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Quality Provision in Interrelated Markets

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Quality Provision in Interrelated Markets

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Abstract

This paper analyses the quality provision of interrelated market firms under different market structures both theoretically and empirically. A theoretical model is built, where a media firm offers newspapers in a primary market and advertising space in the secondary market. Furthermore, the media firm is assumed to choose a continuous quality level for advertisements. To test the hypotheses from the theoretical model empirically, we use data on German regional newspapers. The theoretical outcomes as well as the empirical results support the hypothesis that a monopolist provides a higher quality than a duopolist.

JEL-Classification: L10, L15, L20.

Keywords: Quality Provision, Interrelated Markets, Pricing, Market Structure.

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1 Introduction

The price of a commodity is regarded as the most important parameter in firm behaviour and competition policy. However, not only prices but other parameters play an important role for competitive processes. This is usually referred to non-price competition. Without any information about product quality prices are, however, only weak signals. Therefore, quality and the price-quality relation have been analysed in various frameworks, as an objective, measurable concept or as a subjective concept.

Moreover, there are a number of studies analysing the relationship between product quality and various other factors, such as market structure, concentration or firm structures; a further popular topic is the quality provision of multi-product firms. The aim of this chapter is to analyse the quality-price relation under different market structures in the mass media industry, both theoretically and empirically.

Mass media, such as newspapers, television, popular magazines, or the internet are primarily characterised by the interrelationship of at least two demands, the demand for the media, or more exactly, for copies, broadcasting programs or internet sites and the demand for advertising space. Since the customers of both products are not identical, media firms have to optimise prices of both products simultaneously, because of the interdependency of the (sub-)markets. And not only prices, but product quality also has to be considered by a media firm optimising profits.

Because of the distinctive feature of mass media, the first step is to build an adequate model of interrelated markets where one of the markets, here the advertising market, is determined by a steady continuum of quality levels. The

firm is assumed to set quantities in both markets and to choose a quality level for advertising. Both, a monopoly-monopoly model, where markets are assumed to be monopolistic and a monopoly-duopoly framework, where the advertising market is a Cournot duopoly, are applied to compare the results with respect to quality, quantities and prices.¹ The reason for this consideration of different market structures in reader and advertising markets, is that it has been shown that advertising markets need to be defined in a much broader context than reader markets.

To test the hypotheses from the theoretical model empirically, we use data on German regional newspapers. The advantages of these markets and products are (i) clearly defined regional markets, with (ii) mostly monopolistic or duopolistic structures and (iii) objective quality measures for the printing quality of advertisements. Therefore, it is possible to compare the quality provision of media firms under different market structures.

The organisation of the paper is as follows: first a brief overview of the literature on quality provision is presented, summarising both theoretical and empirical work on the relations of quality on the one hand and concentration or market structure on the other hand. A theoretical model is presented, considering a media firm serving an advertising and a reader market, in the next section. The fourth section analyses the quality of advertisements in German regional newspaper markets empirically, using different econometric techniques. Some summarising and concluding remarks are offered in the last section.

¹The optimisation process of a media firm that is faced with interrelated markets is similar to the problem of a multi-product firm, but actually it is not identical (see Dewenter and Kraft 2002 for a proof). Therefore, an individual modelling is necessary.

2 A review of the literature

Over the last years a number of studies have been published, on the quality-concentration or quality-price relation or other topics of vertical product differentiation. Especially quality decisions of a multi-product monopolist have become an important part of the literature referring regulatory remedies, when quality is undersupplied. However, empirical tests of under- or over-provision of quality, or of the relationship between concentration and quality are rare. Thereby, it is essential to determine actual grades of quality distortion in particular markets, before implementing regulatory sanctions.

There are different ways of considering the influence of increasing quality (see Levhari and Peles 1973): (i) increasing quality may positively affect demand for a product, (ii) it may be a perfect substitute for quantity, (iii) or it may increase the durability of the product. The well-known article by Dorfman and Steiner (1954) is an early joint consideration of price and quality setting by a monopoly firm under the assumption that quality improvement rises the demand for a specific product. The result is a definite optimisation rule for quality expenditures. A further and important implication of the simple and intuitive model is a trade off between price competition on the one hand and quality competition on the other hand.²

The literature on the relation between quality and market structure has produced ambiguous results. Schmalensee (1970), for example, finds that monopoly offers lower qualities than competitive markets. Swan (1970, 1971) instead obtains opposite results, also assuming that quality extends the durability of a product. While Swan asserts that a monopolist will supply the socially optimal

²Other examples of studies on the price-quality relation are Gabszewicz and Thisse 1979, Choi and Chin 1992, Shaked and Sutton 1982, Tirole 1988, or Waughy 1996.

quality, Chi (1999) shows that the monopolist oversupplies quality and decreases the price per unit of quality.

A first theoretical analysis of the quality behaviour of a monopolist producing non-durable goods, is carried out by Spence (1975). In his comparison of the monopolist's quality-choice and the socially optimal quality, he finds that, both over- as well as undersupply of quality by a monopolist is possible. While a monopolist chooses quality so that the consumers' marginal valuation equals her marginal cost, the socially optimal quality is, where consumers' average valuation equals marginal cost. Whether the quality will be over- or undersupplied by the monopolist, depends strongly on the particular demand functions.

Dixit (1979) analyses several strategic variables like quality, quantity and entry, and compares different oligopolistic equilibria like monopolistic competition, full collusion and collusion over entry and quantity with the social optimum. One important result is that if increasing quality rises the price elasticity of demand, all equilibria are characterised by lower welfare but higher quality levels. If increasing quality lowers the price elasticity of demand, quality levels are also lower than in the social optimum.

Mussa and Rosen (1978) develop a model of a multi-product monopolist producing a good of different qualities for consumers with different tastes, where the monopolist cannot discriminate between individual tastes. It is assumed that production costs are entirely determined by quality. As a result the monopolist will reduce quality compared with a competitive situation, but will also offer a broader variety of qualities. Moreover, the monopolist charges a higher price for the same quality than competitive firms, yet the price differentials are increasing with higher quality. Furthermore, the monopolist "may price consumers who are interested in low-quality out of the market", a situation that would not be

existent under competition.

Gal-Or (1983) develops a generalised Mussa-Rosen model and analyses the influence of the market structure on the quality levels. In an oligopoly framework she investigates the impact of increased competition. An important result of her study is that with a uniform distribution of the willingness to pay of the consumers, market entry leads to decreasing quality levels and increasing quantities. Similar results are derived by Nakao (1982) using a dynamic model of innovation. An outcome of the analysis is *“that an increase in the number of oligopolists lowers the pace of improvement in the industry’s average product quality.”*

In contrast to the results of Mussa and Rosen (1978), Kim and Kim (1996) find, that the multi-product monopolist may produce a uniform quality. The so called pooling menu exists because of a spillover effect from high-quality product development. So the learning effects from high-quality products lead to lower costs, producing other differentiated products. But if the monopolist offers a separating menu, it is also possible that she will offer a higher quality than socially optimal. The result depends strongly on the marginal cost reduction of the spillover effects. Also Acharyya (1998) shows that neither a separating menu nor quality distortions are necessarily the result of a monopolistic market.

