Estimating Platform Market Power in Two-Sided Markets with an Application to Magazine Advertising

Minjae Song*

June 2019

Abstract

In two-sided markets two groups of agents interact through platforms. Because agents decision to join a platform is affected by the presence of agents on the other side, their interactions create indirect network externalities and make platforms strategies different from those of firms in one-sided markets. In this paper I use a structural model to show that platforms may make a loss on one side of the market to make a profit on the other side and that platform mergers may benefit some agents by lowering prices or attracting more agents on the other side of the market.

Keywords: Platform competition, competitive bottleneck model, platform mergers

*Bates White Economic Consulting, 2001 K Street NW, North Building, Suite 500, Washington, DC 20006. E-mail: minjae.song@bateswhite.com. I have benefited from discussions with Paul Ellickson, Marshall Freimer, Zaegyoo Hah, Daniel Halbheer, Ulrich Kaiser, Jeanine Miklos-Thal, Michael Raith, Kyoungwon Seo, and participants at various conferences and seminars. I especially thank John Asker and two anonymous referees for helpful comments and suggestions, Ulrich Kaiser for providing me with the data used in this paper, and Zaegyoo Hah for helping me with Fortran coding. All errors are mine. The views expressed in this paper are solely those of the author and do not necessarily reflect the opinions of Bates White or its clients.

1 Introduction

Two-sided markets are characterized by two groups of agents interacting through intermediaries or platforms. Agents in each group care about the presence of the other group, creating cross-platform externalities, also known as indirect network externalities. Platforms account for these externalities in their strategic decisions such as setting prices. Examples are numerous, including payment systems where merchants and consumers interact through credit cards; video game systems where game developers and game players interact through video consoles; and print medias where advertisers and readers interact through newspapers or magazines, just to name a few.[1]

Common pricing behavior observed in two-sided markets is that platforms make a profit from agents on one side of a market and subsidize agents on the other side of the market. Internet platforms such as Google and Facebook do not charge users for "consuming" content on their websites, while charging advertisers for showing their ads to users. Credit cards charge businesses fees for accepting their cards, while charging nothing or giving "rewards" to card users.[2] This pricing behavior is a result of platforms accounting for indirect network externalities in their profit maximization. Armstrong (2006), for example, shows that the profit-maximizing price decreases on one side when the benefit to agents on the other side becomes larger.

Such two-sided pricing poses a challenge in evaluating the competitive effects of a merger between platforms. For one-sided markets the economic theory predicts that prices would increase post merger as long as merging firms sell substitutes and achieve no efficiency gain.[3] Hence, antitrust authorities are typically focused on predicting the magnitude of price increases post merger in assessing merger effects. In two-sided markets, however, a merged platform may lower prices post merger. There are post-merger studies of two-sided markets that show that platforms would not increase prices at least on one side of the market post merger. For example, Chandra and Collard-

[1]See Rysman (2009) for more examples and an overview on the literature of two-sided markets.

[2]See Rochet and Tirole (2003) for other examples where platforms subsidize one side with profits made from the other side.

[3]See the Multiproduct Monopoly section in Chapter 1 of Tirole (1988).

Wexler (2009) use the Hotelling model to demonstrate that mergers in two-sided markets may not necessarily lead to higher prices for either side of the market. They also show empirically that mergers in the Canadian newspaper industry in the late 1990s did not lead to higher prices.[4]

This "ambiguity" in the direction of price changes necessitates using a structural model that fully accounts for interactions between the two sides of the market in assessing effects of platform mergers. In this paper I use such a model to estimate platforms' markup on each side of the market and predict price and welfare changes resulting from platform mergers. I simulate hypothetical mergers to show that prices do move in either direction post merger. Welfare implications are markedly different from those predicted by standard one-sided models, highlighting the importance of accounting for two-sidedness in assessing merger effects. In particular, not only would platform mergers benefit some agents with lower post-merger prices but even agents who experience higher prices post merger would not be necessarily worse off as their willingness to pay for joining a platform can increase as a merged platform can attract more agents on the other side of the market. In other words, a demand curve for some agents can shift out post merger as a result of more agents joining the platform on the other side of the market.

I account for two key features of the two-sided market to provide accurate predictions of competitive effects of platform mergers. The first feature is that agents of each side care about the presence of agents on the other side. Some studies of two-sided markets assume that one of the two groups does not care about the presence of the other (Argentesi and Filistrucchi, 2007; Fan, 2013). Under this assumption a model would likely underestimate the price elasticity of demand if agents appreciate the presence of agents on the other side, which might result in predicting larger price effects post merger.

