



Price structure in two-sided markets: Evidence from the magazine industry

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Abstract

We present and estimate a model of competition in a two-sided market: the market for magazine readership and advertising. Using data on magazines in Germany, we find evidence that magazines have properties of two-sided markets. The results are consistent with the perception that prices for readers are ‘subsidized’ and that magazines make all their money from advertisers. Consistent with advertisers valuing readers more than readers value advertisements, our results imply that higher demand on the reader side increases ad rates, but that higher demand on the advertising side decreases cover prices.

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1. Introduction

Many markets where network externalities are important are, in fact, two-sided markets. Two-sided markets have the property that there are two distinct types of users, each of which wishes to interact on a common platform, and in which the structure of prices between the two sides (rather than just the total level of prices) matters.¹ Some common examples include directory services such as classifieds and Yellow Pages; matching markets such as employment websites, dating agencies; media markets such as magazines, newspapers and Internet Portals; and trading posts such as auctions, B2B markets, and shopping malls.

A key question arising in two-sided markets is how do platforms price to each type of user? Is one side of the market ‘subsidized’ in order to attract the other? [Armstrong \(2005\)](#), [Caillaud and Jullien \(2003\)](#), and [Rochet and Tirole \(2003\)](#) each provide theoretical frameworks of two-sided markets to explain how the structure of prices is determined when either a monopoly platform sets prices, or two platforms compete. This paper takes one such framework and uses it to explore magazine markets in Germany.

The framework considered is based on [Armstrong \(2005\)](#), in which there are two groups of participants, and the benefit to joining a platform depends on the number of agents from the opposite group on the same platform. Armstrong considers three basic settings: (I) a *monopoly platform*; (II) *two-sided singlehoming* where two platforms that are differentiated based on the Hotelling model compete for each group, but all users join a single platform exclusively; and (III) *competitive bottlenecks* where two platforms compete for one group of users who join a single platform exclusively, but not for the other group of users who join both platforms (multihome).

For each of these settings, we adapt Armstrong’s model to fit the magazine industry. Two-sidedness arises since advertisers value the number of readers of the magazine and readers value the number of ads in the magazine. In addition, we allow readers to value the amount of content in the magazine. A magazine chooses a cover price, an advertising price and the amount of content to produce in order to maximize its profits (in the case of competition, given the prices and content choice of the rival magazine). We derive the implied demand system for each of the models and estimate it using data on magazines from Germany. The models then provide a link between the estimated demand parameters and the *structure* of price–cost margins across readers and advertisers, as well as other variables of interest.

The parameters of the models are estimated using an unbalanced panel of nine distinct two-magazine groups in Germany during the period 1972–2003. We show how the estimated parameters can then be used to determine the size of the network effects running in each direction (how much readers value ads, and how much advertisers value readers), and how the structure of the price–cost margins and cross-market comparative static results reflect asymmetries across the two sides of the market. Although the estimation results are broadly similar across the three specifications considered, we focus on the two-sided singlehoming setting since we find strong evidence of price competition on both sides of the market (both for readers and for advertisers), since we find more users on each

¹ See [Rochet and Tirole \(2004\)](#) for a more precise definition. See also [Evans \(2003a,b\)](#).

side singlehome than multihome, and since it offers the most parsimonious specification for estimation.

There is a large existing empirical literature on media markets that allows for interrelated demands between readers and advertisers. Dewenter (2003) provides a survey. Much of this literature focuses on the newspaper industry, and is concerned with estimating the effects of concentration (Reddaway, 1963; Thompson, 1984), the existence of economies of scale (Rosse, 1967, 1970; Bucklin et al., 1989); and showing the existence of two-way network effects (Dertouzos and Trautman, 1990).² Typically, newspapers are assumed to be monopolistic with respect to the readership side. As a result, unlike this paper, the literature does not consider how the structure of prices emerges from competition between two platforms that strategically set prices to each side to take into account interrelated demands.

More recently, Rysman (2004) estimates a two-sided model of Yellow Page directories that allows for such competition. However, Yellow Pages are given free to readers. This means Rysman cannot consider the determination of the *structure* of prices with his data. Moreover, he assumes quantity setting platforms to avoid the fixed point problem that arises in a price setting game with network effects. This motivates our focus on magazines (which charge both readers and advertisers), as well as our particular model specification which allows us to study the structure of price–cost margins with estimates of the demand system alone. Compared to some other two-sided markets (for example, payment schemes), magazines also fit the assumption of the theoretical framework used in that users on each side pay to ‘join’ the platform (rather than based on transactions made between the two types of users).

The rest of the paper proceeds as follows. Section 2 presents the benchmark model of a two-sided market that we estimate. Section 3 describes the data, while Section 4 describes our empirical specification. Results and implications for this model are presented in Section 5, while Section 6 considers the alternative monopoly and competitive bottleneck models. Finally, Section 7 briefly concludes.

2. A model of magazines as a two-sided market

We adapt the generic model of two-sided singlehoming developed by Armstrong (2005, Section 4) to the magazine market. This model is one in which two platforms (in this case magazines) compete. Competition on each side of the market is modelled in a differentiated Bertrand fashion, with demands derived from a Hotelling specification. The complication is that each group values the number of users of the opposite group on the same platform. We extend this model in a straightforward way by noting magazines provide three types of services. They provide content for readers, ads which allow readers to find out about products (possibly) of interest, and an advertising outlet which provides

² There is also a sizeable empirical literature testing for network effects in one-sided market settings, including amongst others, Gandal et al. (2000) who consider the case of compact disk players, and Saloner and Shepard (1995) who consider the case of Automated Teller Machines. The issue addressed in this paper, that of the structure of prices between each side of the market, does not arise in this literature.

firms with a way to inform readers about their products. Specifically, we allow readers’ utility to also depend on the number of content pages in the magazine, and let magazine publishers choose content pages as an additional strategic variable.

Assume there are N^r readers, all of whom read one (and only one) magazine. We follow Armstrong and assume the utility to each reader of magazine i ($i=1, 2$) is a linear function, increasing in the number of pages of content N_i^c and the number of pages of ads N_i^a , and decreasing in the price per copy to readers p_i . Allowing for an unobservable component to the utility of reading magazine i , which consists of the common (across readers) fixed effect θ_i^r , a mean-zero error term ε_i^r and an individual ‘transportation cost’ $t_i(x)$ which captures the preference of an individual reader (located at x) for magazine i , the utility of reading magazine i can be written as

$$u_i = \theta_i^r + \gamma N_i^a + \psi N_i^c - \beta p_i + \varepsilon_i^r - t_i(x), \tag{1}$$

where $t_1(x)=x/2$ and $t_2(x)=(1-x)/2$.³ Assuming x is uniformly distributed between 0 and 1, gives the Hotelling specification of reader demand

$$n_1^r = \frac{1}{2} + \theta_1^r - \theta_2^r + \gamma(N_1^a - N_2^a) + \psi(N_1^c - N_2^c) - \beta(p_1 - p_2) + \varepsilon_1^r - \varepsilon_2^r \tag{2}$$

$$n_2^r = 1 - n_1^r \tag{3}$$

where $n_i^r = N_i^r / N^r$ is the share of readers of magazine i .

The advertisers’ choice of magazine is modelled in a similar fashion. Assume there are N^a advertisers, all of whom place a single advertisement in one (and only one) magazine. The profit to a firm of advertising in magazine i (denoted π_i) is assumed to be a linear function, increasing in the number of readers N_i^r , and decreasing in the fee for placing an ad a_i (the ad rate). The common unobservable component to profits of advertising in magazine i consists of the fixed effect θ_i^a and the mean-zero error term ε_i^a . An individual firm’s preference for advertising in a particular magazine is represented by a transportation cost function, which takes the same form as in the reader’s problem. Assuming a firm’s location is uniformly distributed between 0 and 1 leads to the Hotelling specification of advertiser demand

$$n_1^a = \frac{1}{2} + \theta_1^a - \theta_2^a + \rho(N_1^r - N_2^r) - \eta(a_1 - a_2) + \varepsilon_1^a - \varepsilon_2^a \tag{4}$$

$$n_2^a = 1 - n_1^a, \tag{5}$$

where $n_i^a = N_i^a / N^a$ is the share of ads in magazine i .

