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E-mail address: Klaus.Friesenbichler@wifo.ac.at
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KLAUS S. FRIESENBICHLER

Austrian Institute of Economic Research (WIFO)
A-1103 Vienna, Austria
P.O. Box 91

Tel.: +43-1-7982601-296
Fax: +43-1-7989386
Klaus.Friesenbichler@wifo.ac.at
http://www.wifo.ac.at/

ABSTRACT

Aiming at both low prices and innovation, policy makers and economists have long argued about the optimal intensity of competition. While the current discussion in telecommunication regulation points out that competition can be detrimental to innovation due to the low appropriabity of rents established economic approaches advocate competition to be conducive to innovation. This reflects the dispute in economics between Schumpeterian and neoclassical theories. Aghion et al (2005) offered reconciliation by modelling an inverted U relationship, which in this paper I test for European mobile phone providers.

Innovation is measured by a service launch indicator and R&D investments, and competition is approximated by market concentration. As markets are clearly defined, problems of market definition which usually blur concentration indices are avoided. I find robust and statistically significant support for the tested quadratic relationship for both innovation indicators. The innovation optimising Herfindahl-Hirschman laid around 5,500 between 2001 and 2003, but may however vary over time. This finding points at a conflict in the realisation of the regulatory objectives of low prices and innovation at the same time.

JEL: C13, D21, L22, L51, L96, O30

Keywords: Innovation, R&D, market concentration, inverted U, mobile telecommunication

Introduction

The relationship between innovation and competition has been subject to long and fierce debate among policy makers, lobbyists and economists. The argument has produced vast literature, including numerous static and dynamic theoretical models and empirical studies that address a potential trade-off between competition and innovation. Yet, other approaches claim that competition is a contributor to the pace of technological change.

The relationship between product market competition and innovation is also of great relevance to telecommunication policy, because competition is tightly linked to regulatory regimes and the goals of the liberalisation of the European telecom industries. Without a doubt, prices fall if regulation creates competitive structures as a market outcome. However, does competition also foster product innovation and thus contribute to consumer welfare through modern technologies? This issue gains further significance in times of technological change, such as in the transition period from 2G to 3G which this paper investigates.[1]

There is a multitude of studies about the different facets of innovation in telecommunications, which cover for instance the role of entrants (e.g. Whalley – Curwen, 2006), standards and regulation (e.g. Maeda et al, 2006), or complementary products (e.g. Palmberg – Martikainen, 2005). However, these contributions are often case studies that do not allow for more general conclusions.

Ceteris paribus, this paper looks at the interaction between innovation and intra network competition, i.e. it examines the relation between the concentration of interconnected mobile phone networks in a country with the provision of new technologies and R&D expenditures. Although the estimations presented here rest on a small dataset, the results are surprisingly robust and statistically significant. Further factors that might influence technological change are not discussed, which may include competition between networks or technologies, like for instance of mobile phone services with landline broadband, or investment incentives per se (e.g. Kotakorpi, 2006; Woroch, 2000; Alessina et al, 2002).

The rest of this paper is structured as follows: it first gives a short overview of the basic arguments of the dispute among academics and policy makers, and then describes a unifying model for the two rival schools of thought. A description of the indicators used in this work follows before I test this model with a dataset of European mobile phone providers. The presentation of the empirical results and a brief conclusion finish this paper.

[1] 2G and 3G refer to the second and third generation of mobile telephony.

How much competition does innovation need?

In 1987 the European Union launched an ambitious programme aiming to create a common European telecommunications market. The goal was to generate "self-sufficient" and "fair competition" (European Commission, 1987). Thus, the European Commission regarded competition as an instrument to generate an environment that guarantees both reasonably low prices of telecommunication services and optimum levels of innovation.

Economic models advocating competition as a means to promote innovation are typically based on innovation races, in which incumbent firms defend their market power against entrants or "technological laggards" by means of innovation. Fiercer competition is seen as a means to increase the likelihood of innovation in order to outperform the rivals. Yet, many of those models suggest that incumbents are more active in their innovation efforts, since they are on the market for a longer time span, and due to often high sunk costs, they face greater losses than entrants in the case of losing an innovation race.