A different area of the quality related literature is dealing with adverse selection and asymmetric information. The well known paper by Akerlof (1970) is only one, but nevertheless one of the most important, example of studying effects of asymmetric information. Not only low quality goods, but a break down of the market is predicted by Akerlof. Some other studies are dealing with the car market (e.g. Genesove 1993), the quality of schooling (e.g. Epplé and Romano 1998), or the quality of health services (e.g. Glazer and McGuire 1994).

George (1996) develops a model, where the information about quality is im-

perfect but symmetric. As a conclusion under a monopoly situation the price-quality relationship is always upward-sloping or flat. In a competitive situation, in contrast, the price-quality relation can be downward-sloping either under certain conditions. Furthermore, the monopolist always produces a better quality but charges a higher price.

Some other articles dealing with product quality focus on a different topic, namely on vertical product differentiation (e.g. Shaked and Sutton 1983, 1987). Due to a large markets size a high degree of vertical differentiation results, because of endogenously determined high fixed costs. Thus, high fixed costs is the result but not the cause of concentration. This outcome is contrary to the implications of the structure-conduct-performance paradigm or the theory of contestable markets (see Beath and Katsoulacos 1991, p. 143).

As stated above, empirical analysis of product quality in highly concentrated markets is rare, because of both the observability and/or availability of ‘high quality’ data, regarding monopolies or concentrated markets, and the problem of quality measurement.³ On the one hand, most products are not perfectly homogenous but differentiated and on the other hand, their quality can frequently only be measured in a subjective manner. In addition, if data is available and products are homogenous enough for a comparison, the market is either competitive or monopolistic, but not both.⁴

An empirical analysis on quality *provision*, for example, is carried out by

³Most studies dealing with quality are hedonic price analyses (e.g. Rosen 1974 or Nerlove 1995). The aim of these investigations is to adjust the prices by differences in quality and characteristics of the products, in order to achieve comparability. Furthermore the marginal willingness to pay for quality and or characteristics can be determined by this technique.

⁴In our case, the market for regional newspaper advertising, the product quality is measurable in a objective and non-ambiguous way because of its technical characteristics. Furthermore, the data is observable and available, as it is collected and released by the newspaper publishers themselves. Because of the geographical market delineation of local and regional newspapers one can observe monopolistic, duopolistic and oligopolistic markets. Further on one can state that the products are sufficient homogenous for comparison.

Kwoka (1992) who tests the Mussa-Rosen model of price-quality discrimination. Overall, he finds strong evidence supporting the Mussa-Rosen model. Choi, Lee and Cheng (1992), analysing the Taiwanese mobile telecommunication industry after deregulation, suggest that offering a low quality at a low price seems to be an optimal strategy. Rodrik (1988) investigates the influence of market structure on product quality of South Korean and Taiwanese exports. An important outcome is that more concentrated industry sectors provide better product qualities.

A further study by Hjort-Andersen (1988) (see also Shaw 1982 and Swann 1985) examines the agglomeration in quality space over a variety of quality components, using data on several commodities collected by the German consumer organisation “Stiftung Warentest”. The Hjort-Andersen finds strong evidence for agglomeration of quality components. Unfortunately, due to the limitation of data, nothing can be said about prices or concentration. Finally, a broad field of quality analysis is health care. Chou (2002) for example analyses the quality of nursing homes of profit and non-profit organisations under asymmetric information. A similar study by Ford and Kaserman (2000) investigates the quality of medical care in the dialyses industry. But again, quality-price and quality-concentration relationships have hardly been analysed.

3 Theoretical framework

This section models the price, quantity and quality setting of a media firm that is faced with interrelated demand. Both a monopoly-monopoly approach, where the reader and the advertising market is of monopolistic structure, and a monopoly-duopoly model, where reader markets are monopolistic but advertising market is duopolistic, are presented in the following. Hence, the results from these two approaches can be compared, to determine the differences with respect to quality

provision, quantities and prices.

3.1 Monopolistic advertising markets

The first step is to assume monopolistic structures in both markets, the reader and the advertising market. Furthermore, readers but also advertising customers are related to the respective demand from the opposite market; as readers are somehow interested in advertising and advertising customers are strongly interested in the demand for copies. The reasons for this interrelationship are the following: if readers value advertising as informative, there is a positive relation between the advertising volume and the demand for newspapers. On the other hand, if advertising is not informative from the readers' point of view, there is a negative effect to be found (for a theoretical consideration of advertising as a 'good' or a 'bad' see Becker and Murphy 1993). Only if readers are indifferent to advertising the interdependency would be not existent. Advertising customers, in contrast, have always a positive assessment on the demand for copies. The larger the 'network' in the reader market, the larger is the demand for advertising space, because of an increasing reach of advertising (and decreasing advertising rate per reader). Hence, assuming linear demand structures, the inverse demand function of the copy market can be represented as

$$P_c = a - bQ_c + dQ_a, \quad (1)$$

where P_c is the copy price, Q_c is the demand for copies and Q_a is the demand for advertising space, which is assumed to be positively related to the copy price. Hence, a positive relationship between circulation and advertising is implicitly assumed. The inverse demand function for the advertising market is

$$P_a = e - fQ_a + gQ_c + hX_a, \quad (2)$$

where P_a is the advertising rate and X_a is the continuous quality level. Thus, an improvement in advertising quality leads to a raise in demand for advertising space. Again, due to $g > 0$, a positive link between the demand for copies and the demand for advertising space is assumed. Thus, a (positive) circulation-advertising spiral is present. Furthermore, we assume that quality is observable, i.e. that advertising customers know the quality of the advertisement.⁵ The profit function of a media firm in a monopoly-monopoly framework is, therefore, given by

$$\Pi = [a - bQ_c + dQ_a - C_c] Q_c + [e - fQ_a + gQ_c + hX_a - C_a] Q_a - \frac{C_x}{2} X_a^2, \quad (3)$$

where C_c and C_a are the marginal costs with respect to copies and advertising, respectively. Additionally, $\frac{C_x}{2} X_a^2$ denominates the costs which are rising with increasing levels of quality. Hence, the costs of quality is only a function of quality, but not of circulation or advertising space. The media firm decides to provide a distinct quality level exogenously.

To maximise profits the media firm has to take into account the interdependency of the markets and the effects from variation in quality levels. The first-order conditions with respect to Q_c , Q_a and X_a are

$$\frac{\partial \Pi}{\partial Q_c} = a - 2bQ_c + (d + g)Q_a - C_c = 0, \quad (4)$$

⁵In the case of newspapers this is a realistic assumption, because the newspaper publisher announces not only advertising rate, but also information on qualities and circulation. Therefore, information is symmetric and perfect.

$$\frac{\partial \Pi}{\partial Q_a} = e + (d + g)Q_c - 2fQ_a + hX_a - C_a = 0, \quad (5)$$

and

$$\frac{\partial \Pi}{\partial X_a} = hQ_a - C_x X_a = 0. \quad (6)$$

Solving the quantities and (continuous) quality simultaneously using equations (4)–(6) yields⁶ the optimal number of copies

$$Q_c^* = \frac{(2fC_x - h^2)(a - C_c) + C_x(d + g)(e - C_a)}{C_x[4bf - (d + g)^2] - 2bh^2}, \quad (7)$$

the optimal amount of advertising space,

$$Q_a^* = C_x \frac{(d + g)(a - C_c) + 2b(e - C_a)}{C_x[4bf - (d + g)^2] - 2bh^2}, \quad (8)$$

and the optimal quality level

$$X_a^* = h \frac{(d + g)(a - C_c) + 2b(e - C_a)}{C_x[4bf - (d + g)^2] - 2bh^2}. \quad (9)$$

Interestingly, the optimal quality level and the optimal advertising space are identical except from a multiplier. Thus, the higher the costs of quality improvement (C_x) the smaller is the optimal amount of advertising space (Q_a^*).⁷ Clearly, the higher the effect from advertising quality (h), the higher is the quality level X_a^* .

