ESTIMATING DEMAND AND MARKET POWER IN TWO-SIDED MARKETS: CASE OF HUNGARIAN NEWSPAPER INDUSTRY

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ABSTRACT

I propose a model for estimating demand in two-sided markets where two groups of agents interact through an intermediary platform. The model takes into account the cross-group network effects between the two sides. Based on the estimated demand parameters, platforms' markup on both sides can be recovered, making it possible to measure market power in two-sided markets. One of the most typical examples for two-sided markets is the newspaper industry, where advertisers and readers interact through newspapers. Using two-stage least squares fixed effect estimation in Hungarian daily newspaper market between 2008 and 2016, I find that readers value advertising, their demand elasticities, however, are relatively low with respect to advertising content as well as to cover price. Estimating advertising side did not provide meaningful results, suggesting that distortions are likely to be present in the Hungarian newspaper advertising market.

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1. INTRODUCTION

One of the most current topics within economics nowadays is the case of two-sided markets. With the emergence and rise of digital platforms, it is essential that economists can identify the specific features of these markets and understand how they differ from standard markets. In two-sided markets, two groups of agents interact through platforms. Typical examples include credit cards through which merchants and consumers interact; a music streaming service through which artists and audience interact; and almost all types of media platforms through which advertisers and users interact.

Two-sided markets substantially differ from standard, one-sided markets in many aspects due to cross-group network effects: in case of media industry, for example, the advertisers' demand is a function of size and composition of the audience side, and willingness-to-pay of audience may also depend on the other side of the market. These effects can be, in theory, either positive or negative. One of the main distinctive aspects is the measuring of market power in two-sided markets: applying traditional models to markets like these can be misleading if one neglects the consequences of externality effects. For instance, while observing prices below marginal costs usually serves as an indicator of anti-competitive conduct in one-sided markets, this can be an efficient outcome in a two-sided market because of the cross-group network externalities: it can be optimal to keep price on one side as low as possible – maybe even as low as zero – in order to attract more customers on the other side.

This paper proposes a structural supply-demand model of two-sided markets that accounts for two-way cross-group externalities. The model makes it possible to estimate demand equations (including the cross-group effects) and price elasticities of the two sides and to recover platform's markup from each side. The main advantage of the model is that it only requires aggregate market data for estimation. Two-stage least squares fixed effects estimation on Hungarian daily newspaper market between 2008 and 2016 shows that readership demand is less price-elastic in international comparison, while I did not succeed in providing meaningful results in the advertising side of the market. The latter might be due to different distortive factors that affect advertising market as well due to econometric identification problems. The model itself, however, provides a promising basis for future empirical research on this topic.

The remainder of the paper is organized as follows. In Chapter 2, I review relevant theoretical and empirical literature. In Chapter 3, I propose my model. Data description and estimation results are presented in Chapters 4 and 5, respectively. Chapter 6 concludes.

2. LITERATURE REVIEW

2.1 Theoretical background

Although economic analysis of the media market which is by now usually characterized as a prototype of two-sided markets dates back for many decades[1], the notion and modeling of specific two-sided features is relatively young. Seminal models of platforms and platform competition are Rochet and Tirole (2003) and Armstrong (2006).

Rochet and Tirole (2003) define a market as two-sided if network externalities exist between two consumer groups of a platform, and platforms can effectively cross-subsidize between these groups.[2] One of the canonical examples is the media industry. Newspapers, magazines, television channels, radios are platforms that serve two types of agents: they provide their product or service for audience (viewers, readers or listeners), while they sell surface for advertisers to place ads targeted at the customers on the other side of the platform. The crucial feature of the two-sided market is the existence of cross-group externalities: both the utility of a particular group and the profit the platform can enjoy on that group depends on the size and other features of the other group. Regarding the newspaper industry, advertisers clearly value the quantity and quality of the readers; thus, readers generate a positive cross-group externality. The reverse effect –whether readers value advertising – is slightly more ambiguous, and rather a question of empirics; it highly depends on the type of advertising as well.

[1] An example for an early model of the newspaper industry is Corden, 1952.
[2] Although most of the models can be (and sometimes, are) extended to more than two sides, throughout the paper I only focus on two-sided markets.

Armstrong (2006) proposes three modeling frameworks for two-sided markets. First, he examines the pricing of a monopoly platform. This analysis reveals a common property of platform pricing: one group may be charged below the one-sided optimum (sometimes even below marginal cost or zero) if the group imposes large positive externality on the other group. This is the reason behind e.g. freely distributed newspapers: advertisers value the audience so much that the publisher of the newspaper sets the cover price to zero in order to maximize profit from the advertising side. Thus, for the audience, the newspaper is fully subsidized by the advertisers.

After relaxing the monopoly assumption, the other two models of Armstrong (2006) focus on platform competition. In the second case, agents on both sides of the market join a single platform (two-sided single-homing); two platforms compete in a Hotelling framework. In equilibrium, prices are lower compared to the standard (one-sided) Hotelling equilibrium. This downward adjustment is, again, attributed to the positive external effect imposed on the other group. The extent of the price reduction, however, is larger compared to the monopoly case, due to competition: duopolists strive for keeping agents since leaving agents can join to the competitor platform, making attracting agents from the other side harder.

The third and most relevant model of Armstrong (2006) is the *competitive bottleneck* model. In this setting, one of the two sides single-homes, while the other one multi-homes. This means that each platform has monopoly power over the multi-homing side agents that would like to access the specific single-homing customers; thus, the platform acts as a gateway ("bottleneck") towards its audience. The competitive bottleneck model is commonly believed (for example, Chandra and Collard-Wexler, 2009; Song, 2015) to be a reasonable specification for the newspaper industry, as (if the market correctly specified by frequency, genre, etc.) readers normally commit to a single platform, whereas advertisers usually place ads on multiple platforms simultaneously.

Two-sided market models have some important implications regarding antitrust and competition policy (Rysman, 2009). First, pricing below marginal costs can be an optimal competitive behavior as a result of cross-subsidization, while in a standard one-sided market this conduct is often assumed to count as predatory pricing which is usually an illegal practice. Second, many results show that in two-sided markets, higher market concentration may have positive welfare effects via internalizing the network externalities (e.g. Evans, 2003). Moreover, Chandra and Collard-Wexler (2009) propose that platform mergers may even lead to lower prices as well. This again contradicts standard markets where higher market power is usually assumed to impose negative welfare effects.

2.2 Empirical literature

This section briefly reviews the empirical analyses that have been carried out recently in the newspaper market. I focus only on the papers where the emphasis is put on the two-sidedness of the market.

The first empirical investigations on this topic (although not exactly a newspaper) involved the Yellow Pages industry (Rysman, 2004). He finds positive causal effect of advertising quantity on reader demand and *vice versa*, implying a two-way positive cross-group externality. Yellow Pages, however, are freely distributed, which means that this market is inappropriate for investigating the price structure of two-sided markets.