This model assumes firms have a preference to advertise in a particular magazine. This may capture how well the magazine’s target audience fits with the firm’s ideal

³ We have normalized the Hotelling transportation cost to one half, and allowed for different degrees of product differentiation by introducing the parameter β on prices.

target audience (assuming, for instance, a reader's choice of magazine correlates with some other variables such as income, which the advertiser cares about). Alternatively, the advertiser's choice of publisher may relate to other (non-readership) aspects, such as the location of the publisher relative to the advertising firm, the print quality of ads (glossy or ordinary paper), the lead time needed to meet the publication deadline, the possibility of a feature issue related to the firm's specific products, any cross-advertising possibilities in the publisher's other magazines, and more generally, the service level offered to the advertiser.⁴

The parameters in (2)–(5) measuring the strength of network effects in each direction are γ and ρ , while the intensity of competition (or the inverse of the extent of product differentiation) is measured by the parameters β and η . Despite the error terms ε_i , we assume these theoretical market shares lie between 0 and 1, which they will do by construction in the data.

The share Eqs. (2)–(5) assume all agents choose one of the magazines exclusively. In reality some agents will choose neither magazine and some agents will choose both (multihome). Our results still apply in this case if the reason some agents buy neither magazine (or both magazines) are exogenous to the decisions of the magazines. This is obvious for the case that some agents stay out of the market since such agents are then irrelevant to the analysis. For the case with multihoming, the appendix shows this is also true.

The profits of (the publisher of) magazine i are assumed to be

$$\Pi_i = (p_i - f_i)N_i^r + (a_i - c_i)N_i^a - d_i(N_i^c)^2 - F_i, \quad (6)$$

where f_i is the cost of printing and distributing magazine i per copy sold,⁵ c_i is the cost of 'producing' a single ad for magazine i , d_i determines the cost of 'producing' content for magazine i , and F_i is other fixed costs of operations. Variable costs that are associated with producing ads include liaising with clients on each ad. Note that content only contributes to profit to the extent it causes an increase in circulation, and indirectly ad revenue. Moreover, content is assumed to have increasing marginal costs (it is more and more expensive to get additional interesting stories and material for each issue).

Each magazine sets p_i , a_i and N_i^c to maximize its profits, given the choices of its rival. After observing the choice of these variables, readers decide which magazine to buy and advertisers decide which magazine to advertise in. Rational expectations are assumed, so readers and advertisers work out how many of each type will subscribe to each magazine using the above model when making their own decision. Provided network benefits are not explosive (which requires $4\rho\gamma N^r N^a < 1$, a condition that will be

⁴ The other extreme, in which firms have no particular preference to advertise in either magazine, leads to the competitive bottleneck model considered in Section 6.

⁵ In the case the magazines are sold via subscription, this includes the cost of postage and handling, while if the magazines are sold via kiosks, newsstands and bookstores, then this includes the payment that these retailers require. Unlike the case in the United States, in Germany most subscription prices are quite similar to those offered at the newsstands (Kaiser, 2003).

checked empirically), rational expectations imply unique demands, which are the simultaneous solutions to (2)–(5).

Solving for unique demands, substituting these into (6) for $i=1$ and 2, and taking the first order conditions, we can express the equilibrium conditions for both magazines as⁶

$$p_i - f_i = \frac{n_i^r}{\beta} - \frac{2\rho N_i^a}{\eta} \quad (7)$$

$$a_i - c_i = \frac{n_i^a}{\eta} - \frac{2\gamma N_i^r}{\beta} \quad (8)$$

$$N_i^c = \frac{\psi N_i^r}{2d_i\beta}. \quad (9)$$

Equilibrium cover prices are marked up above cost to the extent of product differentiation on the readership side, but discounted to reflect the externality generated on the advertising side of the market from a magazine attracting more readers. In equilibrium, the magazines discount cover prices to attract more readers, thereby attracting more advertisers. This effect is increasing in the extent to which advertisers value readers and in the number of firms wanting to place ads in magazine i , and is decreasing in the sensitivity of a magazine's ad demand to its ad rate (if ad demand is very sensitive to ad rates, then lowering ad rates becomes a cheaper way for magazines to generate additional advertisers rather than subsidizing readers).

Equilibrium ad rates are determined in a parallel way. They are marked up above cost to the extent of product differentiation on the advertisers' side, but are discounted to reflect the externality generated on the readership side of the market from a magazine attracting more ads. For both cover prices and ad prices, the markup above cost is higher the higher the respective equilibrium market shares reflecting the fact that if a magazine is preferred by readers or advertisers (has a positive value of $\theta_i - \theta_j$), this will cause that magazine to price higher to exploit its more 'loyal' customer base.

Finally, the equilibrium level of content is increasing in the amount readers value content and in the total number of magazine readers (since then each page of content generates more revenue), but is decreasing in the cost of producing content and in the sensitivity of magazine readers' demand to the cover price (if readers are very sensitive to cover prices, then lowering cover prices is a cheaper way for magazines to generate additional readers rather than producing additional content).

Our estimation approach is to estimate the share Eqs. (2) and (4) so as to obtain estimates of the parameters γ , ψ , β , ρ , and η . These can then be used to solve for the equilibrium price–cost margins (7) and (8), which are the expressions of central interest.

⁶ We obtain the same result more simply by totally differentiating the demand system (2)–(5) and solving for the derivatives needed in the first order conditions.

This avoids the need to estimate costs through the first order conditions, which leads to imprecise estimates of all parameters, given the interrelated nature of the two sides of the market and only limited data availability. This illustrates the value of using the linear demand specification.

3. Data

Our initial data set comprises of quarterly information on cover prices, ad prices, number of ad pages,⁷ number of content pages, and circulation numbers for German magazines that existed between the first quarter of 1972 and the fourth quarter of 2003.⁸ The original source of our data is the *Informationsgemeinschaft zur Feststellung der Verbreitung von Werbeträgern e.V.* This association ascertains, monitors and publishes information on magazine dissemination and circulation.

We annualize our quarterly data given that cover prices and ad rates do not typically change within a year. Our identification of markets with just two competing magazines ('two-magazine markets'), a prerequisite to the estimation of the two-sided singlehoming model, proceeds in two steps. First, we place each magazine into a unique magazine segment (or magazine submarket), and then check in what periods between 1972 and 2003 the respective magazine group consisted of just two competing magazines. The initial magazine grouping follows industry convention. We use the grouping by *Jahreszeitenverlag (1981–2003)*.⁹ *Jahreszeitenverlag* distinguishes between 35 different magazine groups. We search for two-magazine markets inside these 35 distinct groups and identify a total of 18 two-magazine markets that existed during our period of observation. The number of years of existence range between 1 and 31 years.

Table 1 gives an overview of our sample selection. All magazines are published in German, including those that are originally from foreign countries such as *Elle* and *Vogue*. Magazines also differ substantially from the original foreign version with respect to content (though not by layout). Since the foreign originals (or other similar foreign magazines) are difficult to obtain and are typically significantly more expensive, we do not believe that they impose a competitive constraint on the German equivalents.

Nine out of the 18 two-magazine markets are eliminated because of difficulties in their definitions or data. Due to missing data for some of the variables, we have to eliminate 'Fiction magazines'. With only observations on 1 year, we are also forced to eliminate 'Fitness', 'Youth' and 'Riddles' magazines, as we first difference the data. We do not consider 'Magazines with special character' (*Neue Revue* and *Reader's Digest Das Beste*) since they are completely different magazines. *Neue Revue* is concerned with the latest

⁷ For simplicity, we assume ads are all the same size, which we define as 'one page'. We do not have any systematic information about advertising sizes but sampling the magazines in our study revealed that most ads tended to be of the same size (a single page).

⁸ Our data and software code are available at <http://www.ulrichkaiser.com/papers/twosided.html>.

⁹ *Jahreszeitenverlag* is a major German magazine publisher which made its annual publication *Funktions-Analyse: Factbook für Inhalte und Portraits von Zeitschriften* available to us upon request. We have access to the 'Factbooks' from 1981 to 2003.