The optimal copy price

⁶In order to guarantee that calculated optimal quantities and prices are indeed maxima, the second-order conditions have been analysed (see the appendix A.1).

⁷Taking the partial derivative of (8) with respect to C_x and simple algebra yields $\partial Q_a^* / \partial C_x = -2bh^2$, which is clearly negative. Increasing quality cost, therefore, results in decreased optimal advertising volumes.

$$P_c^* = \frac{C_x \{ (2bf - dg)(a + C_c) - g^2a - d^2C_c + b[(1 - g)(e - C_a)] \} - bh^2(a + C_c)}{C_x[4bf - (d + g)^2] - 2bh^2} \quad (10)$$

and, furthermore, the optimal advertising rate

$$P_a^* = \frac{C_x \{ (2bf - dg)(e + ca) - d^2e - g^2C_a + f(g - d)(a - C_c) \} - 2h^2bC_a + h^2d(a - C_c)}{C_x[4bf - (d + g)^2] - 2bh^2}, \quad (11)$$

can be derived by inserting optimal quantities into the inverse demand functions. Thus, all quantities, prices and the optimal quality level are calculated which are necessary for a comparison with the results from a monopoly-duopoly model.

3.2 Duopolistic advertising markets

Assuming a duopolistic structure in the advertising market to be present, and assuming furthermore that two completely symmetric firms compete in quantities, yields the inverse demand functions and cost function

$$\begin{aligned} P_c &= a - bQ_c + dq_{ai}, \\ P_a &= e - f(q_{ai} + q_{aj}) + gQ_c + hX_a, \quad \text{and} \\ C &= C_cQ_c + C_aq_{ai} + \frac{C_x}{2}X_a^2. \end{aligned} \quad (12)$$

Thus, the respective profit function can be determined as

$$\Pi_i = [a - bQ_c + dq_{ai} - C_c]Q_c + [e - f(q_{ai} + q_{aj}) + gQ_c + hX_a - C_a]q_{ai} - \frac{C_x}{2}X_a^2, \quad (13)$$

which is similar to the monopoly-monopoly profit function. The only difference is founded by the Cournot competition in the advertising market and by the

fact that Q_a is now divided into q_{ai} and q_{aj} . The quality level instead is still independently optimised by each firm. First order conditions with respect to Q_c , q_a and X_a are

$$\begin{aligned}\frac{\partial \Pi_i}{\partial Q_c} &= a - 2bQ_c + (d + g)Q_a - C_c = 0, \\ \frac{\partial \Pi_i}{\partial q_{ai}} &= e + (d + g)Q_c - 2fq_{ai} - fq_{aj} + hX_a - C_a = 0, \text{ and} \\ \frac{\partial \Pi_i}{\partial X_a} &= hq_{ai} - C_xX_a = 0.\end{aligned}\tag{14}$$

Using the first-order condition $\partial \Pi / \partial q_a$, leads to best response functions

$$q_{ai} = \frac{(e - C_a) + (d + g)Q_c - 2fq_{aj} + hX_a}{f}$$

and

$$q_{aj} = \frac{(e - C_a) + (d + g)Q_c - 2fq_{ai} + hX_a}{f}.$$

Combining the best response functions yields the optimal advertising space which is still depending on Q_c and X_a :

$$q_a = \frac{(e - C_a) + (d + g)Q_c + hX_a}{3f}.\tag{15}$$

Solving the quantities simultaneously using the system

$$\begin{bmatrix} -2b & d + g & 0 \\ d + g & -3f & h \\ 0 & h & -C_x \end{bmatrix} \begin{bmatrix} Q_c \\ q_a \\ X_a \end{bmatrix} = \begin{bmatrix} -(a - C_c) \\ -(e - C_a) \\ 0 \end{bmatrix},\tag{16}$$

yields the optimal quantities

$$Q_{ci}^* = \frac{(3fC_x - h^2)(a - C_c) + 2b(e - C_a)}{C_x[6bf - (d + g)^2] - 2bh^2},\tag{17}$$

$$Q_{ai}^* = C_x \frac{(d+g)(a-C_c) + 2b(e-C_a)}{C_x[6bf - (d+g)^2] - 2bh^2}, \quad (18)$$

and

$$X_{ai}^* = h \frac{(d+g)(a-C_c) + 2b(e-C_a)}{C_x[6bf - (d+g)^2] - 2bh^2}. \quad (19)$$

Again, the optimal advertising space and the optimal quality level are very similar and only distinguished by a different multiplier. Optimal prices can be correspondingly derived as

$$P_{ci}^* = \frac{C_x[(3bf - dg)(a + C_c) - g^2a - d^2C_c + b(1-g)(e - C_a)] - bh^2(a + C_c)}{C_x[6bf - (d+g)^2] - 2bh^2} \quad (20)$$

and

$$P_{ai}^* = \frac{C_x[2bf(e + 2C_a) - dg(e + C_a) - d^2e - g^2C_a + f(g - 2d)(a - C_c)] - h^2(2bC_a - dC_c)}{C_x[6bf - (d+g)^2] - 2bh^2}, \quad (21)$$

using the inverse demand functions. But even if prices seem to be similar to the monopoly-monopoly model, a clear relation is not obvious.

3.3 Comparison of qualities, quantities and prices

To analyse the different outcomes of the two models, optimal qualities, quantities and prices have to be compared. The most important comparison with respect to the scope of this paper is quality provision of a newspaper firm under different market structures. Economic intuition does not lead to a clear result, because, on the one hand, market power (on both the reader and advertising market) could

lead to reduced quality, but on the other hand, monopolistic profits could enable a quality provision on higher levels. This could particularly be more important when markets are interrelated and a higher quality level leads to increasing demand for advertising space and also to an increasing demand for copies.

Proposition 1 (i) *The advertising market duopolist provides a lower quality than a firm which is in a monopoly-monopoly situation.* (ii) *A media firm that is a monopolist in both markets, furthermore, realises a higher quality than a usual single market monopolist.*⁸

Proof: (i) Comparing the optimal quality levels from both models ($X_a^* > X_{ai}^*$) yields the inequality

$$h \frac{(d+g)(a-C_c) + 2b(e-C_a)}{C_x[4bf - (d+g)^2] - 2bh^2} > h \frac{(d+g)(a-C_c) + 2b(e-C_a)}{C_x[6bf - (d+g)^2] - 2bh^2}$$

or

$$6 > 4,$$

which is always true.

(ii) To determine the optimal quality level of a usual monopolist the profit function

$$\pi_m = (e - fQ_a + hX_a - C_a)Q_a - \frac{C_x}{2}X_a^2,$$

has to be maximised with respect to Q_a and X_a . Using the respective first-order conditions yields

$$X_M^* = \frac{h(e - C_a)}{2fC_x - h^2}.$$

⁸The quality provision in a monopoly-duopoly framework can be larger or less the quality in a standard monopoly case. See the appendix A.1.3 for a proof.