Analyzing the German magazine industry, Kaiser and Wright (2006) find evidence that reader's prices are subsidized by advertisers, and publishers make all of their profit in the advertising side of the market. They base their model, however, on duopoly market structure and restrict their analysis only to magazine segments where there are only two competitors. This narrows down the applicability of their estimation methods.

Both Fan (2013) and Van Cayseele and Vanormelingen (2009) provide evidence that readers do not care about advertising, thus network externalities flow only in one direction. The former concludes this based on US newspaper readers, while the latter on Belgian newspaper readers. Filistrucchi et al. (2012), however, find evidence that Dutch readers appreciate advertising. The results regarding whether readers prefer, dislike or are neutral about advertising is ambiguous, and depends on type of advertisements (certainly there are advertisements that are likely to be valuable for the consumers, while others are rather disturbing), structural model assumptions and data.

Song (2015) proposes a framework to estimate market power in two-sided markets, with an application to magazine industry. Starting out from the competitive bottleneck model (multi-homing advertisers and single-homing readers), assuming two-way cross-group externalities, and using data from German TV-magazines, he finds that publishers price papers below marginal cost, thus cross-financing is present. His merger simulations show that mergers in two-sided markets are less harmful to consumers on both sides of the market compared to predictions of one-sided models.

The closest approach to my paper is the work of Argentesi and Filistrucchi (2007). They build a supply-demand structural model, and using Italian daily newspaper data they find that observations are consistent with some tacit or explicit collusion practice rather than individual profit-maximizing firm behavior. The assume, however, one-direction cross-group externality and neglect the possible effect of advertising content on readers.

The overwhelming majority of the papers above use Berry's (1994) method as a starting point to estimate demand in the newspaper markets. This method makes it possible to use aggregate data for demand estimation. For this reason, the following chapter begins by introducing the discrete choice model of Berry (1994). Then I include supply-side as well and show that markups and thus market power of platforms can be calculated based on aggregate data and estimated demand parameters.

3. THE MODEL

3.1 Derivation of the logit demand equation

Berry (1994) proposes a model for estimating demand for differentiated products in oligopolistic markets. The demand is derived from a discrete-choice model of consumer behavior where consumers' utility depends both on product characteristics and individual taste parameters. The observed market shares are assumed to represent the aggregate outcome of individually rational consumer decisions. When it comes to estimations, however, classical endogeneity problem needs to be accounted for.

Let the utility of consumer i for product j be given by

$$u_{ij} = \boldsymbol{x_j}\boldsymbol{\beta} + \alpha p_j + \xi_j + \epsilon_{ij} \tag{1}$$

where p_j stands for the consumer price of the product; $\boldsymbol{x_j}$ and ξ_j are observed and unobserved product characteristics. In this specification, $\boldsymbol{\beta}$ can be thought of as the mean level of heterogeneous consumer's individual taste parameters, while ϵ_{ij} represents the distribution of consumer preferences around this mean.

Let us define the mean utility level for product j as

$$\delta_j \equiv \boldsymbol{x_j}\boldsymbol{\beta} + \alpha p_j + \xi_j \tag{2}$$

Then, conditional on the vectors of product characteristics and prices, and assuming that each consumer chooses exactly one product which yields maximal utility, we can derive the market share functions $\mathcal{s}_j(\boldsymbol{\delta}(\boldsymbol{x}, \boldsymbol{p}, \boldsymbol{\xi}), \boldsymbol{x})$.[3] After this step, the last parameter required for expressing the product demand is an exogeneous market

[3] See Berry (1994) for an exhaustive derivation.

size parameter M. In addition, we have to define an outside good that consumers "choose" if they pick the option not to purchase any of the available options.

After defining the market size, this outside good can then be measured as the share of market not choosing any products. Then the demand for product j is simply

$$q_j = M\mathcal{s}_j(\boldsymbol{x}, \boldsymbol{p}, \boldsymbol{\xi}) \tag{3}$$

Assuming that the observed market shares s_j correspondent to the model-predicted market shares ($s_j = \mathcal{s}_j(\boldsymbol{x}, \boldsymbol{p}, \boldsymbol{\xi})$), market shares depend only on main utility levels:

$$s_j = \mathcal{s}_j(\boldsymbol{\delta}) \tag{4}$$

Inverting this equation implies that the observed market shares and the distributional assumptions uniquely determine the means of consumer utility for each good – δ can be treated as a known transformation of the observed market shares. Thus,

$$\delta_j(\boldsymbol{s}) = \boldsymbol{x_j\beta} + \alpha p_j + \xi_j \tag{5}$$

Solving for the mean utility levels as a function of observed market shares is not trivial. Following Berry (1994), I use the logit model assumptions to solve this problem. Suppose that the error term ϵ_{ij}, through which heterogeneity in consumer tastes enters in the model, is identically and independently distributed with Type I Extreme Value distribution. The market shares are then given by the logit formula

$$s_j(\boldsymbol{\delta}) = \frac{e^{\delta_j}}{\sum_{k=0}^{N} e^{\delta_k}} \tag{6}$$

Then, normalizing the outside good mean utility to zero and taking logs yields

$$\ln(s_j) - \ln(s_0) = \delta_j = \boldsymbol{x_j\beta} - \alpha p_j + \xi_j \tag{7}$$

which is an equation that can be easily estimated with usual instrumental variable methods.

3.2 Model of newspaper demand

In this section, I present how I apply the above demand equation for the Hungarian newspaper market. The above specification is consistent with the single-homing consumers assumption. On the readers' side, this is a plausible assumption considering that I restrict my analysis to the Hungarian daily newspapers that are available nationally. Apart from institutional customers, multi-homing is quite unlikely in this market. Readers side single-homing is the common assumption in the relevant literature as well.

On the advertising side, the question of single- or multi-homing is more ambiguous. While both using the same logit demand specification described above, Song (2015) assumes multi-homing advertisers, Argentesi et al (2007) assumes single-homing advertisers. Since data show that the majority of the advertisers place advertisement only in one of the examined newspapers within one period, I assume that advertisers single-home as well. This implies that the above demand equation can serve as a starting point for modelling both sides of the newspaper market.

Based on equation (7), and taking into account the two-sided feature of the market, I propose the following demand equations. The reader demand for newspapers is specified as

$$\ln(s_{it}^N) - \ln(s_{0t}^N) = x_{it}^N \beta^N + \alpha^N p_{it}^N + \rho^N y_{it}^A + \gamma_i^N \tag{8}$$

where x_{it}^N stands for the newspaper's observed product characteristics; p_{it}^N stands for the cover price of the newspaper; γ_i^N stands for a time-invariant newspaper fixed effect;

and y_{it}^A stands for the amount of advertising present in the given newspaper as an observable product characteristic from readers' point of view. Thus, ρ^N measures the cross-group effect that advertisements impose on readers demand.