Table 1
Sample selection

Segment	Title 1	Title 2	Period		Obs
			Begin	End	
<i>Included magazines</i>					
Health	Goldene Gesundheit	Medizin heute	1977 Q1	1979 Q2	2
Entertaining	Bunte	Gala	1994 Q2	1999 Q1	4
Photo	Color Foto	fotoMAGAZIN	1972 Q3	2003 Q4	31
Do-it-yourself	SelberMachen	Selbst ist der Mann	1979 Q1	2003 Q4	25
Food	Essen & Trinken	Meine Familie & Ich	1973 Q2	1986 Q3	12
Gardening	Flora	Mein schöner Garten	1986 Q2	1998 Q1	11
Monthly high priced women's	Madame	Vogue	1983 Q1	1988 Q3	5
Weekly counseling women's	Bella	Tina	1979 Q3	1983 Q1	3
PC	Chip	PC Welt	1985 Q2	1993 Q2	7
<i>Excluded magazines</i>					
Magazines with special character	Neue Revue	Readers Digest Das Beste	1972 Q3	1990 Q4	18
Travel	Geo Saison	Merian	1990 Q1	2003 Q4	14
Young illustrated	Max	Prinz	1991 Q1	2003 Q4	13
City/lifestyle	Tempo	Wiener	1986 Q4	1994 Q3	7
Sports	Sport Illustrierte	kicker-sportmagazin	1972 Q3	1976 Q3	3
Fitness	Fit for Fun	Vital	1994 Q2	1995 Q4	1
Youth	Bravo	Musikexpress	1977 Q1	1977 Q4	1
Riddles	Extra Rätsel	Freizeit Revue	1985 Q1	1986 Q1	1
Fiction	Romanwoche	Meine Geschichte	1984 Q1	2003 Q4	0

gossip surrounding European celebrities, while *Reader's Digest Das Beste* is the German version of *Reader's Digest*. We think a more appropriate label for these magazines is 'miscellaneous'. For similar reasons we also exclude 'Travel', 'Sports' and 'Young illustrated' magazines.¹⁰

In total, we are left with only 100 usable observations (91 after first differencing), so the usual caveats of empirical work with small samples apply. Depending on the year considered, the 9 two-magazine markets that we include in our estimation make up between 2.2% and 8.4% of the total number of titles published in the total German magazine market, between 0.4% and 5.3% of total circulation, and between 1.1% and 5.4% of total ad pages (in the time period 1972–2003).

The two most important groups (in terms of observations) are 'Do-It-yourself' magazines and 'Photography' magazines. Together, these account for 56% of our usable observations. Some summary statistics on the variables involved in the estimation are given in Table 2. The mean cover price for a magazine in our sample is 2.85 Euros, whereas advertisers pay on average 10,512 Euros per ad. A magazine in our sample has a

¹⁰ Specifically, the 'Travel' magazines come in a different periodicity and one magazine (*Geo Saison*) deals with a wide array of topics while the other one (*Merian*) exclusively is concerned with a single travel destination; *kicker-sportmagazin*, a 'Sports' magazine, exclusively reports about soccer events, while *Sport Illustrierte* covers a wide range of sport events; and *Prinz*, a 'Young illustrated' magazine, comes in 13 different regional editions, faces significant competition from local newspapers and free city magazines, and has its focus on reporting on local events, while *Max* is a regular lifestyle magazine aimed at people below 35.

Table 2
Summary statistics for magazine titles

	Median	Mean	Std. Dev.
Circulation (N_t^r)	706,681	955,577	1,081,557
Advertisements (N_t^a)	471.8	673.3	527.7
Content pages (N_t^c)	1,582	2,003	1,170
Cover prices (p_t)	2.668	2.854	1.170
Ad rates (a_t)	10,021	10,512	4,128

circulation of about 955,577 per year on average (the median is 706,680), and runs about 673 ads per year.

While some magazines have almost no ads, no magazine in our sample has more ads than content. The average share of advertising pages to total pages is 24% (standard deviation 6.2%). The minimum ratio of ad pages to all pages for any magazine-year in our sample is 5.7%, while the maximum is 45.4%. A simple OLS regression of the ratio of ad pages to all pages on a constant, as well as linear and quadratic time trends, shows that the advertising ratio has changed over time, with the maximum ad share reached in 1989.

Our magazines are fairly symmetric, with the average deviation in readership market shares from one-half being 0.136 (a deviation which has been falling over time) and in advertising market shares being 0.098 (a ratio that has been rather steady). The correlation between the two market shares is 0.469%, and has been falling over time. A positive correlation is consistent with our model, which implies, *ceteris paribus*, higher demand on one side increases demand on the other side and vice-versa.

4. Empirical specification

Recall the empirical approach is to estimate the Eqs. (2) and (4) so as to obtain estimates of the parameters γ , ψ , β , ρ , and η . We use GMM to jointly estimate the two equations using our panel data set. To remove magazine-group fixed effects, we first difference the data. Our estimated model becomes

$$\Delta n_{1t}^r = \gamma(\Delta N_{1t}^a - \Delta N_{2t}^a) + \psi(\Delta N_{1t}^c - \Delta N_{2t}^c) - \beta(\Delta p_{1t} - \Delta p_{2t}) + \Delta \varepsilon_{1t}^r - \Delta \varepsilon_{2t}^r \quad (10)$$

$$\Delta n_{1t}^a = \rho(\Delta N_{1t}^r - \Delta N_{2t}^r) - \eta(\Delta a_{1t} - \Delta a_{2t}) + \Delta \varepsilon_{1t}^a - \Delta \varepsilon_{2t}^a, \quad (11)$$

where Δ denotes the first difference operator, and time subscripts have been added.

All explanatory variables in (10) and (11) are potentially endogenous. We thus need to find suitable instruments for circulation, the number of content pages, the number of ad pages, cover prices, and ad rates.

Our main identifying assumption is that (unobserved) cost factors are common across magazines published by a magazine's publisher and that other (demand-side) shocks specific to the magazine are not correlated with these factors, an approach similar to that used by Hausman and Taylor (1981), Hausman et al. (1994) and Berry et al. (1995). This means that cover prices of a publisher's magazines in other segments of the magazine

market are assumed to be driven by common underlying costs associated with a publisher's production, distribution and marketing of its magazines to readers. These costs also determine the particular magazine's cover prices, but are assumed to be uncorrelated with the disturbances in the magazine's product demand equations, which is why the average cover price of a publisher's *other* magazines can be used as instruments for cover prices. The same logic applies to the use of the average ad rate of a publisher's other magazines as an instrument for a magazine's ad rate, and the use of the average content pages per copy of a publisher's other magazines as an instrument for a magazine's content pages per copy.

Additional cost-side instruments for cover prices, ad rates and content pages per copy are the natural logarithm of the number of magazine titles published by the own publisher in a given year (a proxy variable for returns to scope in production) and the natural logarithm of the total number of pages printed by the own publisher in a given year (a proxy for returns to scale in production).

We also assume common (unobserved) demand factors affect publishers, and that these factors are uncorrelated with the magazine's marginal cost shocks. For instance, reflecting perhaps better management, some publishers at certain times may be better than others at attracting successful editors, across its whole range of magazines. Successful editors produce popular content that attracts a larger number of readers. Alternatively, a particular publisher may have access to a wider distribution channel than other publishers, resulting in higher demand for all its magazines. This suggests that a reasonable instrument for a magazine's circulation share is the average circulation share of the publisher's other magazines. Likewise, a similar logic applies to the advertising side. A particular publisher may form an ongoing relationship with a large advertising client through one of its magazines, but this will tend to raise demand for advertising in the publisher's other magazines, given some large advertisers may place ads across different magazine markets ('cross-selling' as it is termed in the media industry). Thus, we use the average advertising share of a publisher's other magazines to instrument for the advertising share of a particular magazine produced by the same publisher. To instrument our explanatory variables (which are differenced), we use current and lagged values of the instruments. Additional instruments are a constant, a linear and a quadratic time trend.

Overall, our instruments show a moderate to high correlation with the explanatory variables. At the same time, the instruments can be formally tested for their statistical validity by using a test for orthogonality of the instruments with the residuals of the equations of interest. This test cannot reject orthogonality of the instruments at the usual significance level.¹¹

5. Results

GMM estimation results for the Eqs. (10) and (11) are displayed in Table 3. Table 4 displays the corresponding non-instrumented seemingly unrelated regression (SUR)

¹¹ The details are available at <http://www.ulrichkaiser.com/papers/twosided.html>.

Table 3
GMM estimation results from the share equations

	Coeff.	Std. Err.	<i>p</i> -value
Readers value ads (γ)	0.1813	0.0259	0.000
Readers value content (ψ)	0.0317	0.0157	0.044
Competition for readers (β)	0.0685	0.0233	0.003
Advertisers value readers (ρ)	0.2301	0.0276	0.000
Competition for advertisers (η)	0.0326	0.0080	0.000

For readability, estimated coefficients and standard errors are all multiplied by 1000 except for ρ where they are multiplied by 1 million, and for β where they are left unchanged.

estimation results. GMM and SUR estimation results differ substantially. For instance, estimated network effects (measured by γ/β and ρ/η) are several times stronger in the SUR model than in the corresponding GMM model. Also, the SUR model produces insignificant estimates of ψ , β and η , and a negative coefficient on the effect of the number of content pages on the demand by readers. In contrast, all the coefficients of interest in the GMM estimation are correctly signed and significant.