Proving $X_a^* > X_M^*$ yields

$$h \frac{(d+g)(a-C_c) + 2b(e-C_a)}{C_x[4bf - (d+g)^2] - 2bh^2} > \frac{h(e-C_a)}{2fC_x - h^2}$$

or

$$(2fC_x - h^2)(d+g)(a-C_c) + C_x(d+g)^2(e-C_a) > 0,$$

which holds for positive monopoly quantities. ■

Hence, competition on advertising markets produces a lower quality than provided by a monopolist. This effect is, apparently, founded in a lower market power of duopolists and, therefore, in lower profits from advertising markets, independently, if there is a positive or negative feedback effect from advertising to reader markets. Or more exactly: independently, if readers value advertising positively or negatively, a media firm *monopolist* always offers a higher quality.

The media market monopolist also offers a higher quality than a usual monopolist, if readers value advertising positively. If advertising is a ‘bad’ from the readers’ point of view, the quality may be lower than in a usual monopolistic market. For that purpose the (negative) valuation of advertising of the readers (d) has to be stronger than the (positive) valuation of the numbers of copies sold of the advertising customers (g).⁹

Comparing quantities one would expect reduced volumes (on the firm level) in both markets in a monopoly-duopoly framework due to the competitive situation in advertising markets.

Proposition 2 *Both quantities provided by the media firm, (i) the number of copies and (ii) the advertising volume, are less in a monopoly-duopoly framework than in a monopoly-monopoly model.*

⁹A sufficient condition that $X_a^* < X_M^*$ is that $(2fC_x)(d+g)(a-C_c) < -C_x(d+g)^2(e-C_a)$.

Proof: (i) Comparing the quantities from the reader market ($Q_c^* > Q_{ci}^*$) yields

$$\frac{(2fC_x - h^2)(a - C_c) + C_x(d + g)(e - C_a)}{C_x[4bf - (d + g)^2] - 2bh^2} > \frac{(3fC_x - h^2)(a - C_c) + 2b(e - C_a)}{C_x[6bf - (d + g)^2] - 2bh^2}$$

or

$$fC_x^2(d + g)[(d + g)(a - C_c) + 2b(e - C_a)] > 0,$$

which holds, as long as all parameters are positive and $a > C_c$ and $e > C_a$. Interestingly, if $d < 0$ and $|d| > |g|$, this relationship would be inverse. Economically: if readers dislike advertising and this effect is stronger than the positive ‘network’ effect from the copy market to the advertising market, the number of copies would be larger in a monopoly-duopoly framework. (ii) Comparing $Q_a \gtrless Q_{ai}$ yields

$$C_x \frac{(d + g)(a - C_c) + 2b(e - C_a)}{C_x[4bf - (d + g)^2] - 2bh^2} > C_x \frac{(d + g)(a - C_c) + 2b(e - C_a)}{C_x[6bf - (d + g)^2] - 2bh^2},$$

because of a larger denominator on the right hand side. ■

Thus, both quantities supplied by the newspaper firm decline, if a competitive situation in the advertising market exists.¹⁰ The advertising volume declines directly, because of the competitive situation in the advertising market, while the number of copies declines because of lower advertising volumes.

Turning to prices one would expect that competition would lead to lower prices in a monopoly-duopoly framework. But concerning the interrelationship of the markets price effects are not trivial.

Proposition 3 *The copy price is higher in monopoly-monopoly than in a monopoly-duopoly situation, if the network effect from the reader market is larger than the readers’ valuation of advertising.*

¹⁰Even if the quantities provided by a single firm are less in the monopoly-duopoly model, the market quantity is not necessarily lower. It can be easily shown that it is larger for the monopoly-duopoly case, since $C_x[2bf - (d + g)^2] - 2bh^2 > 0$.

Proof: Using the inverse demand functions comparing $P_c^* \gtrless P_{ci}^*$ yields

$$a - bQ_c^* - dQ_a^* > a - bQ_{ci}^* - dQ_{ai}^*.$$

Inserting optimal quantities and simple algebra leads to

$$g \gtrless d.$$

Thus, only if readers' valuation of advertising is stronger than a 'network' effect from reader markets, P_{ci}^* would be larger than P_c^* . ■

Hence, competition in the advertising market normally leads to a reduction of the copy price, assuming that the network effect is very important for the advertising customers, and the valuation of advertising from the readers' point of view is less important.¹¹

Proposition 4 *The advertising rate, in a monopoly-duopoly situation, may exceed the advertising rate from a monopoly-monopoly situation.*

Proof: To compare P_a^* and P_{ai}^* using the inverse demand functions yields

$$e - fQ_a^* + gQ_c^* + hX_a^* \gtrless e - fQ_{ai}^* + gQ_{ci}^* + hX_{ia}^*.$$

Simple algebraic manipulation leads to

$$P_a^* \gtrless P_{ai}^*, \text{ if } 2bh^2 \gtrless C_x(2bf - g^2 - dg),$$

which strongly depends on the magnitude of the respective parameters. ■

Therefore, especially if advertising customers value quality relative low and quality is relatively expensive, the duopolistic advertising rate may be higher than in a monopolistic advertising market.

Summarising, the effects from a competitive situation in advertising markets, lead to a lower quality provision of the advertising market duopolist. Both

¹¹It seems to be realistic to assume a strong network effect, because doubling the readership means to halve the advertising rate per reader. Therefore, an alternative modelling of the network effect would be $P_a/Q_c = \alpha - \beta Q_a + \gamma X_a$.

quantities are lower in a monopoly-duopoly situation and price effects are ambiguous. While the copy price in a monopoly-duopoly model exceeds the price in a monopoly-monopoly situation only, if readers value advertising more than advertising customer's value the size of the reader market, the comparison of the advertising rates strongly depends on the magnitude of the parameters.

4 Empirical evidence

The aim of the following section is to determine the effects of different market structures on the quality provision of firms, acting in interrelated markets empirically, and to test the predictions of the theoretical model. The German newspaper sector is particularly suitable for such a study, because of the high concentration in local and regional markets. Furthermore, there is a high number of monopolistic and duopoly markets, but only few with more than two competitors. And moreover, the number of competitors is rather decreasing than increasing at least within the last decade.¹² Thus, strong evidence for a concentration process and restricted competition can be found (see Dewenter and Kraft 2001).

Apart from highly concentrated markets there are also some further characteristics of regional newspapers which can briefly be summarised: the interactions, for example, between the regional markets are fortunately negligible, because imports and exports do not play any decisive role. Thus, the geographical market definition is unproblematic. The reader market, or more exactly, the printing process is characterised by economies of scale due to large fixed costs of the printing technology. Additionally, most of the fixed costs are sunk, consequently barriers to entry are typically present. Finally, newspaper habit is an important feature

¹²The number of German daily newspapers is identified by a steady decrease since the German reunification. But also in the ninety-seventies and the ninety-eighties the number of newspapers rather declined (see Zeitungen 2000, BDZV).

of the industry. Readers of newspapers or magazines get used to the media, thus, habit effects occur.

The quality of newspaper advertisements (independently of the printing technology, conventional or digital) depends on the quality of both the printing machines and the lithographs, measured by lines per centimetre or dots per inch. The higher the number of lines per centimetre, the higher the quality. But not each printing machine is able to handle a huge number of lines and not every digital printing machine is able to handle each resolution. The newspaper publisher, on his part, decides whether she supplies a low or a high quality level for advertisements, by choosing the printing technology and resolution. Thus, the maximum number of lines or the maximum resolution can be used as an objective measure of printing quality of the different newspapers.