The second feature is that platforms charge access (or membership) fees to agents on both sides of the market. We observe free membership given to one group of agents in some two-

[4]When platforms already provide free access on one side, they may use non-price instruments to attract more agents on that side post merger. For example, Jeziorski (2014) shows that the 1996-2006 merger wave in the U.S. radio industry benefited listeners with an increased product variety.

sided markets such as the online search engine industry, the social media industry, the Yellow Pages (Rysman, 2004), and the radio industry (Jeziorski, 2014), but this zero price is often part of platforms' profit maximization strategies rather than an exogenous constraint. If zero price is taken as given, one cannot consider the possibility that platforms that previously granted free access start charging access fees post merger.[5]

By incorporating these two features of the two-sided market, my model allows price elasticities to account for so-called feedback loop effects that a price change triggers in two-sided markets. Suppose two groups, say group A and group B, appreciate the presence of each other on platforms. When a platform attracts more group A agents, say because of a lower price or due to a positive demand shock, this platform will attract more group B agents. The presence of a larger number of group B agents will in turn make the platform more valuable to group A agents and attract more group A agents, which will in turn help the platform attract more group B agents, and so on. This feedback loop should be accounted for in calculating the own and the cross price elasticities, and this can be done by treating a demand system as a system of implicit functions and calculating the price elasticities using the properties of implicit functions.

My model also accounts for the feedback loop effects in finding post merger equilibrium in merger simulations. However, there is a computational challenge arising because shares of agents allocated to each platform are not necessarily uniquely determined when the aforementioned two-sided features are incorporated in a model. In other words, there can be multiple sets of possible membership allocations among platforms at a given set of prices when agents on each side care about the presence of agents on the other side and platforms charge access fees on both sides of the market.[6] As explained in detail below, this allocation multiplicity does not complicate model estimation, as long as data on each platform's share of agents are available for both sides, but

[5]In Appendix IV, I analyze merger effects for two special cases of the two-sided market model. The first case is the setting where readers are indifferent about advertising, and the second case is the setting where publishers distribute magazines for free.

[6]White and Weyl (2012) propose a model in which firms charge "insulating tariffs" in order to avoid the allocation multiplicity.

imposes a computational challenge in running merger simulations because new equilibrium prices depend on which membership allocation is chosen. I handle the allocation multiplicity by finding as many membership allocations as possible, given prices, and choose the one that maximizes the industry-wide profit.[7]

Kaiser and Wright (2006) incorporate these two features of the two-sided market in the Hotelling model to study magazine advertising in Germany. They do not have to deal with the allocation multiplicity thanks to their Hotelling specification, but their model is only applicable to the setting of two platforms in the symmetric equilibrium. Filistrucchi and Klein (2013) consider the allocation multiplicity in a more general setting than the Hotelling model, but the focus of their study is to derive sufficient conditions for membership allocations to be unique, and the demand models they estimate satisfy these sufficient conditions. Hence, their empirical application is limited to the unique equilibrium case.

For an empirical application, I use data on TV magazines in Germany and estimate a competitive bottleneck model where advertisers advertise in as many magazines as they want (multi-homing), while readers choose one TV magazine (single-homing).[8] The two access fees platforms charge are copy prices charged to readers and ad prices charged to advertisers. The number of magazine copies sold and the number of ad pages are used as proxies for the number of readers and advertisers "joining" magazines.

For demand estimation I use the generalized method of moments (GMM), which is widely used to estimate structural demand models in the empirical industrial organization literature (Berry 1994; Berry, Levinsohn, and Pakes, 1995; and many others). However, there are two important differences. First, there are two demand equations to estimate, one for each side, and they need to be estimated jointly to obtain efficient estimates. Second, the size of agents on the other side of the market is part of platform attributes that determine demand and should be treated as an

[7] I use a continuation homotopy method, which finds multiple solutions in a system of nonlinear equations.

[8] My modeling approach is applicable to both two-sided single-homing settings and competitive bottleneck settings. In two-sided single-homing settings, agents on each side join only one platform.

endogenous variable.

Estimation results show that magazines typically lose money from selling magazine copies while making money from selling advertising space. The median magazine loses 2.5 Euros per copy from copy sales while making about 13,000 Euros per one-page advertising. When the advertising side is ignored, the same demand estimates imply the median markup for magazine sales is 50 percent. The results also show that the magnitude of the feedback loop effect is substantive such that the median own-price elasticity for readers, when computed without fully tracing the feedback loop, is less than 60 percent of the correctly calculated one.