However, the counteracting literature claims that competition is harmful to innovation due to a potentially insufficient appropriability of rents. This very thought is currently being raised in the debate about telecom regulation. The slack innovation (and related investment) figures of European telecom providers created a call for a time limited regulatory forbearance. This means that regulatory remedies imposed upon firms that invest into new technologies might get lifted in order to reduce innovation risks and increase ex post innovation rents. For instance, the German government considers 'regulatory holidays' for 'Deutsche Telekom' if the firm invests in modern fibre infrastructure, which could temporarily lead to a total absence of competition in the relevant market.

Notably, other countries like the US adopted a permanent regulatory forbearance strategy, which sets firms free from competition, and allows them to capture all innovation rents that are created in their networks in the manner of a (temporary) monopoly (OFCOM, 2006). Yet, this implies that levels of competition would be set ex ante by regulatory remedies, and firms decide on their innovation behaviour ex ante as well. In this paper I take a similar, yet a slightly different approach and ask about the innovation behaviour of firms in a given competitive environment.

A theoretical founding for a forbearance policy rests on early models that depict a hypothesis by Schumpeter (1943) that claims a trade off between innovation and competition. The rationale is rather intuitive: the ability to benefit from rents stemming from innovation is lower in the presence of competitors. Several authors have cast this thought into economic theory. For instance, Salop (1977) developed a product differentiation model, or Dixit – Stiglitz (1977) a monopolistic model that showed a decrease in ex-post innovation rents due to high levels of competition (Aghion – Griffith, 2005).

This discussion has triggered the emergence of extensive empirical literature about the relationship between innovation and product market competition. According to Cohen – Levin (1988), most of the early studies found a positive expected relationship between market power and innovation (R&D expenditures) in a cross-section analysis of both industries and of firms. However, one strikingly robust finding of early studies was the low contribution of market concentration to the variance in R&D intensity. This leads to the assumption that the interaction between number and size of competitors has no impact on the size of R&D expenditures.

However, with the appearance of advanced statistical tools such as panel regressions in the 1990s, a number of studies re-estimated the relationship between innovation and competition. Yet, not only sophisticated methodology, but also the availability of firm level datasets contributed to the increasingly growing literature. Other than older studies which applied only industry level indicators, these works often use measures that are specific to the firm and not to the market. This new wave of studies predominantly found increasing innovativeness with high levels of competition (Patel – Crespi, 2007)[2].

The inverted U relationship model

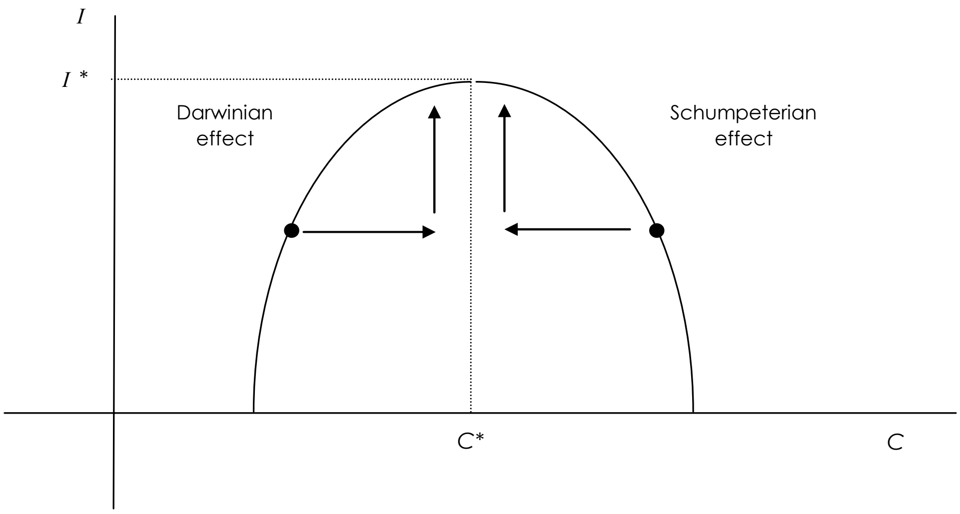
Drawing on the available theoretical and empirical evidence, Aghion et al (2005) model the relationship between innovation and competition as an inverted U. Thus, they offered reconciliation between the Schumpeterian and the neoclassical perception of competition. The model depicts the neoclassical escape competition effect that counteracts the effect of the Schumpeterian hypothesis by means of pre- and post-innovation rents. An increase in competition lowers the pre innovation profits, and creates an incentive to innovate in order to achieve ex-post innovation rents that are higher than the payoffs before innovating. However, if competition becomes too fierce and all competitors have incentives to innovate, post innovation rents fall. If this decrease becomes sufficiently large, the Schumpeterian effect of competition begins to dominate the neoclassical "escape-competition" effect (Tingvall – Poldahl, 2005).