Refrained of the printing technology there is a number of additional measures which determine the quality of advertising, mostly based on computer hard- and software. Especially for commercial advertising customers (usually for display instead of classified advertisements) there are some service offerings connected with purchasing advertisements. The number of graphical software programs, for example, a media firm is able to handle reprocessing the setting copies, affects the objective quality of an advertisement. Some other examples are the different kinds of data carrier which are accepted by a media firm or the number of file formats. Since such service offerings are directly connected with purchasing advertising space, they are also a determinant of quality.

Of course, from an advertising customers point of view, also the socio-demographic structure of the readership can be interpreted as product quality. Since the closer the socio-demographic structure of the readership is to the ideal of the target group, the higher is the reach of advertising and, therefore, quality. But those

variables, such as income, age distribution or the standard of education are - from the advertisers' point of view- only subjective measures and, hence, not well suited for this kind of analysis. This could rather be denominated as some kind of horizontal instead of vertical product differentiation.

4.1 Data

In the empirical study to be reported, newspaper data of 531 German cities with at least 10.000 households are considered. Thus, a sample of 709 newspaper editions belonging to 153 independent publishers of regional and local newspapers is established. Altogether, there are 367 monopolists, 302 duopolistic and 40 oligopolistic firms with more than two competitors. All data used in this analysis is extracted from the ZIS (Newspaper Information System) of the ZMG (Newspaper Marketing Society of Germany). All variables refer to the year 1999, apart from circulation which refers to 1998. This procedure is necessary, because all publishers are setting the advertising rate for about one year in advance, taking into account the actual circulation.

The most important (endogenous) variable is LPC describing the maximum number of lines per centimetre possible, for a conventional printing technology. LPC is, of course, in integer values. Furthermore, as assumed in the theoretical model, the advertising rate (P) is endogenous. To achieve a standardised measure of the advertising rate, P is calculated as the advertising rate divided by the width of the printable area of the newspapers and by circulation. Thus P is a standardised and comparable advertising rate per reader. Further endogenous variables used as measures for service offerings are PROGRAMS, describing the number of computer software programs, DATAC is the number of data carrier and FILE is the number of different file formats applied by the newspaper.

The relevant explanatory variables are measures of market size and concentration. Therefore, three dummy variables D1, D2 and D3 are used to identify monopolistic, duopolistic and oligopolistic markets. Furthermore, the Herfindahl index (HERF) is used as an alternative measure. Apart from the quality variables, there the following variables used: circulation (CIRC) and circulation to the square (CIRC2), the size of the newspaper (SIZE), the number of households (HH) within a city and a variable DDIGI which is a dummy equal to one, if digital printing technology is also available. Additionally, a dummy DRH which is equal to one, if there are restrictions on the minimum height of an advertisement and a dummy DSUPP which is equal to one, if the newspaper offers the opportunity of adding supplements (as an alternative form of advertising) are used. Finally, a variable REST, which is a dummy variable, determining the existence of issue restrictions is used. Different compositions of these variables will be used as controls (see the correlation matrix in Table 1).

Insert Table 1 about here

4.2 Results

4.2.1 Conventional Printing Techniques

Single quality equations

To analyse the influence of market structure and concentration on the quality level, provided by the newspaper firms, firstly the measures of conventional printing technologies have been analysed. Therefore, simple negative binomial models have been regressed using different control variables. All models (NBREG I-NBREG VI) describe the endogenous variable LPC representing the level of

quality. The market structure is determined by the dummies D1 and D3. Natural logarithm of the variables HH, CIRC, CIRC2, SIZE and P, and further variables: DRH, DDIGI and DSUPP, are used as controls.

Considering the first three specifications D1 and D3 are used to measure the influence of the market structure on quality (see Table 2).

Insert Table 2 about here

NBREG I as well as NBREG II support the hypothesis that monopolistic firms provide higher quality levels than duopolistic firms. The dummy variable D1 is statistically significant and positive, thus, the average number of lines per centimetre is higher than for the duopolistic control group. As expected, also the oligopolistic markets seem to have lower quality levels than monopolistic and duopolistic markets; D3 is significantly negative. The difference between the two specifications is only by adding the logarithm of circulation to the square in NBREG II.

Solely NBREG III shows no evidence for different quality levels in miscellaneous market structures. Adding the logarithm of the advertising rate leads to insignificant values of D1 and D3. But because of possible endogeneity of the advertising rates, this outcome is not very surprising.

Furthermore, the marginal effects for NBREG I – NBREG III are calculated (see the Tables B.1-B.3 in the appendix). As one can see from Table B.1, a change of the market structure from duopoly to monopoly or oligopoly lasts in a variation of the average maximum number of lines per centimetre of about seven. Interestingly, this ratio is symmetrical and holds for NBREG I and II.

Due to the simultaneous use of HH and CIRC (and CIRC2 respectively) only the logs of the number of households is significant. This outcome is not very

surprising because of the high correlation of HH and CIRC (see the correlation matrix). The dummy DRH is statistically significant and negative in each regression. Restrictions on the height of an advertisement is obviously connected with a low quantity, which is an intuitive result. Also the variable DDIGI is negatively significant, the existence of a digital printing machine is seemingly connected with a low conventional quality. The existence of supplements is insignificant and the SIZE has a negative influence on quality.

Also the second set of regressions produces similar results (see Table 3). Again, there is evidence for increasing quality with increasing concentration, regarding the first two columns (NBREG IV and NBREG V). Furthermore, the results are robust with respect to the significance of the parameters. NBREG VI as well as NBREG III do not support the outcomes of the theoretical model, presumably due to the endogeneity of P. In all regressions (NBREG I - NBREG VI), there is strong evidence for overdispersion, all α 's are significantly different from zero.¹³ The usage of the negative binomial model instead of the Poisson model is adequate.

Insert Table 3 about here

Interdependent quality and advertising rate

Next, an interdependent model will be tested, taking into account the endogeneity of advertising rates and quality levels (see Table 4). Therefore, in addition to the quality equation above, a price equation has been regressed simultaneously using 2SLS. Because of the structure of the quality variable (the lines per centimetre are in discrete values), LPC had to be transformed into logarithmic values (lnLPC).

¹³All regressions were repeated using Poisson models without any significant changes in signs or the magnitude of the parameters.

Insert Table 4 about here

To identify both equations, a variable REST has been introduced to the price equation (but not to the quality equation), measuring the influence of restrictions on the issues. Note, that circulation is not endogenous here, because it is measured in terms of 1998 instead of 1999. Furthermore, the variable SIZE is absent in the price equation, since advertising rates are already adjusted by the size of a newspaper. Regarding the quality equation, again, the hypothesis of higher quality provision by a monopoly firm is supported. Both dummies (D2 and D3) are statistically significantly negative. Also the price equation supports the findings from the theoretical model: both duopolies and oligopolies charge lower prices than monopolistic firms. Unfortunately, one outcome is a bit surprising: the advertising rate has a seemingly statistically insignificant (and negative) impact on quality. This is contra-intuitive, because higher prices are expected in monopolies and monopolies are found to provide high quality levels. Therefore, one would expect a significantly positive relation. Nevertheless, the coefficient is relatively small and the total effect could only be calculated using the reduced form parameters.