5.1. Magazine readership demand

Magazines with more content and more ads attract a greater share of readers, while those with higher prices attract a smaller share of readers. We use our estimates of these effects to compare how much readers value content versus ads. For instance, each reader's willingness to pay for a 1% increase in content pages per year is (ψ/β) ($N_i^c/100$) Euros. After multiplying by the number of readers, readers in total are willing to pay 10,671 Euros for an extra 1% of content over a year (the standard error is 3845), and they are willing to pay 19,286 Euros for an extra 1% of advertisements over a year (the standard error is 8134).¹² Despite the fact it seems readers are willing to pay more for ads than for content, we cannot reject equality of the two effects (the *p*-value is 0.258).¹³

5.2. Magazine advertising demand

Advertising demand depends significantly on both the number of readers (positively) and ad rates (negatively). Combined, these effects imply advertisers (in total) are willing to pay 51,380 Euros to be able to reach an extra 1% of readers over a year (the standard error is 14,981). This is considerably more than the estimated 19,286 Euros readers are willing to pay in total to be able to read an extra 1% of ads over a year,

¹² Standard errors are calculated using the 'Delta' method (e.g. Greene, 2003, Section 5.4.2), which is also used below for other non-linear functions of parameters.

¹³ A possible reason for why readers may appear to value ads more than content is that our measures of content and ads are simply page-counts which do not take into account perceived quality differences. To the extent that there is less variation in the quality of ads across magazines than there is in the quality of content, using page-counts is a better proxy for ads than it is for content. The downward bias that is introduced as a result may therefore be greater for ψ than for γ .

Table 4
SUR estimation results of share equations

	Coeff.	Std. Err.	<i>p</i> -value
Readers value ads (γ)	0.2537	0.0336	0.000
Readers value content (ψ)	-0.0200	0.0145	0.166
Competition for readers (β)	0.0272	0.0209	0.194
Advertisers value readers (ρ)	0.2296	0.0451	0.000
Competition for advertisers (η)	0.0159	0.0117	0.172

For readability, estimated coefficients and standard errors are all multiplied by 1000 except for ρ where they are multiplied by 1 million, and for β where they are left unchanged.

although the difference between the two results is again not statistically significant (the *p*-value is 0.137).

5.3. Checking for non-explosive network effects

For our demand functions to be valid, we require the expression $1 - 4\rho\gamma N^r N^a$ to be positive. If not, network effects dominate, and the model predicts tipping to the case where one magazine takes the whole market. Using our parameter estimates, the estimated value of this expression over our sample is 0.547, with a corresponding standard error of 0.055. Thus, explosive network effects are rejected in favor of demand functions that are well behaved.

5.4. Implied structure of prices–cost markups

One of the key points of interest in a two-sided market is to understand the determinants of the *structure* of prices. How much is charged to readers versus advertisers? In our model, one determinant of the structure of prices is the structure of costs. Since we do not measure or estimate costs, we concentrate instead on the structure of price–cost markups. Eqs. (7) and (8) specify the determinants of these price–cost markups. The first term in each case is a regular Hotelling type markup that reflects the degree of product differentiation. This term is estimated to be 7.298 Euros per reader with a standard error of 2.487, and 15,323 Euros per ad with a standard error of 3775.

The apparently weak competition for advertisers raises the question of why firms view magazines as differentiated. The existing literature focuses on the link between readership characteristics and ad rates across publishers, which provides one view of the source of differentiation (Thompson, 1989; Koschat and Putsis, 2002). Another possibility is that other (non-readership) aspects also influence the choice of magazines, such as the type of service and customization each magazine offers. Section 6 focuses on two quite different explanations for the same result. The first is that the strong differentiation reflects that the magazines labelled as rivals may actually cater to quite different readerships and so behave as separate monopolies. The second explanation is that the market is actually one of a competitive bottleneck—advertisers do not view the rival magazines as differentiated at all, but since they advertise in both magazines (multihome) the magazines do not compete for advertisers, and this accounts for the large markup on the advertising side.

The additional terms in Eqs. (7) and (8) are the network externality terms that arise from the two-sided nature of the market. Given positive network effects, magazines will charge readers less to the extent this attracts more readers, and thereby more demand (and profits) from advertisers. Similarly, by charging advertisers less, each magazine attempts to attract more ads so as to attract readers. Our estimates can provide some insight into which effect is more important.

The estimated network externality term $2\rho N_i^a/\eta$ for the equilibrium cover price equation has a mean value of 9.497 Euros per reader with a corresponding standard error of 2.769. This measures how much cover prices will rise if advertisers do not value the number of readers. Given an actual mean cover price of 2.85 Euros, this represents a more than three-fold increase. The estimated network externality term $2\gamma N_i^r/\beta$ for the equilibrium advertising price equation has a mean value of 5059 Euros with a corresponding standard error of 2133 Euros. This measures how much equilibrium ad rates will rise if magazine readers do not value ads. This represents an approximately 50% increase in the ad rate (the mean ad rate is 10,512 Euros). In percentage terms, the subsidy to readers appears much more substantial.

5.5. Sources of profit contributions

That magazines receive the bulk of their margins from advertisers is confirmed by calculating the direct contribution to profits from readers and from advertisers. We calculate the equilibrium price–cost markup for readers multiplied by the number of readers: $N_i^r/\beta - 2\rho N_i^a N_i^r/\eta$, which is a measure of the direct contribution to a magazine's equilibrium profits from readers. Based on our estimates, the implied value of this expression is $-2,100,830$ Euros (the standard error is 4,530,730) per year, so that on average, magazines in our sample make losses on the reader market. This is in accordance with other studies on print media markets for Germany, for example [Ludwig \(2003\)](#) and [Wagner \(1981\)](#). Given the insignificance of our estimate, an alternative way of stating this result is that we cannot reject the hypothesis that magazines obtain no direct profit contribution from the readership side.

Compare these results to the direct contribution to a magazine's profit from advertisers, which can be calculated as $N_i^a/\eta - 2\gamma N_i^r N_i^a/\beta$. The mean estimate over the sample is 6,911,360 Euros (per year) with a standard error of 3,715,350 (the p -value is 0.063), so we can reject the hypothesis that advertisers make no direct contribution to profits (although only at the 10% significance level). Based on these point estimates, magazines are more than compensated for their losses on the reader market by gains on the advertising market. Of course, readers contribute to profits indirectly by raising demand from advertisers, but this is why readers are 'subsidized' in equilibrium.

5.6. Printing and distribution costs

The results above suggest magazines may actually set their cover prices below cost. In fact, the net effect of the product differentiation markup and the network externality discount is for magazines to set their cover price at 2.198 Euros below cost (note, however, the standard error on this estimate is 4.741 so the result is not

significant at any reasonable level). Using the equilibrium pricing relationship (7) to back out costs which generate the observed mean cover price implies average costs per reader of 5.052 Euros (the high standard error in the estimate of the price–cost margin means we can rationalize considerably lower costs also). According to these results, the magazines discount cover prices, so as to attract readers, and therefore more lucrative advertisers.

The view that magazines set cover prices below the cost of printing and distributing each magazine is consistent with external data reported in Ludwig (1996a,b). In 1992, he conducted case studies for *Die Zeit*, a weekly periodical that comes in a newspaper format, and *Der Spiegel*, a weekly news magazine. Ludwig (1996a, p. 294) finds that *Die Zeit*, which sold at 2.04 Euros, incurred cost for paper and printing of 1.74 Euros and distribution cost of 0.36 Euros. The cover price of *Die Zeit* hence did not cover paper, printing and distribution costs (the difference is 0.06 Euros). In the case of *Der Spiegel*, Ludwig (1996b, p. 94) estimates the difference between paper, printing as well as distribution costs and cover prices is 0.21 Euros.

We also obtained confidential data for one women's magazine (which we call magazine *X*) and one fitness magazine (which we call magazine *Y*) in Germany. The data on magazines *X* and *Y* were gathered from industry professionals, an affiliate with a major global advertising agency and an affiliate with a major printing technology group. We calculate magazine *X*'s paper and printing cost is 4 Euros per copy so its cover price of 4 Euros just covers paper and printing but not the costs of distribution which are included in our variable f_i . Magazine *Y*'s paper and printing cost are 3.6 Euros, which means that magazine *Y* makes losses from the readership side given a copy price of 3.3 Euros. Compared to these numbers, which indicate magazines prices are set close to marginal cost (a plausible rule of thumb for pricing), the difference between costs and cover prices implied by our point estimates seem too high, an issue we discuss below.

5.7. Production cost of ads

The net effect of the product differentiation markup and the network externality discount is for magazines to set their ad rates at 10,264 Euros per ad above cost, with a corresponding standard error of 5518 Euros. Given actual average ad rates, the backed out costs implied by this result and (8) are costs of 247 Euros per ad. However, with a standard error of 5518 Euros in the price–cost margin, a wide range of observed costs can be consistent with these results.