The dynamic model pays tribute to the endogeneity of competition and technological capabilities: when firms are technologically at a similar level, competition is fierce, because they offer homogenous products. Ex post innovation rents are high because innovation allows a firm to technologically overtake its rivals and thus the company obtains a competitive advantage. However, returns are even lower if innovations are not implemented. Here, competition increases the incremental profit of an innovating firm that attempts to outperform its rivals. Furthermore, if a firm improves its technology and eventually "overtakes" the non-innovative firm, an increase in competition is innovation enhancing, because an innovation induced reduction in competition would also reduce the innovation costs and thus increase static rents. Once a firm technologically "leapfrogged" its rivals, competition becomes 'unlevelled', i.e. a technological gap between the firms becomes evident. Now, the laggards' incentives to innovate decrease with fiercer competition, as their post innovation rents are lower than in the earlier situation of less competition.

[2] See Falk (2004) or Patel – Crespi (2007) for an overview of empirical literature.

The main prediction that the model produces is that the relationship between innovation and competition is inversely U shaped (see figure 1).[3] Put differently, if one takes the counteracting Schumpeterian and the neoclassical effects together, an optimal level of competition can theoretically be derived, i.e. an intensity of competition where innovation is maximised. Although the model is rather complex and challenging to solve analytically, it is rather intuitive and straightforward. Since unfortunately no closed-form solution exists, the model can only be tested empirically (Tingvall – Poldahl, 2005).

Figure 1: Inverted U relationship of innovation and competition by Aghion et al (2005.)



Source: Aghion et al. (2005), Böheim (2004); C: competition intensity, C optimal competition intensity.*

[3] The model makes four predictions altogether. Other predictions that are not being tested here are that the higher product market competition becomes, the more different firms are in their technological capabilities in the equilibrium of the model. Thirdly, the more similar the technologies that firms operate are the steeper the inverted U-relationship because of the relatively stronger leapfrog effect, and lastly, innovation incentives are higher under financial pressure, especially at low levels of competition.

The database and the indicators

In order to test the inverted U relationship between competition and innovation in the mobile phone industry, I have constructed a comprehensive database that covers the main subsidiaries of the major European providers as well as several smaller national operators between 2001 and 2003. The data covers four variables: market concentration and market size at country level as a weighting factor on the one hand, and research and development expenditures per subscriber and a novel product innovation indicator at firm level on the other hand.

The data at country level was obtained from reports of the respective national regulatory authorities of Austria, Finland, Sweden, Norway, Italy, Belgium, Netherlands, Germany, France, UK, Ireland, the Czech Republic, Hungary, Slovenia, Croatia and Albania. Firm specific and missing country data were taken from annual reports and company presentations. The data about the service innovation were derived from four datasets: the UMTS Forum, 3G Americas, the GSM Association, and the EMC World Cellular Database. In order to smother investment and development cycles, the figures were averaged over the three year period. The following sections briefly describe the indicators used.