Most of the controls carry the expected sign (if significant). Both variables identifying the single equations are significantly positive and negative, respectively. CIRC and HH have negative influence on the advertising rate, which is not surprising, because circulation is already included in $\ln P$. In the quality equation both variables are insignificant.

To summarise the results from the conventional printing technique regressions, there is some evidence for both higher prices in monopolistic markets and also higher quality levels, provided by monopolistic newspaper publisher. Nega-

tive binomial models of single equations as well as the 2SLS system estimations support the theoretical outcomes.

4.2.2 Service offerings

Not only the the printing technology, but also the service offerings are adequate measures of quality levels, as mentioned above. The advertising customer's effort reduces and the processing of setting copies simplifies, due to those offerings. For this reason, an analysis of the connection between market structure and the extent of services could lead to further insights. Since all endogenous variables scheduled for this investigation are in discrete values, again, a count data problem occurs. Therefore, the variables PROGRAMS, DATAC and FILE are used to run negative binomial regression in order to determine the influence of market structure.

As one can see from Table 5, and in contrast to the conventional printing techniques regressions, all of the service regressions do not support the hypothesis that monopolies provide a higher quality level. For all endogenous variables D2 has a positive instead of the expected negative impact. Furthermore, also D3 is significant in two of three regressions and the parameters have higher magnitudes than D2. Hence, the results are consistent with the assumption that monopolies provide lower quality levels than duopolies and duopolies provide lower qualities than oligopolies. However, only the equation describing DATAC fails to produce consistent results, regarding the insignificance of D3. Moreover, also the control variables show the opposite sign, in comparison to the other regressions. Additionally, also α , determining the existence of overdispersion, is not significantly different from zero. But even re-estimating this equation using the Poisson model yields very similar results with respect to the sign, the magnitude and the

significance of the parameters, and none of the results did change significantly. Therefore, the surprising outcomes give reason to further analysis.

Insert Table 5 about here

A particular characteristic of count data, apart from the violation of equidispersion, is the occurrence of excess zeros which also lead to the overdispersion problem (see Winkelmann 1994), but in a specific manner. For service offerings the problem can be interpreted as follows. First, a zero in the, e.g. number of graphical software packages, can be interpreted as a decision by the firm, not to use this kind of service at this point of time, but perhaps others. However, it is also possible that service does not play any role in the firms' strategies at all. An adequate model to deal with excess zeros is developed by Lambert (1992). The so-called zero-inflated Poisson model (ZIP) has been advanced to zero-inflated negative binomial models (ZINB), to control for overdispersion of different kinds.

To analyse the possibility of excess zeros, zero-inflated Poisson and zero-inflated negative binomial models are used to re-estimate the latter regressions. Since ZIP or ZINB models are two-step procedures, at least two different specifications had to be built. The first step is to distinguish between zero and non-zero observations using logit (or probit) analyses. The aim is to identify variables which are able to explain the excess zero problem and to control for a correspondingly overdispersion. Therefore, the dependent variable in the first regression is coded (0,1) if the endogenous variable in the second regression is ($>0,=0$). This is the reverse specification in comparison to the usual probit or logit analysis. The second step is to run a regression on the count data which is augmented by the probabilities identifying that an observation is zero or non-zero.

To execute the second step of the ZIP/ZINB model the same specification as for the negative binomial models has been applied. To distinguish between zero and non-zero observations only three variables have been chosen. The dummies D2 and D3 are controlling for the market structure and are, therefore, added to both equations. Furthermore, CIRC has been used to control for size effects, because of the existence of scale economies. Probably, an investment in a high quality printing machine could be worthwhile only if the demand for copies is high.

Table 6 includes the results from the zero-inflated negative binomial models. In all but one of the models the hypothesis of equidispersion can be rejected, the

Insert Table 6 about here

parameter α is only insignificant different from zero for FILE. The same is true for the Vuong statistic, testing a valid use of zero-inflation models. Only the regression describing the number of file formats fails to be superior to the standard count data models. But also the other two models produce the former results. The PROGRAMS model still supports the hypothesis that monopolists provide lower quality levels than duopolies and oligopolies. The DATAC model, in contrast, only partly support this proposition. Though, D2 is significant and positive (but of low magnitude), D3 is not significantly different from zero. Altogether, there is only weak evidence for different quality levels. In the FILE equation D2 and D3 are statistically significant only at the 10% level. Overall, there is weak evidence for different number of files, programmes and data carrier in different market structures.

Even more interesting results are driven from the inflate equations regarding the number of computer software and the number of data carrier, supported by the publishers. The coefficients of both D2 and D3 are significantly different from zero and negative. It seems that even the probability to provide these kinds of services at all, is larger in duopolies and oligopolies than in monopolies.¹⁴

Moreover, also the probability of duopolies providing such services is larger than for oligopolies. Interestingly, circulation seems to have no impact on this decision. All coefficients regarding CIRC are statistically insignificant. Overall, service offerings, in contrast to the conventional printing technique, seem to be positively influenced by competitive markets structures.¹⁵

To summarise the results from the service offering regressions, there is no evidence for the hypotheses drawn from the theoretical model. Neither simple count data models, nor zero-inflation models support the assumption that monopolies provide higher quality level, i.e. higher numbers of graphical software, data carrier or file formats. Monopolies provide obviously less service offerings than duopolists or oligopolists.

5 Conclusions

In this paper, the quality provision of media firms, i.e of newspaper publishers, has been analysed theoretically and empirically. First, a simple model of interrelated markets has been built, to compare the influence of two different market structures on the quality levels of newspaper advertisements. While in a

¹⁴Remember that the endogenous variable in this stage is equal to one, if the newspaper does not offer such a service.

¹⁵All regressions were carried out by different specifications for the count data and inflate stage, furthermore, also different techniques, the Hurdle Poisson and Hurdle Negative Binomial models have been used to analyse service offerings. But none of the regressions predicted higher quality in service for monopolists.

monopoly-monopoly situation the copy prices and possibly also the advertising rates are higher than in a monopoly-duopoly situation, the media firm monopolist always provides a higher quality than the advertising market duopolist. Quantities from both markets are always lower in the monopoly-duopoly model (on the firm level). Furthermore, it is worthwhile to mention that some of the results are only valid, if the readers' valuation of advertising is positive and newspaper advertisements are informative from the readers' point of view. Consequently, some of the theoretical results depend on the fact that a circulation-advertising spiral exists.

The results from the empirical analysis support (at least partly) the theoretical findings. At least regressions of conventional printing techniques produced some evidence for higher quality levels in monopolistic markets. Using negative binomial models and 2SLS the conventional printing technique quality has been analysed. Single equation regressions as well as a test of the interdependent model of advertising rates and quality levels support our theoretical consideration. Moreover, the results are relatively stable against different specifications. Clear distinctions between the market structures have been found. And not only the results from monopolistic and duopolistic markets, but also prices and quality provision in oligopolistic markets is consistent with the theory.

The usage of information on service offerings, in contrast, provides some evidence against the theoretical outcomes. Monopolies provide less data carrier and programs than duopolists and oligopolists. Even the decision to provide these service offerings at all, is positively affected by more competitive markets. However, this decision seems to be independent of circulation. Hence, the hypotheses from the theoretical models can be rejected with the data used on service offerings. Service competition seems to be more intense in more competitive advertising

markets.