Three patterns of price changes stand out in hypothetical merger simulations. First, copy prices are predicted to increase much more modestly than what the one-sided market model predicts. They even decrease in some cases. There still exists the upward pricing pressure coming from merged publishers internalizing substitution or diversion effects, i.e., recapturing some of their customers who switch away, following a price increase, with newly acquired magazines. However, merged publishers have weaker incentives to raise copy prices because they would lose some advertisers when they lose readers. It appears that the degree of competition within TV magazine segments is a good indicator for whether copy prices would increase or decrease post merger. Among three segments divided based on the publication frequency, copy prices most likely decrease in the weekly segment which has the largest number of TV magazines.

However, it does not mean that copy prices always increase less than what the one-sided market model predicts. The effect of internalizing the substitution effects can be amplified due to ad revenues associated with a merged publisher's newly acquired magazines. That is, a higher copy price of a merged publisher's magazine can make its newly acquired magazines more valuable for advertisers as these magazines can capture some of the readers who switch away from the magazine that becomes more expensive post merger.

Second, ad prices tend to move in the opposite direction to copy prices post merger.[9] This

[9] In this paper, I measure the ad price as the price that advertisers pay for one page of advertising per issue.

is consistent with merged publishers adjusting ad prices to account for changes in the size of the reader base. When a magazine gains readers from a lower copy price, merged publishers charge a higher ad price since that magazine becomes more valuable to advertisers. When a magazine loses readers from a higher copy price, merged publishers lower ad prices to compensate advertisers for a smaller reader base.

Third, the merged publisher may raise copy prices and ad prices at the same time, and this pattern is seen with the monthly magazines in all three pairwise mergers simulated in this paper and some bi-weekly magazines in one of the pairwise mergers. The monthly TV magazine segment is the least competitive segment where only two monthly magazines are on sales.

Welfare analyses indicate that platform mergers do not decrease consumer welfare as much as what the one-sided market model predicts. A merger that the one-sided market model predicts to decrease consumer welfare by 23 percent results in a 0.7 percent drop in consumer welfare in the two-sided market model. Moreover, among the three pairwise mergers, the one that the one-sided market model predicts to result in the largest reduction in consumer welfare does not lead to the worst welfare outcome in the two-sided market model. Welfare analyses also show that despite higher ad prices advertisers are not necessarily worse off because magazines usually attract "enough" extra readers with lower copy prices and larger reader bases shift out advertisers' demand curve such that advertisers' willingness to pay increases.

The estimation of platform markup and the analysis of platform mergers have been done in various industries, but none of these studies show that merged platforms would decrease prices post merger. For example, Filistrucchi and Klein (2013) run merger simulations for the Dutch daily newspaper market and find that prices would be predicted to increase on both sides of the market post merger when a demand system satisfies sufficient conditions for the unique membership allocation.[10] Filistrucchi, Klein, and Michielsen (2012) run merger simulations for the same market

[10] Affeldt, Filistrucchi, and Klein (2013) measure upward pricing pressure in a two-sided market setting for the Dutch daily newspaper market and show that publisher mergers would generate upward pricing pressure on both sides of the market.

and find that circulation prices would go up post merger while ad prices would not change. No price change on the advertising side in their study is due to the constant elasticity specification in which ad prices are unaffected by changes in demand on the reader side.[11] Unlike these studies, I show that a less restrictive two-sided market model would predict lower post-merger prices.

The paper is organized as follows: Section 2 presents a structural model of the two-sided market, followed by an estimation procedure in section 3. Section 4 presents empirical results and section 5 merger simulations. Section 6 concludes.

2 A Structural Model of Two-sided Markets

There are two groups of agents, groups A and B, and each group may like or dislike the presence of the other group on platforms. There are J platforms competing to attract agents from both sides. The feature that agents on both sides of the market care about the presence of agents on the other side distinguishes modeling platform demand from modeling demand for standard one-sided oligopoly markets. As a result, no matter whether agents single-home or multi-home, group A's platform demand affects group B's platform demand, and vice versa.