The advertising demand for newspapers is represented by

$$\ln\left(s_{it}^A\right) - \ln(s_{0t}^A) = \boldsymbol{x_{it}^A \beta^A} + \alpha^A p_{it}^A + \rho^A y_{it}^N + \gamma_i^A \tag{9}$$

where, similarly to the readership equation, x_{it}^A stands for observed product characteristics, p_{it}^A stands for the price of advertising, γ_i^A is newspaper fixed effect, and y_{it}^N stands for the number of readers of the specific newspaper in the given period as an observable product characteristic from advertisers' point of view. ρ^A measures the effect of circulation on advertising demand.

3.3 Elasticities of demand

The above specified model makes it possible to derive demand elasticities based on estimated demand parameters and observable price and market share data. These elasticities tell us how demand on one side of the market reacts to price change on the same side as well as to quantity or price change on other side of the market. Notice, however, that these elasticities are partial in the sense they are interpreted as a *ceteris paribus* effect and neglect the indirect effects through other side demand changes.

Elasticities of demand can be calculated based on equations (6) – (9). Combining these equations yields that

$$s_i^N = \frac{e^{x_i^N \beta^N + \alpha^N p_i^N + \rho^N y_i^A + \gamma_i^N}}{\sum_{j=0}^{N} e^{x_j^N \beta^N + \alpha^N p_j^N + \rho^N y_j^A + \gamma_j^N}} \tag{10}$$

and

$$s_i^A = \frac{e^{x_i^A \beta^A + \alpha^A p_i^A + \rho^A y_i^N + \gamma_i^A}}{\sum_{j=0}^{N} e^{x_j^A \beta^A + \alpha^A p_j^A + \rho^A y_j^N + \gamma_j^A}} \tag{11}$$

Taking derivatives and using the elasticity formula[4] yields that own-price elasticity of readership demand is

$$\eta_{s_i^N, p_i^N} = \alpha^N p_i^N (1 - s_i^N) \tag{12}$$

and elasticity of readership demand with respect to own advertising content is

$$\eta_{s_i^N, y_i^A} = \rho^N y_i^A (1 - s_i^N) \tag{13}$$

Cross-price elasticity of paper demand is

$$\eta_{s_i^N, p_j^N} = -\alpha_N p_j^N s_j^N \tag{14}$$

Cross-advertising elasticity of paper is

$$\eta_{s_i^N, y_j^A} = -\rho_N y_j^N s_j^N \tag{15}$$

Own-price, own-advertising, cross-price and cross-advertising elasticities of advertising demand can be calculated analogously.

3.4 Supply side of newspaper market

This section shows that the price-cost margin on the supply side can be recovered using estimated demand parameters. Thus, estimation of newspaper demand provides an empirical estimation of publishing companies' market power as well.

[4] Elasticity formula: $\eta_{y,x} = \frac{\partial y}{\partial x}\frac{x}{y}$, which shows the percentage change in y as a response to a 1 percent change in x.

I assume that publishing companies of papers are price-setters and competing in Bertrand-Nash fashion in an oligopolistic market on both the readership and advertising side. They make profit in both sides of the market, while their pricing decision on one side has an effect on the other side of the market as well: raising paper price, for example, affects paper demand, plus induces that due to decreasing circulation, advertisers leave for other papers, imposing a decrease in profit from advertising side as well. In addition, assuming two-sided externalities, paper price change has an indirect effect on paper demand due to change in advertising quantity as well.

These features are summarized in the following profit function.[5]

$$\Pi_i = (p_i^N - c_i^N) y_i^N \left(\boldsymbol{p^N}, \boldsymbol{y^A}\left(\boldsymbol{p^A}, \boldsymbol{y^N}(\boldsymbol{p^N}, \boldsymbol{y^A})\right)\right) + (p_i^A - c_i^A) y_i^A \left(\boldsymbol{p^A}, \boldsymbol{y^N}\left(\boldsymbol{p^N}, \boldsymbol{y^A}(\boldsymbol{p^A}, \boldsymbol{y^N})\right)\right) \tag{16}$$

where c_i^N and c_i^A stand for marginal costs of producing paper and advertising content, respectively. Firms maximize this by the following first order conditions.

- FOC(p_i^N):

$$(p_i^N - c_i^N) = -\frac{y_i^N}{\frac{dy_i^N}{dp_i^N}} - \frac{(p_i^A - c_i^A)\frac{dy_i^A}{dp_i^N}}{\frac{dy_i^N}{dp_i^N}} \tag{17}$$

- FOC(p_i^A):

$$\left(p_i^A - c_i^A\right) = -\frac{y_i^A}{\frac{dy_i^A}{dp_i^A}} - \frac{(p_i^N - c_i^N)\frac{dy_i^N}{dp_i^A}}{\frac{dy_i^A}{dp_i^A}} \tag{18}$$

[5] For simplyfing notation, I omitted time subscript throughout this section.

Note that in these equations, $\frac{dy_i}{dp_i}$ stands for the total derivative, incorporating all the direct and indirect effects. If no externalities were present, these total derivatives would be equal to the partial derivatives, implying zero effect of cover (advertising) price change on advertising (readership) demand. With two-sided cross-group externalities, however, total derivatives are functions of elasticities of demand. See *Appendix A* for decomposition of total derivatives.

Decomposing total derivatives to partial derivatives shows that demands are more sensitive to price changes compared to the benchmark (no cross-group externalities) case. Increasing cover price of a paper, for example, decreases readership demand plus decreases advertising demand which further affects readership demand. The effects, however, do not stop here: cover price change affects demand for competing papers, which changes advertising demand for those papers; advertising demand of rival papers can also affect readership demand[6]. Throughout this mechanism, all price changes have effect on the other side of the market as well.

The partial and total derivatives can also be expressed with the estimated demand parameters and observed market share and price data. See *Appendix A* for the formulae.

Rearranging equations (17) and (18) and solving for paper and advertising markups yields[7]

$$\frac{p^N - c^N}{p^N} = \frac{\frac{y^A}{p^N}\frac{dy^A}{dp^N} - \frac{y^N}{p^N}\frac{dy^A}{dp^A}}{\frac{dy^A}{dp^A}\frac{dy^N}{dp^N} - \frac{dy^A}{dp^N}\frac{dy^N}{dp^A}} \tag{19}$$

[6] The assumption that readership demand for a paper depends only on the advertising quantity of that specific paper but not the rival ones would be a potential, empirically plausible simplification of the model. This would require, however, strong microeconomic foundations.
[7] In order to simplify notation, *i* subscripts have been omitted.

$$\frac{p^A - c^A}{p^A} = \frac{\frac{y^N}{p^A}\frac{dy^N}{dp^A} - \frac{y^A}{p^A}\frac{dy^N}{dp^N}}{\frac{dy^A}{dp^A}\frac{dy^N}{dp^N} - \frac{dy^A}{dp^N}\frac{dy^N}{dp^A}} \tag{20}$$

Thus, markups depend on all own- and cross-price[8] effects. Notice that all the total derivatives are negative; since the effect of price change on the same side is likely to be much higher than the effect of price change on the other side, the denominators in the markup expressions are likely to be a positive number. In the numerator, however, there are two countervailing effects. The markup from same-side revenue is positive, and the higher the more own-price-elastic the other side demand is. The markup, however, is reduced by the other side of the market through the cross-group network effect: a price increase reduces profit from the other side through other side demand decrease.