Although we are unable to obtain actual figures on the costs of producing ads due to business secrecy issues, our interviews of industry participants suggest that the actual cost is considerably higher than the point estimate of 247 Euros per ad. Taken together with the result on the readership side, this finding suggests our model overstates the impact of two-sidedness on the structure of prices. It seems unlikely magazines subsidize readers by marking up charges to advertisers to the extent our estimated model implies. If demand from readers is slightly less price elastic (a slightly lower value of β) and demand from advertisers is slightly more price elastic (a slightly higher value of η), we can reconcile our point estimates with industry views, which

explains why a wide range of observed costs are (statistically) consistent with our findings.¹⁴

5.8. Content pages production cost

Unlike price–cost margins, we cannot determine the optimal level of content implied by the fitted model without knowing the content page production costs parameters d_i , since according to (9), $N_i^c = \psi N_i^r / (2\beta d_i)$. However, in order to do comparative statics on the model, it is useful to solve for the value of d_i which makes the value of N_i^c predicted by the model equal to its (average) counterpart in the data. Thus, we solve (9) for $d_i = \psi N_i^r / (2N_i^c \beta)$, taking the mean over the sample. The implied level of d_i is 0.124. The implied value of the marginal production cost of a page of content from the model is then $mc_i = 2d_i N_i^c = \psi N_i^r / \beta$, which has a mean value (across all observations) of 442 Euros.

It is interesting to compare these cost estimates with direct measures of the magazines' costs. We were able to obtain cost information on three German magazines—*Der Spiegel*, *Zeit-Magazin* and *Stern* in Ludwig (2003). Ludwig obtained his data, which refer to 1992, from case studies. *Stern* belongs to the group of weekly political magazines and *Zeit-Magazin* is the supplement to *Die Zeit*.

Ludwig (2003, p. 208) reports that the average per copy content page production cost is 0.96 Euros for *Der Spiegel*, 0.62 Euros for *Zeit-Magazin* and 0.75 Euros for *Stern*. The average per copy content production cost derived from our model is $d_i(N_i^c)^2/S_i$. Using the 1992 data for content pages N_i^c we obtain the following implied costs for the three magazines: 0.42 Euros for *Der Spiegel*, 0.46 Euros for *Zeit-Magazin*, and 0.39 Euros for *Stern*. Our estimates are somewhat lower than Ludwig's. Again, a lower value of β (less price elastic demand from readers) will help reconcile our results with those of Ludwig.

5.9. Comparative statics in two-sided markets

Another way to interpret our estimation results is to consider how a shock to a magazine on one side of the market affects its equilibrium price on the other side of the market. While an increase in magazine 1's demand on the reader side will cause it to charge more to readers, it is not obvious how such a shock will affect its charges to advertisers. As we will show, in theory, an increase in demand can increase or decrease the cross-market price, reflecting two opposing effects. We thus use our estimated parameters to determine which effect dominates.

Given the linear functional forms implied by the Hotelling model, the comparative static derivatives depend only on the estimated parameters, and d_i which we set to 0.124 from above (this constant is denoted d). We consider positive demand shocks on the reader side (θ_1^r) and on the advertising side (θ_1^a) for magazine 1. Totally differentiating the system defined by (2)–(5) and (7)–(9) for $i=1$ and 2, the impact of

¹⁴ A higher η will also help lower the implied differentiation between magazines in the eyes of advertisers.

demand shocks on prices on the opposite side are summarized in the following comparative static results

$$\frac{da_1}{d\theta_1^r} = -\frac{da_2}{d\theta_1^r} = \frac{2(\rho - \frac{\eta}{\beta})N^r}{D} \quad (12)$$

$$\frac{dp_1}{d\theta_1^a} = -\frac{dp_2}{d\theta_1^a} = \frac{2\eta(\gamma - \frac{\beta\rho}{\eta} + \frac{\rho\psi^2N^r}{\eta d})N^a}{\beta D} \quad (13)$$

where

$$D = 9\eta - \left(8\beta\rho^2N^rN^a + 20\gamma\rho\eta N^rN^a + \frac{8\gamma^2\eta^2N^rN^a}{\beta} + \frac{3\psi^2\eta N^r}{\beta d} \right). \quad (14)$$

Consider first an exogenous increase in demand by readers for magazine 1. Our main interest is in what happens to the choice of advertising rates on the other side of the market. When network effects are assumed away, the answer is nothing. Allowing for network effects, the theoretical implications for advertising rates of an increase in reader demand depend on the sign of the expression $\rho - \eta/\beta$. A high value of ρ means that the exogenous increase in readership demand will translate into a relatively large increase in advertising demand. As a result, the magazine will want to increase its advertising rates to exploit this higher demand. We call this the *cross-market demand effect*. On the other hand, a high value of η/β means that when magazine 1 enjoys higher margins on the reader side of the market (as a result of the exogenous increase in demand by readers), it will want to cut ad rates since doing so generates a large increase in advertisers (the η effect), and the increase in advertisers generates a large increase in the now more profitable readers (the γ effect). This effect has to be measured relative to the level of β , the sensitivity of reader demand to cover prices. If β is high, then it does not make sense to cut ad prices a lot to generate the extra reader demand, when this demand can anyway be generated by a small decrease in cover prices. We call this effect the *cross-market subsidy effect*, since it captures the incentive for a magazine to subsidize one side to capture the higher margins on the other (now) more profitable side.

Our estimated results imply the cross-market demand effect dominates the cross-market subsidy effect for a shock to reader demand. Magazine 1 does not want to subsidize advertisers so as to attract a few more readers. Rather, it wants to exploit the larger effect of higher reader demand on advertising demand by charging advertisers more.¹⁵

Consider instead an exogenous increase in demand for advertising in magazine 1. Whether magazine 1 will respond to the higher advertising demand (and so price) by raising or lowering cover prices depends on the sign of the expression $\gamma - (1 - \psi^2N^r/\beta d)(\beta\rho/\eta)$. If the cross-market demand effect (γ) dominates, then higher advertising

¹⁵ We find $da_1/d\theta_1^r = 896.53$, so an exogenous increase in magazine 1's market share of readers from 50% to 55% will cause it to charge advertisers 44.83 Euros more per ad.

demand will increase reader demand sufficiently such that magazine 1 will want to increase its cover price. If, on the other hand, the cross-market subsidy effect ($\beta\rho/\eta$) dominates, then higher advertising demand will cause magazine 1 to lower its cover price. The cross-market subsidy effect is weakened somewhat by the ability of magazine 1 to attract more readers by producing more content rather than lowering the cover price. This is measured by the term $(1 - \psi^2 N^r / \beta d)$, which reduces the cross-market subsidy effect by about 23% in our sample. Despite this, we find the cross-market subsidy effect dominates, so that the magazine will actually decrease its cover price in response to the demand increase from advertisers (and it will also increase its production of content).¹⁶

These results provide another sense in which advertisers care more about the number of readers than vice-versa. A positive shock to reader demand raises a magazine's equilibrium ad rate, whereas a positive shock to advertising demand lowers a magazine's cover price.¹⁷ These differing responses reflect that, when measured relative to how easy it is to attract each type of user by adjusting prices, it is easier to attract more advertisers by subsidizing readers than vice-versa.

5.10. Separate magazine group estimates

Magazine group fixed effects drop out from our estimation equations since we estimate our model in first differences. However, it seems plausible that the slope coefficients also differ across magazine groups and so the estimates for each magazine group may deviate from the results obtained from the pooled estimation. Although we suspect results will be affected by parameter heterogeneity, with on average only ten observations per magazine group, it is not feasible to allow slope coefficients to vary across each group. Instead, here we just provide some evidence on whether parameter values vary between one of the larger magazine groups and the rest of the magazines. We conduct such 'tests' with our two largest magazine groups, 'Photo magazines' and 'Do-It-Yourself magazines'.

Allowing all of the parameters to vary depending on whether magazines are in the Photo group or not, we cannot reject joint homogeneity of the parameters (the p -value is 0.989). We also cannot reject joint parameter homogeneity in the case of the Do-It-Yourself magazines (the p -value is 1.000). However, in both cases the precision of the parameter estimates decreases substantially, possibly reflecting the effect of identifying the five magazine group specific parameters with only 23 observations (Do-It-Yourself magazines) and 29 observations (Photo magazines).