First, innovation was measured by R&D expenditures of firm i per subscriber (subs). The R&D figures of multinationals that are only available at parent company level were dispersed over the firm's subsidiaries according to the respective subscriber base. The variable R&D per subscriber of firm i can be described as

(1) $$R\&D_i = \tfrac{1}{t}\sum_{t=1}^{3}\frac{R\&D_{i,t}}{subs_{i,t}}$$

Yet, R&D is a mere input variable, which reflects how actively a firm attempts to improve its technology. The indicator does not necessarily tell about the product innovativeness of a firm. Given the cross sectional nature of the dataset robustness tests are necessary, because the R&D indicator might not be totally adequate due to unconsidered lagged effects of inputs to innovation. Often technologies that were created extramurally are just being implemented and turned into new products, which reflects a company's contribution to the innovation dynamics of the market. Thus, I have created an alternative innovation indicator in order to check for the robustness of the results.

Other than R&D expenditures, the service innovation indicator is output oriented. The services that act as a basis for the product innovation index are UMTS, GPRS, EDGE and MMS. All of these were introduced in the time investigated and contributed to the transition from 2G to 3G.

The index draws on the monthly lags (λ) after the first mover of each country launched the respective service (sc). Since product launch lags are a sign of not being innovative, the index

The index was normalised by putting it into relation with the value of the provider with the biggest lags. Moreover, it was deducted from one in order to reverse positive and negative effects. A different reversion of positive and negative effects by for instance inverting the variable would have distorted the values for very late innovators. Thus, this 'product catch up index' for company i (CU_i) can be described as follows:

(2) $$CU_i = 1 - \frac{\frac{1}{4}\sum_{n=1}^{4}\lambda_{i,sc}}{\max(\frac{1}{4}\sum_{n=1}^{4}\lambda_{i,sc})}$$

Despite being at firm level, the index also reflects the innovativeness of the whole industry in a country. This puts emphasis on the fact that these services were not introduced at the same time in all countries. Furthermore, the computation method gains from the cross sectional data, since it uses a catch up indicator, whereas in a panel, product launch could just be measured by a dummy variable.

The level of competition was measured by the Herfindahl-Hirschmann index (H), a measure of market concentration, which for market j is calculated as the sum of the squared market shares (s) of n providers in year t. The market shares refer to the total mobile phone subscriber numbers (SIM cards) at country level, data which was provided by the statistics of the respective regulatory authorities.

In a monopoly, the Herfindahl-Hirschmann index would be 10,000, calculated as a hundred squared. Such a high index implies the total absence of competition, whereas a low index indicates high levels of competition. Here the index also was normalised and deducted from one in order to reverse the positive and effects of the indicator. Hence, one can formally write:

(3) $$H_j = 1 - \frac{1}{t}\sum_{t=1}^{3}\frac{\sum_{i=1}^{n}s_{i,t}^2}{10,000}$$

The calculation of the Herfindahl index is often burdened by unclear market boundaries. I use the market size and market shares figures that were officially published by the national regulatory authorities. Thus, clear market definitions within fixed geographical boundaries are available, which – compared to other studies - greatly improves the quality of the Herfindahl-Hirschmann index.

Table 1: Descriptive statistics.

Variable	Observations	Mean	Standard Deviation	Minimum	Maximum
Herfindahl (H)	46	.61	.12	.22	.75
Catch Up Index (CU)	46	.62	.19	0	.99
R&D per subscriber (RD subs)	46	.76	.82	0	4.6

Source: WIFO calculations.

This leads to estimation equation 4 for the relation between the product innovation indicator and market concentration and to equation 5 for research and development expenditures per subscriber and competition.

$$(4) \qquad CU_i = \alpha + \beta_1 H + \beta_2 H^2 + MNE_i + \varepsilon_i$$

$$(5) \qquad RD\ per\ subs_i = \alpha + \beta_1 H + \beta_2 H^2 + MNE_i + \varepsilon_i$$

Methodology and regression results

Testing the inverted U relationship as predicted by Aghion et al (2005), RESET tests first suggest a nonlinear function, with no improvement of the results when a further term was added. Thus there is evidence for the suggested quadratic function. Because of the small dataset, several specifications and robustness checks were conducted in order to improve the quality of the results. Therefore, the regressions were estimated by both quantile regressions and Huber-White estimators. Furthermore, the estimations are weighted by market size in order to pay tribute to the greater importance of larger markets in the overall market dynamics of the European Union.