Whether markup is higher or lower compared to the benchmark case without network externalities depends on the relative magnitude of elasticities and thus is an empirical question. Since the above markup formulae can be expressed with observable or estimable parameters, the markups can be calculated as well based on the above described logit demand model. I use datasets from Hungarian daily newspaper market to estimate this model.

The following two chapters present the data and the results of estimating the above demand equations and markups.

[8] Cross-price effect here stands for effect of price change of the same platform in the other side of the market.

4. DATA

4.1 Data sources

I analyze the market of nationally distributed Hungarian daily newspapers. In 2016, there were 9 such papers in operation; 2 of them (*Magyar Nemzet* and *Népszabadság*) have been shut down since then, but I include them in the analysis as they both had a large market shares in the previous years. I excluded three papers (*Világgazdaság*, *Magyar Hírlap* and *Magyar Idők*) from the analysis due to data deficiency or short operation period. This leaves us with 6 newspapers included in the analysis. Among them, there are 2 tabloids (*Blikk* and *Bors*), 3 political papers (*Népszabadság*, *Magyar Nemzet*, *Népszava*) and one sport paper (*Nemzeti Sport*).

I use datasets compiled from different sources. For newspaper circulation, I downloaded publicly available audited quarterly data from the website of MATESZ (www.matesz.hu). Quarterly data are available from 2001 to present. I found newspaper prices from 2008 to present on the website of Lapker (www.lapker.hu), from where I scraped the data. Unfortunately, I could not find cover price data from earlier than 2008.

Monthly data on the list price and surface of advertising in newspapers were obtained from a private company Kantar Media. The dataset is detailed on advertisement level (advertising company and content of advertisement is reported) and available from 1991 to 2016.

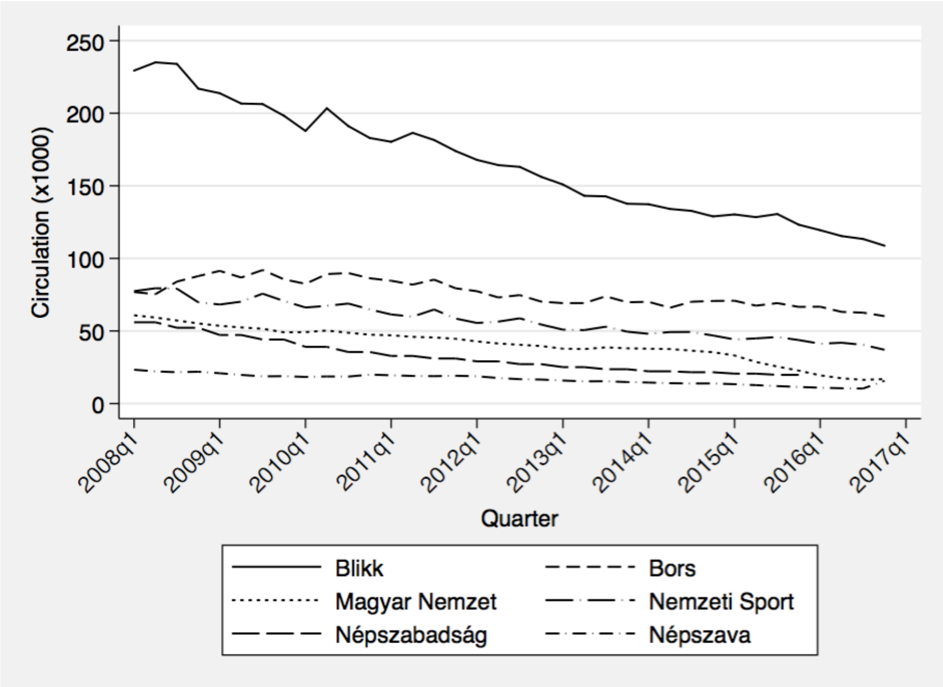
The period I possess all the data for spans from 2008 to 2016. Thus, readership demand can be estimated only for this period. For estimating advertising demand, however, cover price data is not required, implying that a longer period is available for that side of the market.

4.2 Descriptive statistics

Means and standard deviations of variables for each paper can be found in *Appendix B*. Throughout the observed period, there were on average 317 pages of advertising placed within a quarter in one paper. The two tabloid papers, *Blikk* and *Bors* are outliers with more than 500 and 600 advertising pages, respectively. These papers stand out in circulation as well. Average cover price is around 150 HUF, while one page of advertising costs on average 1.7 million HUF. This immediately sheds light on the likely presence of cross-financing within the industry: raw data suggests that price-cost markup is significantly higher on the advertising side of the market.

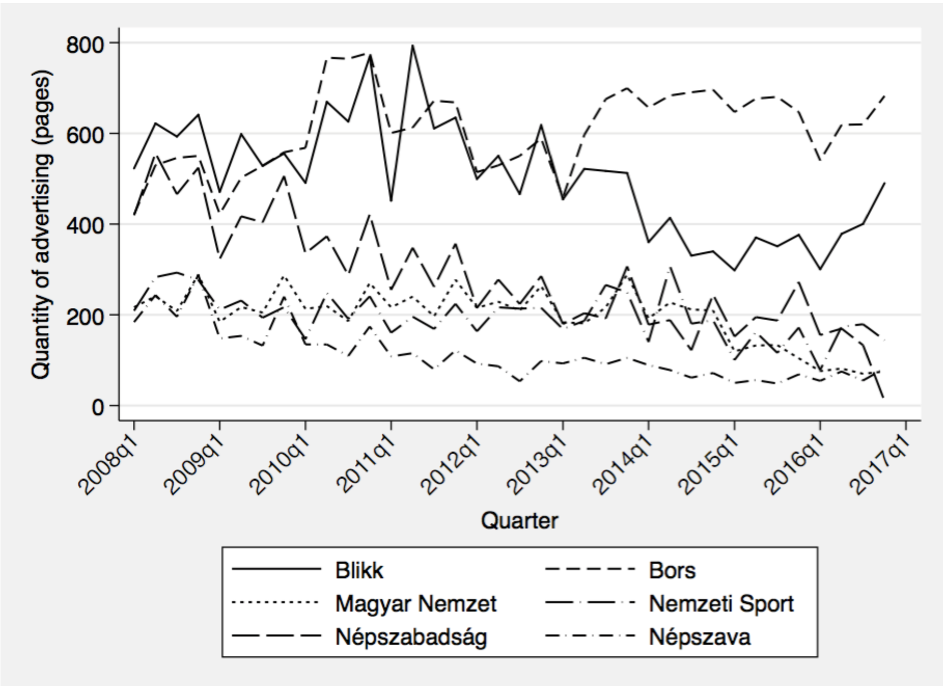
Figure 1 provides newspaper circulation data between 2008 and 2016. The two tabloid papers, *Blikk* and *Bors* were the market leaders – the former stands out with a higher than 40% market share throughout the period. An overall declining tendency can be observed, which is consistent with the global trends regarding demand for print media.