To make stronger conclusions, we consider heterogeneity in each of the five parameters, one at a time. For example, we test whether there are significant differences in the parameter γ by replacing $\gamma(\Delta N_{1t}^a - \Delta N_{2t}^a)$ in (10) with $\gamma(\Delta N_{1t}^a - \Delta N_{2t}^a) + D_g \gamma_g (\Delta N_{1t}^a - \Delta N_{2t}^a)$, where the dummy variable D_g takes on the value 1 if the corresponding magazine is in magazine group g (either Photo or Do-It-Yourself). The

¹⁶ We find $dp_1/d\epsilon_1^a = -1.768$, which suggests an increase in advertising market share from 50% to 55% will cause magazine 1 to charge readers 0.09 Euros less, and to produce an additional 21 content pages.

¹⁷ An increase in cost on one side of the market increases the magazine's price, decreasing demand on the same side. Thus, an increase in cost has the same cross-market effect as the corresponding decrease in demand.

parameter γ_g measures the difference in the effect of advertising pages on readership demand for magazines in group g compared to the rest of the magazines. If the parameter is statistically significant, we cannot accept parameter homogeneity.

Looking at each of the parameters separately, Do-It-Yourself magazines behave quite similarly to the rest of the magazines, with the exception of the γ parameter which is significantly lower. The parameter γ_g is estimated to be -0.0004 , and the p -value from a test that it is zero is 0.026. Calculating $\gamma + \gamma_g$ implies we cannot reject the hypothesis that readers do not value ads at all in Do-It-Yourself magazines (p -value from this test is 0.189). In contrast, the parameter estimates suggest readers are more sensitive to the number of ads and content pages in Photo magazines than they are for other magazines (γ_g is estimated to be 0.0005, and the p -value of a test that it is zero is 0.000; ψ_g is estimated to be 0.0001, and the p -value of a test that it is zero is 0.012). For Photo magazines, ρ and η are also both significantly different from the parameter estimates for other magazines (the p -values from the test that ρ_g and η_g are each zero are 0.001 and 0.000, respectively). Advertiser's demand is about twice as sensitive to the number of readers as for other magazines, but we cannot reject that advertising demand in photo magazines is completely price inelastic. This evidence suggests parameter heterogeneity is important. Unfortunately, with our limited data set, a more definitive understanding of parameter heterogeneity across different magazine groups does not seem feasible.

6. Alternative models

The share equations in the benchmark model considered thus far assume all agents choose one of the magazines exclusively. In reality, some agents will choose neither magazine and some agents will choose both (multihome). As the appendix shows, our results still apply in this case if the reason some agents buy both magazines (or neither) are exogenous to the decisions made by the magazines. On the other hand, where the number of such agents is endogenous, there may be biases in our results.

To avoid these biases, ideally, we should use a model that allows for some agents on each side of the market to multihome, and some to drop out, depending on the choice variables of the magazines. Consider first the case of multihoming. We calculate (in the appendix) that the proportion of readers that multihome in the magazines we consider is about 8% while the proportion of advertisers that multihome is around 17%. This suggests the appropriate model should allow for partial multihoming on each side of the market. Unfortunately, the combination of two-sided network effects and partial (endogenous) multihoming on each side of the market makes equilibrium analysis complex. This may explain why a theoretical model with these features does not currently exist, even though it is arguably the most relevant case to consider.

Allowing for endogenous participation is more straightforward, but such a model with competing magazines involves estimating an additional eleven parameters.¹⁸ Given a

¹⁸ As discussed in Section 6.1, we require six additional parameters to control for the market size on each side of the market. Allowing for competition on both sides of the market without assuming the market is covered also requires allowing own and cross effects to differ, which introduces another five parameters to estimate.

sample size of just 91 observations, this can explain the instability in results we find from such an exercise. Specifically, the effect of the number of ads and content pages in a magazine on the rival magazine's readership demand has the incorrect sign, and the effect of the number of readers in a magazine on the rival magazine's advertising demand is insignificant. In contrast, cross-price effects are correctly signed, significant, and somewhat smaller in magnitude than own-price effects.

In this section, we consider two models that provide alternative ways to deal with the issue of partial market coverage and multihoming. These models correspond to the models of a monopoly platform and of competitive bottlenecks considered by [Armstrong \(2005\)](#). In the case of a monopoly platform, each magazine is considered to be a monopoly (here problems of multihoming do not arise by definition). In the competitive bottleneck specification, advertisers always advertise in both of two competing magazines (that is, multihome). In both cases, we control for market size directly by assuming the potential number of readers is determined by the population for Germany, while the total demand by advertisers is linked to the GDP for Germany. We also allow for a linear time trend in each demand equation. The producer price index for newspaper print paper in Germany is added to our initial list of instruments.¹⁹

6.1. Monopoly model

In this section, we consider the possibility each magazine is effectively a separate monopoly. For the case of monopoly platforms, [Armstrong](#) assumes a particular specification in which utilities are a linear function of the number of users on the other side of the market as well as price, and that demand from each side is some increasing function of utility.²⁰

We adopt the exponential function for this increasing function so that demands are log-linear. That is, using our existing notation, $N_i^r = e^{u_i}$ where $u_i = \theta_i^r + \gamma N_i^a + \psi N_i^c - \beta p_i + \varepsilon_i^r$, and $N_i^a = e^{\pi_i}$ where $\pi_i = \theta_i^a + \rho N_i^r - \eta a_i + \varepsilon_i^a$. This particular function ensures demands are always non-negative, and that the equilibrium conditions are comparable to those obtained for the model of Section 2. Demand functions become

$$\log N_i^r = \theta_i^r + \gamma N_i^a + \psi N_i^c - \beta p_i + \varepsilon_i^r \quad (15)$$

$$\log N_i^a = \theta_i^a + \rho N_i^r - \eta a_i + \varepsilon_i^a. \quad (16)$$

¹⁹ This variable is not relevant to our benchmark Hotelling model, which is entirely in terms of relative prices and demands.

²⁰ Some other recent theoretical models of two-sided markets ([Anderson and Coate, in press](#); [Ferrando et al., 2004](#); [Gabszewicz et al., 2001](#)) use a demand specification in which the demand for advertising only depends on the ad rate per subscriber, and not the ad rate or the number of readers separately. We could not find any particular support for this specification relative to the linear specification of utility in any of the models estimated. The non-linear specification of utility also complicates the expressions for the price-cost margins. This motivates our choice of using linear utility functions.

Profit functions remain the same as in (6). Solving for the first order conditions implies

$$p_i - f_i = \frac{1}{\beta} - \frac{\rho N_i^a}{\eta} \quad (17)$$

$$a_i - c_i = \frac{1}{\eta} - \frac{\gamma N_i^r}{\beta} \quad (18)$$

$$N_i^c = \frac{\psi N_i^r}{2\beta d_i}. \quad (19)$$

The empirical specification is obtained by adding time subscripts, taking logs, and assuming

$$\theta_{i,t}^r = \alpha_i^r + a_1 t + a_2 \log POP_t + a_3 \log POP_t^2$$

$$\theta_{i,t}^a = \alpha_i^a + b_1 t + b_2 \log GDP_t + b_3 \log GDP_t^2$$

to control for potential demand for a magazine, where i is a magazine, t is a time subscript, POP_t is the population of Germany in year t , and GDP_t is the gross domestic product in Germany in year t , in 1985 Euros. Taking first differences to remove the magazine fixed effect terms α_i , the specification we estimate is

$$\Delta \log N_{i,t}^r = \gamma \Delta N_{i,t}^a + \psi \Delta N_{i,t}^c - \beta \Delta p_{i,t} + a_1 + a_2 \Delta \log POP_t + a_3 \Delta \log POP_t^2 + \Delta \varepsilon_{i,t}^r \quad (20)$$

$$\Delta \log N_{i,t}^a = \rho \Delta N_{i,t}^a - \eta \Delta a_{i,t} + b_1 + b_2 \Delta \log GDP_t + a_3 \Delta \log GDP_t^2 + \Delta \varepsilon_{i,t}^a. \quad (21)$$

Table 5 reports the corresponding GMM estimation results. All the coefficients of interest (ψ , γ , β , ρ and η) are positive and statistically significant. Population is a significant determinant of reader demand, and GDP a significant determinant of advertising demand (results not reported). Demand functions appear well behaved since

Table 5
GMM estimation results for monopoly model

	Coeff.	Std. Err.	<i>p</i> -value
Readers value ads (γ)	0.5669	0.0804	0.000
Readers value content (ψ)	0.1723	0.0429	0.000
Readers sensitivity to price (β)	0.1694	0.0530	0.001
Advertisers value readers (ρ)	1.3098	0.0781	0.000
Advertisers sensitivity to price (η)	0.0936	0.0205	0.000

For readability, estimated coefficients and standard errors are all multiplied by 1000 except for ρ where they are multiplied by 1 million, and for β where they are left unchanged.

we can reject explosive network effects given $1 - \rho\gamma N_i^r N_i^a$ is positive (it equals 0.459, with a standard error of 0.079).