Advertising rates are high in monopolistic regional German newspaper markets and the same is true for quality levels when conventional printing techniques are considered. As well as in the model of Dorfman and Steiner a trade off between price and quality competition exists. Although, monopolistic exploitation is present in primary markets, it is not necessarily present in all (sub-)markets and with respect to all parameters (like quality, prices or service). Especially the feedback effects between reader and advertising markets, the size of the reader market and the existence of a circulation-advertising spiral are important features affecting demands, prices and qualities in interrelated markets.

Further research would be interesting considering not only conventional but also digital printing techniques, because most of the newspapers in Germany use also the digital version. Furthermore, a distinction between classified and displayed advertising would be a very interesting feature with respect to pricing and quality setting. However, data is hardly to find for such a study. But also the theoretical part could be improved using non-specific demand equation instead of linear ones to analyse the quality setting of a media firm in a more general context.

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A Mathematical appendix

A.1 Hessian matrix of the monopoly-monopoly approach

To analyse the existence of maxima instead of minima it is necessary to calculate second derivatives. The Hessian matrix of the monopoly-monopoly case can therefore be presented as:

$$\mathcal{H} = \begin{bmatrix} \partial^2 \Pi / \partial Q_c^2 & \partial^2 \Pi / \partial Q_c \partial Q_a & \partial^2 \Pi / \partial Q_c \partial X_a \\ \partial^2 \Pi / \partial Q_a \partial Q_c & \partial^2 \Pi / \partial Q_a^2 & \partial^2 \Pi / \partial Q_a \partial X_a \\ \partial^2 \Pi / \partial X_a \partial Q_c & \partial^2 \Pi / \partial X_a \partial Q_a & \partial^2 \Pi / \partial X_a^2 \end{bmatrix} = \begin{bmatrix} -2b & d+g & 0 \\ d+g & -2f & h \\ 0 & h & -C_x \end{bmatrix}.$$

The principal minors $\det(\mathcal{H}_1)$, $\det(\mathcal{H}_2)$ and $\det(\mathcal{H}_3)$ are

$$\det(\mathcal{H}_1) = \partial^2 \Pi / \partial Q_c^2 = -2b < 0,$$

which is clearly negative,

$$\det(\mathcal{H}_2) = \begin{vmatrix} \partial^2 \Pi / \partial Q_c^2 & \partial^2 \Pi / \partial Q_c \partial Q_a \\ \partial^2 \Pi / \partial Q_a \partial Q_c & \partial^2 \Pi / \partial Q_a^2 \end{vmatrix} = 4bf - (d+g)^2 > 0,$$

which is positive for positive quantities and

$$\begin{aligned} \det(\mathcal{H}_3) &= \begin{vmatrix} \partial^2 \Pi / \partial Q_c^2 & \partial^2 \Pi / \partial Q_c \partial Q_a & \partial^2 \Pi / \partial Q_c \partial X_a \\ \partial^2 \Pi / \partial Q_a \partial Q_c & \partial^2 \Pi / \partial Q_a^2 & \partial^2 \Pi / \partial Q_a \partial X_a \\ \partial^2 \Pi / \partial X_a \partial Q_c & \partial^2 \Pi / \partial X_a \partial Q_a & \partial^2 \Pi / \partial X_a^2 \end{vmatrix} \\ &= -\{C_x[4bf - (d+g)^2] - 2bh^2\} < 0, \end{aligned}$$

which is negative for positive quantities.

Thus the principal minors alternate in sign (with $\det(\mathcal{H}_1) < 0$, $\det(\mathcal{H}_2) > 0$ and $\det(\mathcal{H}_3) < 0$). Hence, the Hessian matrix is negative definite and all quantities and prices are identified as maxima.

A.2 Hessian matrix of the monopoly-duopoly approach

The Hessian matrix of the monopoly-duopoly case can be presented as:

$$\mathcal{H} = \begin{bmatrix} \partial^2 \Pi / \partial Q_c^2 & \partial^2 \Pi / \partial Q_c \partial q_a & \partial^2 \Pi / \partial Q_c \partial X_a \\ \partial^2 \Pi / \partial q_a \partial Q_c & \partial^2 \Pi / \partial q_a^2 & \partial^2 \Pi / \partial q_a \partial X_a \\ \partial^2 \Pi / \partial X_a \partial Q_c & \partial^2 \Pi / \partial X_a \partial q_a & \partial^2 \Pi / \partial X_a^2 \end{bmatrix} = \begin{bmatrix} -2b & d+g & 0 \\ d+g & -3f & h \\ 0 & h & -C_x \end{bmatrix}$$

And the principal minors are:

$$\det(\mathcal{H}_1) = -2b,$$

$$\det(\mathcal{H}_2) = 6bf - (d+g)^2,$$

and

$$\det(\mathcal{H}_3) = -\{C_x(6bf - (d+g)^2) - 2bh^2\} < 0,$$

which, again, leads to the conclusion that the principal minors alternate in signs. Hence, the Hessian matrix from the monopoly-duopoly model is negative definite and all quantities and prices are identified as maxima.

A.3 Comparison of X_{ai}^* and X_M^*

To prove $X_{ai}^* \gtrless X_M^*$ optimal quality levels from the monopoly-duopoly and the monopoly model have to be compared:

$$h \frac{(d+g)(a-C_c) + 2b(e-C_a)}{C_x[6bf - (d+g)^2] - 2bh^2} \gtrless \frac{h(e-C_a)}{2fC_x - h^2}.$$

Simple algebraic modification yields

$$\underbrace{[(d+g)^2 - 2bfC_x]}_{\gtrless 0} \underbrace{(e-C_a)}_{>0} + \underbrace{(2fC_x - h^2)(d+g)(a-C_c)}_{>0} \gtrless 0,$$

which is an ambiguous result.

B Tables

B.1 Marginal effects for negative binomial models

Table 7: Marginal effects for NBREG I

variable	dy/dx	Std. Err.	z	$P > z $
lnHH	-	-	-	-
lnCIRC	-	-	-	-
DRH*	-9.5498	1.8312	-5.22	0.000
DDIGI*	-7.4120	2.9118	-2.55	0.011
DSUPP*	.30644	3.4820	0.09	0.930
lnSIZE	-23.182	8.3279	-2.78	0.005
D1*	6.7571	1.7393	3.88	0.000
D3*	-6.7474	2.8737	-2.35	0.019

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Table 8: Marginal effects for NBREG II

variable	dy/dx	Std. Err.	z	$P > z $
lnHH	-	-	-	-
lnCIRC	-	-	-	-
lnCIRC2	-	-	-	-
DRH*	-9.5265	1.8287	-5.21	0.000
DDIGI*	-7.4415	2.9144	-2.55	0.011
DSUPP*	.37255	3.496	0.11	0.915
lnSIZE	-23.243	8.3111	-2.80	0.005
D1*	6.7181	1.7387	3.86	0.000
D3*	-6.7977	2.8932	-2.35	0.019

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Table 9: Marginal effects for NBREG II

variable	dy/dx	Std. Err.	z	$P > z $
lnHH	-	-	-	-
lnCIRC	-	-	-	-
lnCIRC2	-	-	-	-
DRH*	-15.11	2.6033	-5.81	0.000
DDIGI*	-7.1300	2.8950	-2.46	0.014
DSUPP*	.13164	3.4899	0.04	0.970
lnSIZE	-28.324	8.5628	-3.31	0.001
lnP	-5.6471	1.3460	-4.20	0.000
D1*	1.5285	1.9229	0.79	0.427
D3*	-3.698	3.0071	-1.23	0.219