Figure 1. Quarterly average circulation of daily printed copies (2008-2016)



The quantity of advertising between 2008 and 2016 is represented on *Figure 2*. The pattern is clear: quantity of advertisement in a given paper is higher the higher its circulation. The overall declining trend, however, is not as straightforward as in the case of circulation, and it is also more fluctuating.

Figure 2. Sum of quarterly advertising content (2008-2016)



Figures of cover prices and advertisement list prices can be found in *Appendix C*. Newspaper prices usually change only at most a several times a year and show a generally increasing trend. This is partly explained by the fact that the represented price data are nominal values. Advertising price graph shows no clear patterns and its volatility highly differs across papers.

5. ESTIMATION RESULTS

5.1 Readership demand

For estimating equation (8), I need to define total potential market size. I decided to set it to 5 million, which is about half of the total population of Hungary. After taking into account the fact that individuals under 14 rarely read newspapers and that households usually buy a single paper which is read by multiple people, this seems to be a legitimate assumption.

As both cover price and advertising quantity are likely to be endogenous in the readership demand equation, I need to instrument these variables. As instruments, for each newspaper I use cover price and advertising quantity of a specific corresponding weekly magazine. In addition, for instrumenting cover price, I use the wage bill and material type expenditures of the publishing companies. I chose the weekly papers such that they are somehow connected to the corresponding daily newspapers: either they have the same publisher company, or they are similar to each other regarding their genre, topic or political orientation (see list of instruments in *Appendix D*).

In order that these are a valid instrument, however, some strong assumptions are required. First, we have to assume that cover prices and advertising quantities of the paired papers are highly correlated through cost-push shocks of the publishing and advertising companies. Second, exclusion restriction requires that paper prices and advertising quantities of instrument papers are not in direct connection with the demand of daily newspapers. This implies a special consumer behavior: they perceive the decision of buying a daily paper and buying a weekly paper separated. When deciding about buying a daily paper, they neglect the price (and advertising quantity) of weekly papers, because these two types of products are not strategic substitutes (nor strategic complements) for them. Considering that dailies and weeklies usually have different functions that cannot easily replace each other (for example, dailies usually serve as providers of latest news day-by-day, whereas weeklies cannot be up-to-date and rather provide deeper insight to specific topics), this can be a legitimate assumption.

Estimation results are shown in *Table 1*. The first column presents the ordinary least squares (OLS) estimation with the endogeneity bias. Second column reports two-stage least squares (2SLS) estimation results. Relevance of the instruments is tested by Kleibergen-Paap *rk* Langrange Multiplier test. Rejecting the null at all significant levels indicates that the model is identified. Kleibergen-Paap Wald F weak instruments test indicates that instruments I used are just strong enough to make plausible inferences from the model.

According to the 2SLS estimation, after controlling for newspaper and quarter fixed effects, a 10 HUF increase in the cover price decreases the relative newspaper demand by roughly 4 percent. The effect of advertising content on demand is positive: 20 additional pages of advertising content in a quarter (which roughly correspondents to one page per issue) increase relative demand by approximately 0.8 percent. Thus, my results support the claim that there exists a positive (although small) cross-group externality effect of advertisements for readers.

Table 1. Fixed effects OLS and 2SLS estimation of readership demand

	OLS	2SLS
Cover price (HUF)	-0.00152*** (0.000453)	-0.00396*** (0.000677)
Advertisements (pages)	0.000752*** (0.000109)	0.000405** (0.000173)
Constant	-3.261*** (0.0867)	
Newspaper FE	Yes	Yes
Time FE	Yes	Yes
Observations	205	148
Kleibergen-Paap LM stat.		17.142 (0.0018)
Kleibergen-Paap Wald F stat.		9.082

Note: Dependent variable: log market shares minus log market shares of the outside goods. ***: Significance at 1% level. **: Significance at 5% level. Corresponding weekly magazine data and publishing company balance data are used as instruments. IV relevance test: Kleibergen-Paap rk LM statistics. Weak IV test: Cragg-Donald F statistics.

Table 2 presents the calculated elasticities[9] of readership demand with respect to cover price and advertising content. Own-price elasticities are in a range from 0.45 (*Blikk*) to 0.77 (*Népszabadság*), implying that readers of the two tabloid papers, *Blikk* and *Bors*, are characterized by a significantly more price-inelastic demand than other papers. Overall, my estimations show that Hungarian daily newspaper demand is less price-elastic than in other countries, but its variation across papers is higher: Argentesi and Filistrucchi (2007) reported own-price elasticities between 0.73 and 0.76 regarding four Italian daily newspapers, while Song (2015) found elasticity as high as 3.5. The latter, however, is estimated on the German TV-magazine industry, which is a much

[9] Notice that these are partial elasticities in the sense that they can be interpreted as *ceteris paribus* and do not consider the fact that paper price changes advertising demand which has an additional effect on demand and thus market share as well.

narrower market definition, therefore papers are much closer substitutes than in my research.

Table 2. Elasticity of readership demand with respect to price and advertising

	Price	Advertising
Blikk	-0.448	0.197
	(0.0923)	(0.0484)
Bors	-0.447	0.243
	(0.130)	(0.0364)
Magyar Nemzet	-0.600	0.0791
	(0.0734)	(0.0247)
Nemzeti Sport	-0.616	0.0791
	(0.121)	(0.0210)
Népszabadság	-0.767	0.122
	(0.170)	(0.0462)
Népszava	-0.687	0.0457
	(0.143)	(0.0235)

Note: standard deviation in parentheses.

Elasticities with respect to advertising content vary highly across papers. They are in a range from 0.05 (*Népszava*) to 0.24 (*Bors*). The pattern is clear here as well: tabloid readers react to changes in advertising quantity more sensitively than readers of political or sports dailies. All the estimated elasticities, however, are much lower than own-price elasticities: altogether, readership demand with respect to advertising can be labelled as relatively inelastic.

5.2 Advertising demand

For estimating the advertising demand equation, a definition of total potential market size is required. Compared to the readership side, I have a more specific source to address this issue in case of advertisements: I use the quantity of advertising placed on all daily papers within a quarter. Thus, advertising in any daily paper other than the newspapers I include in the analysis stands for the definition of outside good.