Compared with our benchmark results in Section 5, readers' total willingness to pay for a 1% increase in ads is somewhat higher than before (it is now 24,385 Euros with a standard error of 8133), but their willingness to pay for a 1% increase in content is more than twice as high as before (it is now 23,462 Euros with a standard error of 8519). As a result, their willingness to pay for content is now very similar to that for ads, and the difference is certainly not statistically significant (the p -value from a test of equality is 0.915). Advertisers' willingness to pay for a 1% increase in readers is around twice the level compared to before (at 101,901 Euros with a standard error of 20,800), which is now significantly higher than readers' willingness to pay for a 1% increase in ads (the p -value from a test of equality is 0.000). That readers value content similarly to ads seems a more plausible feature of the estimated monopoly model compared to our benchmark model where the point estimate suggested they value content substantially less. Another more plausible aspect of the monopoly model is that the backed-out costs per advertisement are 3032 Euros rather than the implausibly low 247 Euros implied by our benchmark model. On the other hand, the monopoly model implies magazines set cover prices 3.513 Euros below cost which implies backed-out costs per reader which are even higher than before.

We test the monopoly model by examining whether there is evidence of cross-magazine effects. We find strong evidence of such effects regardless of whether we add cross-magazine price effects on just one side or both sides of the market, or allow for cross-magazine effects on all the variables in the utility function (either on one or both sides of the market). For instance, including $\beta_2 \Delta p_{j,t}$ in (20), the estimate of β_2 equals 0.162 with a standard error of 0.036. Including $\eta_2 \Delta a_{i,t}$ in (21) as well, the estimates of β_2 and η_2 are both highly significant, while all the other coefficients retain their correct sign (and significance). As expected, the cross-price effects β_2 and η_2 are somewhat lower than own-price effects β and η . However, expanding the model to include the cross effects of the other terms in (15) and (16) leads to estimates of ψ_2 and γ_2 which have the incorrect sign, and of ρ_2 which is insignificant. This may reflect the inability to reliably estimate 16 parameters with just 91 observations, or to appropriately control for market size. In comparison, the two-sided singlehoming model, which imposes stronger assumptions, only requires the estimation of five parameters.

6.2. Competitive bottleneck model

The last model we consider assumes magazines compete on the reader side, but act as monopolists on the advertising side. Following [Armstrong \(2005\)](#), the demand by firms for advertising in magazine i is some increasing function of the number of readers of magazine i and decreasing in the ad rate of magazine i . Specifically, the firm's decision to advertise on magazine i does not depend on whether it chooses to advertise on the rival magazine. This reflects the fact that the firm can advertise on both magazines (multihome), and so it will advertise on each magazine whenever doing so is profitable. Compared to the monopoly model above, the only difference in specification is that readers demand now depends on the difference in utility across the two rival magazines.

Adopting the identical functional forms to the monopoly case, and taking logs, demand functions become

$$\log N_1^r = \theta_1^r + \gamma(N_1^a - N_2^a) + \psi(N_1^c - N_2^c) - \beta(p_1 - p_2) + \varepsilon_1^r - \varepsilon_2^r \tag{22}$$

$$\log N_2^r = \theta_2^r + \gamma(N_2^a - N_1^a) + \psi(N_2^c - N_1^c) - \beta(p_2 - p_1) + \varepsilon_2^r - \varepsilon_1^r \tag{23}$$

$$\log N_1^a = \theta_1^a + \rho N_1^r - \eta a_1 + \varepsilon_1^a \tag{24}$$

$$\log N_2^a = \theta_2^a + \rho N_2^r - \eta a_2 + \varepsilon_2^a. \tag{25}$$

Given the same profit functions for magazines, solving for the first order conditions implies the following equilibrium conditions

$$p_i - f_i = \frac{1}{\beta} - \frac{\rho N_i^a}{\eta} - \frac{\gamma \rho N_j^r N_j^a}{\beta} \tag{26}$$

$$a_i - c_i = \frac{1}{\eta} - \frac{\gamma N_i^r}{\beta} \tag{27}$$

$$N_i^c = \frac{\psi N_i^r}{2\beta d_i}. \tag{28}$$

While the determination of the ad rate is identical to the case of monopoly magazines, the pricing to readers is lower relative to the monopoly price by the term $\gamma \rho N_j^r N_j^a / \beta$, reflecting the effect of competition for readers. The empirical specification is obtained in the same way as in the monopoly case, with the specification of the θ terms being identical.

Table 6 reports the corresponding results. With the exception of the coefficient on content, the coefficient estimates are qualitatively the same as the monopoly and two-sided singlehoming models, all being of the correct sign and statistically significant. The test for well-behaved demand functions is that the expression $1 - \gamma \rho S_i N_i^a - \gamma \rho S_j N_j^a$ is positive. We find the expression equals 0.6118 with a standard error of 0.0213, indicating network effects are not explosive. Since demands have the same log-linear form as the monopoly model, the results can be directly compared across the two models. Most estimates are broadly similar, except the coefficient on how much readers

Table 6
GMM estimation results for competitive bottleneck model

	Coeff.	Std. Err.	p-value
Readers value ads (γ)	0.4586	0.0152	0.000
Readers value content (ψ)	0.0021	0.0067	0.758
Price competition for readers (β)	0.1645	0.0201	0.000
Advertisers value readers (ρ)	1.1162	0.0488	0.000
Advertisers sensitivity to price (η)	0.1074	0.0097	0.000

For readability, estimated coefficients and standard errors are all multiplied by 1000 except for ρ where they are multiplied by 1 million, and for β where they are left unchanged.

value content (ψ) which is now close to zero and not at all significant (the p -value from a test that it is zero is 0.758). Not surprisingly, this also implies that readers value ads significantly more than content, a result that seems implausible (the p -value from a test that they value ads and content the same is 0.000).

To test the validity of this competitive bottleneck model, we test it against a model in which competition is added to the advertising side. Regardless of whether we just add the rival magazine's ad price, or also allow for the effect of the number of readers on the rival magazine, we find strong evidence that competition matters. For instance, including $\eta_2 \Delta a_{2,t}$ in (24) and $\eta_2 \Delta a_{1,t}$ in (25), the estimate of η_2 is only about 30% smaller than the estimate of η_1 and still highly significant. Including the cross-price effect in the advertising demand equation also substantially increases the estimated value that readers place on content. The estimate of ψ is now marginally significant (at the 10% level). These results suggest the competitive bottleneck framework does not provide a good fit for magazine markets in Germany. This is perhaps not surprising given the average proportion of advertisers that multihome in our sample is estimated to be around 17%, compared to the 100% predicted by the competitive bottleneck model.

7. Conclusions

In this paper, we obtained estimates of the parameters of a two-sided market model of competing magazine publishers. Using panel data from the German magazine industry between 1972 and 2003, we find non-explosive network benefits, so that the estimated demand system is well behaved. We ask, what is the markup charged to advertisers relative to that charged to readers? Our results are consistent with the conventional wisdom that advertisers value readers more than readers value advertisements, and that as a result, magazines 'subsidize' cover prices, and make their profit from advertisers.

We apply this estimated model to consider cross-market comparative statics. Reflecting the fact advertisers value readers more than readers value advertisements, we find that an increase in reader demand results in an increase in ad rates while an increase in advertising demand results in a decrease in cover prices. This asymmetric result reflects the incentive to subsidize readers to attract additional advertisers when the advertising side becomes more lucrative, but not vice-versa. Rather, if demand on the reader side increases (or costs fall), our estimated model implies magazines will want to increase ad rates to exploit the resulting increased demand on the advertising side.

One surprising finding is that even though we selected pairs of magazines that are broadly similar, the magazines seem to set high ad rates as though they are highly differentiated in the eyes of advertisers. A possible explanation for this is that the magazines selected actually serve quite different readership markets. Interestingly, a model of monopoly magazines performs at least as well as our benchmark model in capturing two-sidedness. However, a difficulty for the monopoly model is that cross-price effects are found to be significant. Cross-price effects are also a problem for the competitive bottleneck model, in which magazines compete for readers but not for advertisers (who all multihome). Demand for advertising in each magazine is found to be sensitive to the rival magazine's ad rate. Moreover, in our sample, the average proportion of advertisers that

multihome is only around 17%. Alternatively, the high markups sustained by magazines on the advertising side of the business may reflect some form of differentiation, collusion or other friction in the market for advertisers.

