equilibrium profit $\Pi_I$ depends on r. This gives the following optimal mark-up for the incumbent:

$$\frac{\partial \Pi_I}{\partial r} = 0 \quad \Leftrightarrow \quad r^* = \frac{a - c_2}{2} \tag{17}$$

At a lower level of r, the incumbent's profit would increase if the mark-up increased. If r gets too large the service providers would decrease their quantities and this would dominate the higher price r the incumbent receives.

However, one has to consider that because of the service providers' outside option to use the old network technology the maximum mark-up the service providers are willing to pay is the full cost reduction: $r_{max} = c_1 - c_2$.

So, the questions of interest is whether the optimal r*, which has been derived above, is within the interval of r for which the service providers are willing to pay the mark-up or whether a corner solution exists. Thus, the question is, whether r* is smaller than the full cost reduction from the new technology.

$$r^* = \frac{a - c_2}{2} \le c_1 - c_2 \quad \Leftrightarrow \quad a \le 2c_1 - c_2 \tag{18}$$

However this last inequality is the condition for a drastic innovation, which is excluded from this analysis. So for the case of a non drastic innovation this means that there is no internal solution, r* is not an equilibrium since it is too high and will not be accepted by the service providers.

$$a \ge 2c_1 - c_2 \quad \Leftrightarrow \quad r^* = \frac{a - c_2}{2} \ge c_1 - c_2 \tag{19}$$

Hence the incumbent will choose to set r equal to the cost reduction which is below its optimal r* but guarantees participation by the service providers.

**References:**

European Commission (2007), Investment: breathing new life into Europe's telecoms market, Factsheet 2007 EU Telecoms Reform No.5.

Kamien, Morton (1992), Patent Licensing, in: Auman, R.J. and S. Hart (Eds.), Handbook of Game Theory, Chapter 11, pp. 331-354.

Kamien, Morton I. und Yair Tauman (1986), Fee Versus Royalties and the Private Value of a Patent, The Quarterly Journal of Economics, Vol. 101, No. 3, pp. 471-492.

Kamien, Morton I. und Yair Tauman (2002), Patent Licensing the inside story, The Manchester School Vol. 70 No. 1, pp.7-15.

Katz, Michael L. und Carl Shapiro (1985), On the Licensing of Innovations, The RAND Journal of Economics, Vol. 16, No. 4, pp. 504-520.

Katz, Michael L. und Carl Shapiro (1986), How to License Intangible Property, The Quarterly Journal of Economics, Vol.101, No. 3, pp. 567-590.

OECD (2007), Communication Outlook, Paris.

Rostoker, M. (1983), A survey of corporate licensing, IDEA 24, pp. 59-92.

Spengler, Joseph J. (1950), Vertical Integration and Antitrust Policy, The Journal of Political Economy, Vol. 58, No. 4, pp. 347-352.

Tirole, Jean (1993), The Theory of Industrial Organization, Cambridge, Massachusetts, MIT Press.

Wang, X. Henry (1998), Fee versus royalty licensing in a Cournot duopoly model, Economics Letters 60, pp. 55–62.

ITU Study Group 13 (2005): NGN Next Generation Networks, http://www.itu.int/dms_pub/itu-t/oth/1D/0B/T1D0B0000010003PDFE.pdf .

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