For estimating equation (9), I need to instrument advertising price and paper circulation to address endogeneity issue. Analogously with the readership demand estimation, I use the advertising prices and circulations of matched weekly magazines for instruments. IV relevance requires that circulations and advertising prices are correlated, while exclusion restriction implies that this correlation does not stem from the advertising demand side, and that instruments do not affect advertising demand for the daily newspapers. For this, we need to assume that for advertisers, advertising in weekly newspapers and advertising in daily newspapers are two entirely different markets: none of price or circulation changes in the weekly paper market has any effect on the daily paper market and *vice versa*. My definition of market size is consistent with this assumption.

Table 3 presents OLS and 2SLS estimations of advertising demand. Estimated parameters of the two models differ a lot, which may reflect to high level of endogeneity in the OLS model. I got insignificant coefficients in the OLS model. Advertising price is significant in the 2SLS model and indicates that a 1000 HUF increase in the unit price (which is a considerable increase taking into account that mean unit price in the sample is 1700 HUF) decreases advertising demand by less than 0.1 percent. Paper circulation has no significant effect on advertising demand in neither of the models.

Table 3. Fixed effects OLS and 2SLS estimation of advertising demand

	OLS	2SLS
Advertising unit price (1000 HUF)	0.000104 (8.49e-05)	-0.000857*** (0. 000252)
Paper circulation (x1000)	0.000969 (0.00184)	-0.00423 (0.00286)
Constant	-12.58*** (0.548)	
Newspaper FE	Yes	Yes
Time FE	Yes	Yes
Observations	212	151
Kleibergen-Paap LM stat.		11.199 (0.0018)
Kleibergen-Paap Wald F stat.		2.958

Note: Dependent variable: log market shares minus log market shares of the outside goods. ***: Significance at 1% level. Corresponding weekly magazine data are used as instruments. IV relevance test: Kleibergen-Paap rk LM statistics. Weak IV test: Cragg-Donald F statistics.

Although instrument relevance is supported by the Kleibergen-Paap *rk* Langrange Multiplier test, Kleibergen-Paap Wald F test indicates that my instruments are too weak to ensure a consistent estimation. This fact, together with the insignificance of important parameters implies that this model cannot provide a meaningful estimation of advertising demand using this dataset: although I find significant negative price elasticities, I find no effect of paper circulation on advertising demand which contradicts to common sense as advertisers' main goal is usually to target as many people as possible.

There are many potential explanations of failing to model advertising side. First, aggregation on a quarterly level results in losing a lot of information in case of daily newspapers. With more frequent data, variation in paper circulation could be traced more efficiently – aggregation smooths demand shocks which makes estimation imprecise.

Second, there are many, potentially observable newspaper features that can affect advertising demand other than simple circulation: demographic and socioeconomic composition of readers likely affects companies decision when choosing a platform to advertise in. A number of similar papers (Fan, 2013; Argentesi and Filistrucchi, 2007; Kaiser and Wright, 2006) use such control variables in their estimations. I was not succeeded in finding these pieces of information.

Third and most important, Hungarian media advertising market is heavily distorted by politics. Majority of the amount spent on these platforms comes from the government or state-owned companies. Using the same dataset as me, Szeidl and Szűcs (2017) establish that government's spending in the advertising market is more based on political favoritism than market-based decision. In addition, apart from political distortions, it is hard to think of the government as a standard profit-maximizing firm, since both their means and ends are different. Incorporating this feature would require an alternative modelling of advertising demand.

6. CONCLUSION

This paper proposes a model of two-sided markets where two groups of agents interact through an intermediary platform. The model takes into account the presence of network effects between two groups, and makes it possible to estimate demand on both sides of the market based solely on aggregate market shares and price data. Then, based on demand parameters, platform's markup from each side can be recovered, thus quantifying platforms' market power becomes possible.

Empirical investigation on Hungarian daily newspaper market between 2008 and 2016 finds that readers' elasticity with respect to cover price varies between -0.45 and -0.77, the tabloid papers being more price-inelastic than others. This implies that in an international comparison, readers' demand for daily newspapers is price-inelastic. I also find evidence that there is a positive externality effect of advertising on readership demand: *ceteris paribus*, readers value advertising content in a newspaper, and readers of tabloids value it more than others. The elasticity of paper demand with respect to advertising content, however, is relatively low.

I have not managed to get meaningful estimation results regarding advertising market due to the weakness of my instrumental variables. There are well documented distortive factors present in the Hungarian media advertising market as well, such as the fact that the largest actors in the market are government- or state-owned firms which usually substantially differ from standard profit-maximizing firms.

The estimation of the model I proposed in this paper should be repeated on another relevant newspaper market dataset in the future, possibly with extended time horizon and increased sample size. In addition, the model may be transformed to other forms of two-sided market as well.

APPENDIX

Appendix A – Derivation of formulae

The total derivatives of advertising demand $y_i^A\left(\boldsymbol{p^A}, \boldsymbol{y^N}\left(\boldsymbol{p^N}, \boldsymbol{y^A}(\boldsymbol{p^A}, \boldsymbol{y^N})\right)\right)$ with respect to prices are[10]

$$\frac{dy_i^A}{dp_i^A} = \frac{\partial y_i^A}{\partial p_i^A} + \sum_j \frac{\partial y_i^A}{\partial y_j^N} \sum_k \frac{\partial y_j^N}{\partial y_k^A} \frac{\partial y_k^A}{\partial p_i^A} \tag{A1}$$

and

$$\frac{dy_i^A}{dp_i^N} = \sum_j \frac{\partial y_i^A}{\partial y_j^N} \frac{\partial y_j^N}{\partial p_i^N} \tag{A2}$$

Decomposing (A1) to cross- and own elasticities yields

$$\frac{dy_i^A}{dp_i^A} = \frac{\partial y_i^A}{\partial p_i^A} + \frac{\partial y_i^A}{\partial y_i^N}\frac{\partial y_i^N}{\partial y_i^A}\frac{\partial y_i^A}{\partial p_i^A} + \frac{\partial y_i^A}{\partial y_i^N}\sum_{j\neq i}\frac{\partial y_i^N}{\partial y_j^A}\frac{\partial y_j^A}{\partial p_i^A} + \sum_{j\neq i}\frac{\partial y_i^A}{\partial y_j^N}\frac{\partial y_j^N}{\partial y_j^A}\frac{\partial y_j^A}{\partial p_i^A} + \sum_{j\neq i}\frac{\partial y_i^A}{\partial y_j^N}\frac{\partial y_j^N}{\partial y_i^A}\frac{\partial y_i^A}{\partial p_i^A}$$
$$+ \sum_{j\neq i,k}\frac{\partial y_i^A}{\partial y_j^N}\sum_{k\neq i,j}\frac{\partial y_j^N}{\partial y_k^A}\frac{\partial y_k^A}{\partial p_i^A} \tag{A3}$$

Decomposing (A2) the same way yields

$$\frac{dy_i^A}{dp_i^N} = \frac{\partial y_i^A}{\partial y_i^N}\frac{\partial y_i^N}{\partial p_i^N} + \sum_{j\neq i}\frac{\partial y_i^A}{\partial y_j^N}\frac{\partial y_j^N}{\partial p_i^N} \tag{A4}$$

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[10] Notice that there is a simplification at this point: in order to avoid infinite feedback loops, I neglect the partial effects after one point.