Given the limited data used in this study, we treat our results as illustrative. The approach used shows how one can draw conclusions on the role of network effects in determining the structure of pricing in studying two-sided markets. It also illustrates the interesting way cross-market comparative statics can work in two-sided markets. Future work could explore similar issues based on a more extensive data set of magazines. One approach worth considering is to use a more comprehensive data set on specific magazine segments, where magazine segments in different countries, regions or languages can be considered to have different demands and costs, and for which the demand from each side of the market (advertising versus readership) should depend on country/region specific factors that can be observed.

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Appendix A. Multihoming

In this appendix, we show how the two-sided singlehoming model can be extended in a way that allows some people to read two (rival) magazines and some firms to put the same ad in two (rival) magazines. Following the literature on two-sided markets, we call this situation “multihoming”. To do this, we assume that agents’ choice of whether to singlehome or multihome is independent of the magazine’s decision variables. Under this assumption, we show our existing results apply even in the presence of multihoming. This appendix also provides some evidence of the extent of multihoming on each side of the market in our sample.

The extension of our model follows [Doganoglu and Wright \(2006\)](#). They allow for partial multihoming in a generic model by allowing for two types of agents on each side—those with a high network benefit parameter who always choose to multihome and those with a low network benefit parameter who always choose a single platform (singlehome). In the context of our model, we define the proportion of high-types on the reader side as λ^r and the proportion of high-types on the advertiser side as λ^a . If there are R_1 readers who buy magazine 1 exclusively, R_2 readers who buy magazine exclusively, and R_M who buy both magazines, then $\lambda^r = R_M / (R_1 + R_2 + R_M)$. Likewise, $\lambda^a = A_M / (A_1 + A_2 + A_M)$ where A denotes the number of advertisers. Using our earlier notation, the total number of readers of magazine i can then be written as $N_i^r = R_i + R_M$, and likewise for advertisers, $N_i^a = A_i + A_M$. Then $N^r = N_1^r + N_2^r = R_1 + R_2 + 2R_M$ and $N^a = N_1^a + N_2^a = A_1 + A_2 + 2A_M$.

Denoting the market shares of magazine 1 for low type readers and advertisers as l_1^r and l_1^a , respectively, the previous market share Eqs. (2)–(5) still apply as before to these types of agents. The inclusion (or not) of multihoming agents is irrelevant to the low types' decision of which magazine to choose, since users get the benefit of these multihoming agents regardless of which magazine they choose. However, the left hand side share terms in these equations now only apply for low types (which we do not observe directly), so these have to be rewritten in terms of observables. For instance, on the readership side we use the observed value of $n_1^r = N_1^r / (N_1^r + N_2^r)$ in the estimation of (2), but the market share implied by the theory is now $l_1^r = R_1 / (R_1 + R_2)$. Using the definitions of λ^r and N_i^r above, we can rewrite l_1^r in terms of observables (and likewise for l_1^a) so that $l_i^r = ((1 + \lambda^r) n_i^r - \lambda^r) / (1 - \lambda^r)$ and $l_i^a = ((1 + \lambda^a) n_i^a - \lambda^a) / (1 - \lambda^a)$, which when substituted into the share Eqs. (2)–(5) yield

$$n_1^r = \frac{1}{2} + \left(\frac{1 - \lambda^r}{1 + \lambda^r} \right) (\theta_1^r - \theta_2^r + \gamma(N_1^a - N_2^a) + \psi(N_1^c - N_2^c) - \beta(p_1 - p_2) + \varepsilon_1^r - \varepsilon_2^r) \tag{29}$$

$$n_2^r = 1 - n_1^r \tag{30}$$

$$n_1^a = \frac{1}{2} + \left(\frac{1 - \lambda^a}{1 + \lambda^a} \right) (\theta_1^a - \theta_2^a + \rho(N_1^r - N_2^r) - \eta(a_1 - a_2) + \varepsilon_1^a - \varepsilon_2^a) \tag{31}$$

$$n_2^a = 1 - n_1^a. \tag{32}$$

After taking first differences, the implied demand system becomes statistically identical to that in (10) and (11). Assuming that magazines cannot set different prices depending on whether agents singlehome or multihome, the profit function for each magazine is identical to that in (6), where $N_i^r = n_i^r N^r$ and n_i^r is now defined in (29), and where $N_i^a = n_i^a N^a$ and n_i^a is now defined in (31). Since the estimated demand system is the same as before, all our implied results using the first order conditions (7)–(9) still apply. The only difference arises from the interpretation of the underlying parameters, which if calculated by using the adjustment terms above, apply to the utility functions for low type agents on each side of the market. (By construction, high types will have higher values of γ and ρ than low types, but the same values of ψ , β , and η .)

To give some idea of how many agents multihome, we calculate values for λ^r and λ^a , the proportion of readers who multihome and the proportion of advertisers who multihome. Unfortunately, we do not have systematic information on multihoming for all magazines or all years in our sample. Instead, we collected information on multihoming from two sources. On the reader side, we have consumer survey data for most of the magazines in our sample from 1997 to 2003. On the advertisers' side, we purchased all available magazines in our sample published in September 2004 and counted duplicated ads.

Table 7
Multihoming percentages for readers

Group	1997	1998	1999	2000	2001	2002	2003	Average share multireader
Health	3.56	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	3.56
Entertaining	2.64	3.53	3.55	5.04	6.23	5.73	5.54	4.61
Photo	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Do-it-yourself	11.08	11.98	11.11	7.81	10.47	9.25	7.49	9.88
Food	6.38	5.82	5.53	4.29	6.66	5.21	3.88	5.40
Gardening	4.43	6.16	5.35	5.12	5.35	5.20	3.45	5.01
Monthly high priced women's	6.38	6.78	5.80	6.38	5.21	6.56	4.86	6.00
Weekly counseling women's	11.40	11.73	10.73	11.11	11.62	9.65	8.48	10.67
PC	16.53	n.a.	n.a.	n.a.	n.a.	9.49	11.50	12.51

Information on multiple readership of magazines from the same magazine group is taken from AG.MA, as described in Section 3. The original source of the AG.MA data is a consumer survey that is biannually collected by the “Institut für Demoskopie, Allensbach”. Around 20,000 interviews are conducted annually in Germany. This data contains information on what fraction of magazine 1's readers also read the next available issue of magazine 2 (and vice-versa).²¹ If we define the fraction of readers of magazine i who also read magazine j as $\lambda_{i,j}$, so $\lambda_{i,j} = R_M / (R_i + R_M)$, then λ^r can be calculated from the observed $\lambda_{i,j}$ ratios by taking the inverse of $1/\lambda_{i,j} + 1/\lambda_{j,i} - 1$. The results, reported in Table 7, indicate multihoming on the reader-side is typically in the 5–10% range. Taking the weighted average value from Table 7, using the number of observations on each magazine group as the weights, implies $\lambda^r = 0.0786$.

To obtain a measure of the degree of multihoming amongst advertisers, we analyzed magazines in our sample for issues published in September 2004 by purchasing all available magazines in our sample on September 8, 2004. Magazines from the same magazine group were published either the same day (in the case of weekly magazines) or the same month (in the case of monthly magazines). Only *Goldene Gesundheit* was unavailable as it exited the market in June 1997.

Counting ads within each two-magazine group that appear in both magazines simultaneously, and dividing by the total number of distinct ads within the group, we obtain multihoming percentages of 10.29% for ‘Entertaining’, 14.29% for ‘Photo’, 16.66% for ‘Do-it-yourself’, 17.95% for ‘Food’, 15.00% for ‘Gardening’, 10.63% for ‘Monthly high priced women's’, 37.21% for ‘Weekly counseling women's’, and 30.16% for ‘PC’. These numbers indicate a higher degree of multihoming on the advertising side than the reader side. Taking the weighted average value, using the number of observations on each magazine group as the weights, implies $\lambda^a = 0.169$.

The presence of multihoming agents implies our estimated parameters understate the true magnitude of parameters in the agents' utility functions. The above results give an idea of

²¹ This measure may overstate the level of multihoming for two reasons. First, people may be more likely to read, say, *Madame* one month and *Vogue* the next, than to read both magazines in the same month. It also seems likely that the degree of multihoming will be higher in readership than in actual purchase.

how much parameter estimates need to be scaled up on each side. Specifically, the estimated parameters $\hat{\gamma}$, $\hat{\psi}$ and $\hat{\beta}$ in Table 3 should be multiplied by 1.171 to get the parameter values which apply to the singlehoming readers. Likewise, the estimated parameters $\hat{\rho}$ and $\hat{\eta}$ in Table 3 should be multiplied by 1.407 to get the parameter values which apply to the singlehoming advertisers. However, none of our implied results are affected by this scaling since they are based on the estimated demand system, which remains valid under the assumptions of this model of multihoming.

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