Both, factors specific to the market and the market structure are reflected in the regulatory environment, and a further inclusion of regulatory variables – if possible with such a small dataset – might cause an endogeneity problem. Yet, attempts to do so did not improve the results or change their robustness. Since the innovation behaviour of multinational enterprises differs to national providers, a dummy variable was used to control for these differences.

The regression results show the predicted inverted-U shaped relationship between each of the two innovation indicators and market concentration. The results are robust and also significant over all specifications, as Wald tests show. However, the goodness of fit is rather low, which indicates that there are further effects than market concentration that have an influence on innovation (Table 2). These results were remarkably robust over a number of specifications. Alternative estimations that are not presented here show the same inverted U when the multinational firm dummy was not included, or the regressions were run without weighting.

Table 2: Results of Huber-White estimators (ro) and quantile regression (qu) with the variables as described above and weighted by market size.

Independent / Dependent Variable	**RD per subs; ro**	**RD per subs; qu**	**CU; ro**	**CU; qu**
H	6.94	10.50	1.03	2.46
H²	-6.39	-10.66	-1.32	-2.80
MNE	-.96	-.44	.15	.19
P-Value	.16	0.00	.135	0.00
Sig		***		***
Wald test of H				
P-Value	0.04	0.00	0.02	0.00
Sig	**	***	**	***
Observations	43	43	46	46
(Pseudo) R²	.29	.23	.15	.22

Source: own calculations, significance stars at 99% (***) and 95% (**) levels.

The results indicate an optimal Herfindahl index of about 5000 to 5600. This rather high value reflects the structure of the respective markets at the investigated time of 2001 through 2003. However, since these results provide insight into basic underlying dynamics, they do not necessarily allow conclusions about an optimal market structure that is stable over time. Since markets are in a process of permanent change, the level of market concentration that is optimal for innovation might adjust as well, and the optimal innovation level might have moved towards a more or even a less competitive level.

Summary and conclusions

This paper investigates the relationship between innovation and competition in mobile telephony, and thus contributes to a long theoretical and empirical dispute that is also reflected in discussions on telecommunication regulation. While in the Schumpeterian tradition, competition is perceived to hamper innovation due to lower ex post innovation rents, neoclassical models suggest that competition fosters innovation since firms strive to outperform their rivals.

Aghion et al (2005) offer reconciliation by predicting this relationship to be of an inverted U shape. This means that at low levels of competition, the neoclassical effect dominates. However, with competition becoming too fierce, a Schumpeterian effect appears which increases incentives to innovate if competition slackens. Thus, the model also suggests an optimal level of competition where innovation is maximised.

This "bell shaped" relationship is then tested for a pooled dataset of European mobile phone providers in the cross section between 2001 and 2003, which was the transition period from 2G to 3G. Innovation is measured by both a novel product launch indicator as an output, and average R&D investments per subscriber as an innovation input variable.

Competition is approximated by averaged Herfindahl-Hirschman indices, and has been derived from statistics by the national regulatory authorities. Previous studies have had problems measuring competition by market concentration indices, since these were often blurred by unclear market definitions. However, as markets are clearly defined, the issue of market definition can be avoided. I find significant and robust support for the tested quadratic relationship for both innovation indicators. The Herfindahl-Hirschman index that optimises innovation lays around 5,500. Thus, the results indicate rather high levels of market concentration to be best for innovation at that time.

The finding that there is an optimal level of market concentration counteracts some of the objectives of Europe's current regulatory framework, even if optimal intensity can shift over time, and its estimation only indicates a broad range in which the optimum is found. While an increase in competition drives prices down, the optimal innovation intensity lays at a significantly higher level of market concentration. Thus, a policy that fosters merely competition, which is generally associated with low market concentration, may induce effects that work against consumer' welfare due to a suboptimal innovation performance.

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