The total derivatives of paper demand $y_i^N\left(\boldsymbol{p^N}, \boldsymbol{y^A}\left(\boldsymbol{p^A}, \boldsymbol{y^N}(\boldsymbol{p^N}, \boldsymbol{y^A})\right)\right)$ with respect to prices yield

$$\frac{dy_i^N}{dp_i^N} = \frac{\partial y_i^N}{\partial p_i^N} + \sum_j \frac{\partial y_i^N}{\partial y_j^A} \sum_k \frac{\partial y_j^A}{\partial y_k^N} \frac{\partial y_k^N}{\partial p_i^N} \tag{A5}$$

and

$$\frac{dy_i^N}{dp_i^A} = \sum_j \frac{\partial y_i^N}{\partial y_j^A} \frac{\partial y_j^A}{\partial p_i^A} \tag{A6}$$

Decomposing yields

$$\frac{dy_i^N}{dp_i^N} = \frac{\partial y_i^N}{\partial p_i^N} + \frac{\partial y_i^N}{\partial y_i^A}\frac{\partial y_i^A}{\partial y_i^N}\frac{\partial y_i^N}{\partial p_i^N} + \frac{\partial y_i^N}{\partial y_i^A}\sum_{j \neq i}\frac{\partial y_i^A}{\partial y_j^N}\frac{\partial y_j^N}{\partial p_i^N} + \sum_{j \neq i}\frac{\partial y_i^N}{\partial y_j^A}\frac{\partial y_j^A}{\partial y_j^N}\frac{\partial y_j^N}{\partial p_i^N} + \sum_{j \neq i}\frac{\partial y_i^N}{\partial y_j^A}\frac{\partial y_j^A}{\partial y_i^N}\frac{\partial y_i^N}{\partial p_i^N} + \sum_{j \neq i}\frac{\partial y_i^N}{\partial y_j^A}\sum_{k \neq i,j}\frac{\partial y_j^A}{\partial y_k^N}\frac{\partial y_k^N}{\partial p_i^N} \tag{A7}$$

and

$$\frac{dy_i^N}{dp_i^A} = \frac{\partial y_i^N}{\partial y_i^A}\frac{\partial y_i^A}{\partial p_i^A} + \sum_{j \neq i}\frac{\partial y_i^N}{\partial y_j^A}\frac{\partial y_j^A}{\partial p_i^A} \tag{A8}$$

The partial derivatives can be written as a function of demand parameters and observed market data by noticing that from equations (10) and (11),

$$y_i^N = \frac{e^{x_i^N\beta^N + \alpha^N p_i^N + \rho^N y_i^A + \gamma_i^N + \epsilon_i^N}}{\sum_{j=0}^N e^{x_j^N\beta^N + \alpha^N p_j^N + \rho^N y_j^A + \gamma_j^N + \epsilon_j^N}} M^N \tag{A9}$$

and

$$y_i^A = \frac{e^{x_i^A\beta^A + \alpha^A p_i^A + \rho^A y_i^N + \gamma_i^A + \epsilon_i^A}}{\sum_{j=0}^N e^{x_j^A\beta^A + \alpha^A p_j^A + \rho^A y_j^N + \gamma_j^A + \epsilon_j^A}} M^A \tag{A10}$$

where M^N and M^A stand for size of newspaper and advertising market, respectively.

Taking derivatives of these equations yields the following list of partial derivatives.

$$\frac{\partial y_i^N}{\partial p_i^N} = \alpha^N s_i^N (1 - s_i^N) M^N \tag{A11}$$

$$\frac{\partial y_i^A}{\partial p_i^A} = \alpha^A s_i^A \left(1 - s_i^A\right) M^A \tag{A12}$$

$$\frac{\partial y_i^N}{\partial p_j^N} = -\alpha^N s_i^N s_j^N M^N \tag{A13}$$

$$\frac{\partial y_i^A}{\partial p_j^A} = -\alpha^A s_i^A s_j^A M^A \tag{A14}$$

$$\frac{\partial y_i^N}{\partial y_i^A} = \rho^N s_i^N (1 - s_i^N) M^N \tag{A15}$$

$$\frac{\partial y_i^A}{\partial y_i^N} = \rho^A s_i^A (1 - s_i^A) M^A \tag{A16}$$

$$\frac{\partial y_i^N}{\partial y_j^A} = -\rho^N s_i^N s_j^N M^N \tag{A17}$$

$$\frac{\partial y_i^A}{\partial y_j^N} = -\rho^A s_i^A s_j^A M^A \tag{A18}$$

Substituting these into (A3), (A4), (A7) and (A8) we get empirically calculable formulae of total derivatives:

$$\frac{dy_i^A}{dp_i^A} = \alpha^A s_i^A \left(1 - s_i^A\right) M^A$$

$$+ \rho^A \rho^N \alpha^A M^N (M^A)^2 \left(s_i^A\right)^2 \left(\left(1 - s_i^A\right)^2 (1 - s_i^N) + 2\left(1 - s_i^A\right) s_i^N \sum_{j \neq i} s_j^A s_j^N \right.$$

$$\left. + \sum_{j \neq i} \left(s_j^A\right)^2 s_j^N \left(1 - s_j^N\right) - \sum_{j \neq i,k} \sum_{k \neq i,j} s_j^A s_j^N s_k^A s_k^N \right)$$

(A19)

$$\frac{dy_i^A}{dp_i^N} = \rho^A \alpha^N s_i^N s_i^A M^N M^A \left((1 - s_i^N)\left(1 - s_i^A\right) + \sum_{j \neq i} s_j^N s_j^A \right) \quad \text{(A20)}$$

$$\frac{dy_i^N}{dp_i^N} = \alpha^N s_i^N (1 - s_i^N) M^N$$

$$+ \rho^N \rho^A \alpha^N M^A (M^N)^2 (s_i^N)^2 \left((1 - s_i^N)^2 \left(1 - s_i^A\right) + 2(1 - s_i^N) s_i^A \sum_{j \neq i} s_j^N s_j^A \right.$$

$$\left. + \sum_{j \neq i} \left(s_j^N\right)^2 s_j^A \left(1 - s_j^A\right) - \sum_{j \neq i,k} \sum_{k \neq i,j} s_j^N s_j^A s_k^N s_k^A \right)$$

(A21)

$$\frac{dy_i^N}{dp_i^A} = \rho^N \alpha^A s_i^N s_i^A M^N M^A \left((1 - s_i^N)\left(1 - s_i^A\right) + \sum_{j \neq i} s_j^N s_j^A \right) \quad \text{(A22)}$$

Plugging these equations into markup equations (19) and (20) provides an empirically tractable formula for markups.