(*) dy/dx is for discrete change of dummy variable from 0 to 1

Table 1: Correlation matrix

	HH	CIRC	DDIGI	SIZE	P	DRH	DSUPP	REST
HH	1							
CIRC	0.9743	1						
DDIGI	0.0403	0.0414	1					
SIZE	-0.0415	-0.0335	-0.0619	1				
P	-0.0636	-0.0840	0.0435	-0.2554	1			
DRH	-0.0359	-0.0205	-0.0217	0.2544	-0.4020	1		
DSUPP	-0.0223	-0.0219	-0.0744	0.0345	-0.0896	0.0774	1	
REST	-0.0077	-0.0129	-0.0667	0.2161	-0.0132	-0.0103	0.0449	1

Table 2: Negative binomial regressions of conventional technology I-III

LPC	NBREG I	NBREG II	NBREG III
lnHH	-0.0578 (-3.21)	-0.0606 (-3.13)	-0.0455 (-2.47)
lnCIRC	0.0750 (3.87)	0.0461 (0.60)	-0.0385 (-0.48)
lnCIRC2	-	0.0461 (0.39)	0.0034 (0.84)
DRH	-0.0690 (-5.26)	-0.0689 (-5.25)	-0.1077 (-5.98)
DDIGI	-0.0538 (-2.60)	-0.0540 (-2.61)	-0.0518 (-2.53)
DSUPP	0.0022 (0.09)	0.0027 (0.11)	0.0009 (0.04)
lnSIZE	-0.1723 (-2.79)	-0.1727 (-2.81)	-0.2106 (-3.32)
lnP	-	-	-0.0419 (-4.16)
D1	0.0500 (3.89)	0.0497 (3.87)	0.0113 (0.80)
D3	-0.0511 (-2.30)	-0.0514 (-2.30)	-0.0277 (-1.22)
Cons	5.8614 (16.00)	6.0236 (10.92)	6.2160 (11.20)
α	0.0202	0.0202	0.0192
std.err.	(0.0024)	(0.0024)	(0.0022)
Log.Likel.	-3216.12	-3216.07	-3204.02

Notes: t-Statistics are reported in brackets. Robust covariance matrices are calculated using the Huber-White-Sandwich estimator.

Table 3: Negative binomial regressions of conventional technology IV-VI

LPC	NBREG IV	NBREG V	NBREG VI
lnHH	-0.0597 (-3.26)	-0.0679 (-3.38)	-0.0446 (-2.35)
lnCIRC	0.0688 (3.52)	-0.0077 (-0.10)	-0.0539 (-0.69)
lnCIRC2	-	0.0042 (1.03)	0.0038 (0.93)
DRH	-0.0664 (-5.21)	-0.0660 (-5.20)	-0.1103 (-6.29)
DDIGI	-0.0584 (-2.80)	-0.0586 (-2.81)	-0.0545 (-2.63)
DSUPP	0.0050 (0.20)	0.0060 (0.23)	0.0025 (0.10)
lnSIZE	-0.1547 (-2.49)	-0.1565 (-2.53)	-.2086 (-3.26)
lnP	-	-	-.0468 (-4.93)
HERF	0.1032 (3.57)	0.1067 (3.62)	0.0131 (0.42)
Cons	5.7743 (15.57)	6.2064 (11.37)	6.2384 (11.28)
α	0.0207	.0207	0.0193
std.err.	(0.0025)	(0.0025)	(0.0022)
Log.Likel.	-3222.51	-3222.14	-3205.18

Notes: t-Statistics are reported in brackets. Robust covariance matrices are calculated using the Huber-White-Sandwich estimator.

Table 4: Interdependent model of conventional technology (2SLS)

	lnP	lnLPC
D2	-0.3025 (-3.79)	-0.0293 (-3.48)
D3	-0.4995 (-4.33)	-0.0272 (-2.02)
lnLPC	4.2410 (3.04)	-
lnP	-	-0.0491 (-1.26)
REST	0.4612 (3.30)	-
lnSize	-	-0.3118 (-4.98)
lnCIRC	-0.4116 (-8.91)	-0.0500 (-0.93)
lnHH	-0.3923 (-8.12)	-0.0122 (-0.52)
DSUPP	-0.4276 (-3.46)	-0.0223 (-1.35)
DRH	-0.0048 (-3.30)	0.0006 (4.56)
Const	-20.2549 (-4.14)	5.008 (22.29)
\bar{R}^2	0.37	0.10
F-Stat.	69.97	10.09

Notes: t-Statistics are reported in brackets.

Table 5: Service offerings regressions

	PROGRAMS	DATA C	FILE
D2	0.2387 (3.00)	0.1429 (3.35)	0.1499 (3.06)
D3	0.3747 (2.91)	0.0654 (1.24)	0.1998 (2.73)
lnHH	-0.2644 (-2.50)	0.0050 (0.12)	-0.0947 (-1.76)
lnCIRC	0.02260 (2.01)	-0.0260 (-0.61)	0.4260 (0.72)
DRH	-0.0021 (-1.47)	0.0020 (1.92)	-0.0002 (-0.21)
DSUPP	0.4499 (2.31)	-0.0145 (-0.29)	0.3478 (3.62)
SIZE	0.7012 (2.07)	-0.3911 (-2.19)	0.1715 (0.88)
Const	-1.8843 (-0.94)	4.2174 (4.02)	0.6044 (0.53)
α	0.6993	0.0843	0.0780
std.err.	(0.0514)	(0.1780)	(0.0157)
Log.Likel.	-2154.90	-1790.49	-1537.12

Notes: t-Statistics are reported in brackets. Robust covariance matrices are calculated using the Huber-White-Sandwich estimator.

Table 6: Zero-inflated service offerings regressions

	PROGRAMS	DATA C	FILE
Count			
D2	0.1678 (2.20)	0.0845 (2.40)	0.1051 (1.65)
D3	0.2395 (2.03)	0.0038 (0.08)	0.1577 (1.93)
lnHH	-0.3210 (-3.00)	-0.2765 (-0.71)	-0.1109 (-1.97)
lnCIRC	0.2864 (2.52)	0.0136 (0.34)	0.0634 (1.07)
DRH	-0.0018 (-1.34)	0.0027 (2.03)	0.0024 (0.21)
DSUPP	0.5403 (2.80)	0.0202 (0.42)	0.3551 (3.68)
SIZE	0.7289 (2.22)	-0.3656 (-2.28)	0.1960 (1.03)
Const	-1.9905 (-1.02)	4.0621 (4.30)	0.4556 (0.41)
Inflate			
D2	-0.6832 (-2.05)	-1.1773 (-2.46)	-17.6309 (-4.81)
D3	-1.872 (-2.03)	-1.6972 (-2.12)	-18.6723 (-20.21)
lnCIRC	0.1413 (0.82)	0.2453 (1.25)	0.4669 (1.20)
Const	-3.2544 (-2.02)	-4.7008 (-2.55)	-7.4605 (-1.77)
Vuong	4.11	4.75	1.55
Prob.	(0.0000)	(0.0000)	(0.0611)
α	0.4498	0.0258	0.0599
std.err.	(0.0365)	(0.0085)	(0.2454)
Log.Likel.	-2127.95	-1718.83	-1531.70

Notes: t-Statistics are reported in brackets. Robust covariance matrices are calculated using the Huber-White-Sandwich estimator.

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