Appendix B – Descriptive statistics table

Table B1. Quarterly advertising and readership mean quantity and price data

	Circulation share	Advertising share	Advertising (pages)	Ad price (1000HUF / page)	Circulation (1000)	Cover price (HUF)
Blikk	0.43	0.26	503.5	2457.5	165.4	116.9
	(0.01)	(0.03)	(126.0)	(449.7)	(37.6)	(23.3)
Bors	0.20	0.33	609.6	740.5	76.1	114.6
	(0.03)	(0.08)	(91.1)	(132.3)	(9.1)	(33.1)
Magyar Nemzet	0.10	0.10	196.9	2030.7	40.6	152.8
	(0.01)	(0.02)	(61.6)	(239.3)	(12.1)	(18.4)
Nemzeti Sport	0.15	0.10	197.6	1634.6	57.3	157.3
	(0.01)	(0.02)	(52.5)	(162.1)	(12.1)	(30.5)
Népszabadság	0.08	0.14	281.9	2118.8	32.9	201.1
	(0.01)	(0.04)	(125.5)	(367.0)	(11.5)	(43.8)
Népszava	0.04	0.06	113.3	1227.8	16.8	174.0
	(0.00)	(0.02)	(58.4)	(218.5)	(3.5)	(36.1)
Mean	0.17	0.17	317.1	1701.7	65.5	153.3
	(0.13)	(0.11)	(200.6)	(644.2)	(52.2)	(44.2)

Note: Shares within the 6 papers included in this analysis are reported. Standard deviations in parentheses.

Appendix C – Paper price and advertising price graphs

Figure C1. Quarterly average unit price of advertising (2008-2016)

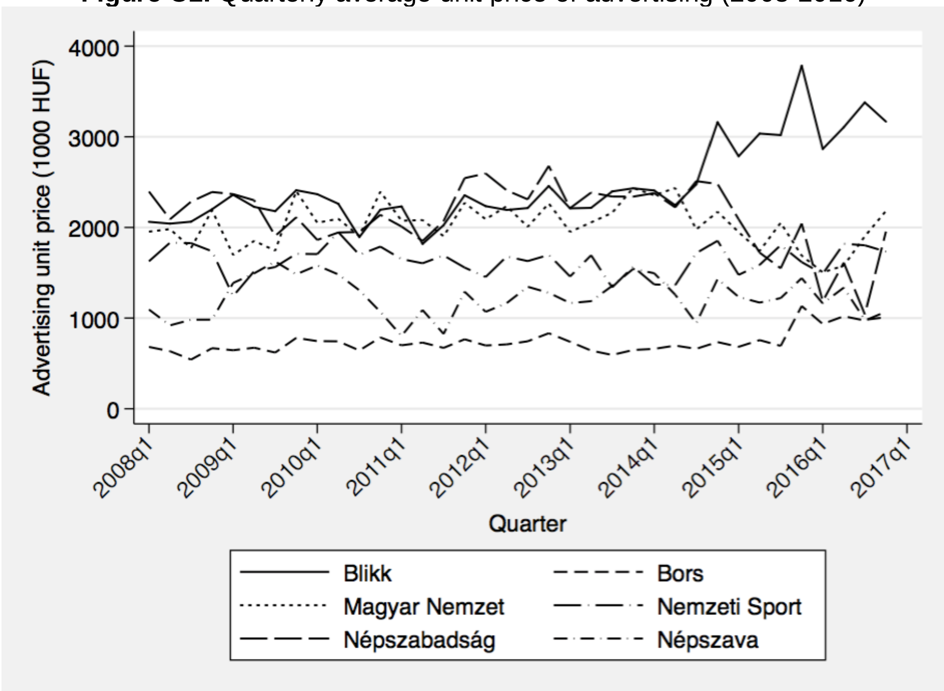
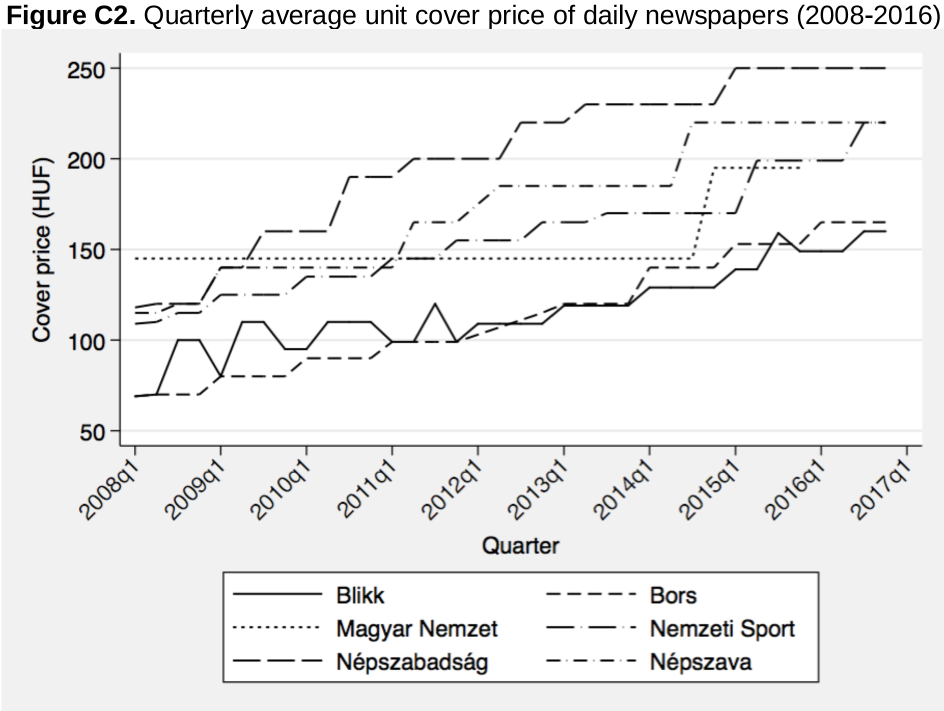


Figure C2. Quarterly average unit cover price of daily newspapers (2008-2016)



Appendix D – List of instruments

Table D1. List of instrumental variables

Daily newspaper	**Coupled weekly magazine**
Blikk	*hot!*
Bors	*Fanny*
Magyar Nemzet	*Heti Válasz*
Nemzeti Sport	*Képes Sport*
Népszabadság	*HVG*
Népszava	*168 Óra*

Note: For each daily newspaper, the corresponding weekly newspaper's variables were used as instruments in 2SLS estimation.

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