More formally, let $\mathbf{s} = \left(\mathbf{s}^A, \mathbf{s}^B\right)$ be platform demand in the form of platforms' market shares for groups A and B. Given platform quality, δ^A and δ^B, and prices that platforms charge on both sides, $\mathbf{p}^A$ and $\mathbf{p}^B$, demand for platform j can be written as

$$s_j^A = D_j^A\left(\mathbf{p}^A, \mathbf{s}^B, \delta^A | \Omega\right) \quad (1)$$

$$s_j^B = D_j^B\left(\mathbf{p}^B, \mathbf{s}^A, \delta^B | \Omega\right) \quad (2)$$

for $j = 1, ..., J$, where D_j^A and D_j^B are continuously differentiable functions and Ω is a set of model

[11] Rosse (1970) and Dertouzos and Trautman (1989) estimate demand and cost functions for circulation and advertising in the newspaper industry. Although these studies account for the first-order effects of changes in circulation on advertising and the first-order effects of changes in advertising on circulation, they do not incorporate full feedback loop effects in recovering cost functions.

parameters to estimate. Notice that s_j^A and s_j^B on the left-hand side are elements of $\mathbf{s}^A$ and $\mathbf{s}^B$ on the right-hand side of the equations.

Equations (1) and (2) show how the two groups of agents interact through platforms. Any events affecting the membership decisions of group A agents affect the membership decisions of group B agents as well. But the effect does not end here. Group B agents' membership decisions in turn affect group A agents' decisions, which also in turn affects group B agents' decisions, and so on. This chain effect is called a feedback loop in the two-sided market literature and should be accounted for in calculating price elasticities or running merger simulations.

Since $\mathbf{s} = \left(\mathbf{s}^A, \mathbf{s}^B\right)$ is a nonempty, closed, bounded, and convex subset of $\mathbf{R}^{2J}$ and the demand functions (D^A and D^B) are continuous, we know from Kakutani fixed-point theorem that, given $\mathbf{p} = \left(\mathbf{p}^A, \mathbf{p}^B\right)$, there exists at least one set of market shares that satisfies all of these $2 \times J$ equations at the same time.[12] Thus, I can treat observed market shares, $\mathbf{s}$, as one of those sets. However, there could be multiple sets of market shares that satisfy these equations for the same set of prices. Although this multiplicity does not present an additional challenge in estimating the model, it comes into play in computing platform markup and running merger simulations. I provide details on this issue in Section 2.3.

Platform j maximizes its profit by setting membership prices for the two groups, p_j^A and p_j^B. Assuming the constant marginal costs, c_j^A and c_j^B, platform j's profit is

$$\pi_j = \left(p_j^A - c_j^A\right) s_j^A M^A + \left(p_j^B - c_j^B\right) s_j^B M^B$$

[12] In principle, market shares can take the value of 0 or 1. In static demand models where entry and exit are not allowed, market shares take the value between 0 and 1, which makes the set of market shares an open set. In that case it should be assumed that an interior solution exists.

when it has a single platform, and the profit maximizing first-order conditions are

$$\frac{\partial \pi_j}{\partial p_j^A} = s_j^A M^A + \left(p_j^A - c_j^A\right)\frac{\partial s_j^A}{\partial p_j^A} M^A + \left(p_j^B - c_j^B\right)\frac{\partial s_j^B}{\partial p_j^A} M^B = 0 \tag{3}$$

$$\frac{\partial \pi_j}{\partial p_j^B} = s_j^B M^B + \left(p_j^B - c_j^B\right)\frac{\partial s_j^B}{\partial p_j^B} M^B + \left(p_j^A - c_j^A\right)\frac{\partial s_j^A}{\partial p_j^B} M^A = 0 \tag{4}$$

where M^A and M^B denote the market size for each side of the market, i.e., the total number of agents on each side. Recovering platform markup is equivalent to finding marginal costs that simultaneously satisfy this pair of the first order conditions for each platform. Note that the market size terms are not dropped from the profit maximization condition as in the one-sided market model and that the relative magnitude of the two market sizes affects marginal cost and platform profits estimates.[13]

2.1 Two Examples

Two-sided Single-homing Model Assume that agents of both groups choose to join a single platform for exogenous reasons. Any discrete choice demand models can be used to model agents' platform choices in this case. For simplicity, let's assume that agents on both sides are homogeneous but receive an idiosyncratic taste shock when they make a platform choice. If the taste shock is drawn from the Type I extreme value distribution, demand functions for platform j are

$$D_j^A\left(\mathbf{p}^A, \mathbf{s}^B, \mathbf{x}^A | \Omega\right) \equiv \frac{\exp\left(\mathbf{x}_j^A \beta^A + \alpha^A s_j^B - \lambda^A p_j^A + \xi_j^A\right)}{1 + \sum_{m=1}^{J} \exp\left(\mathbf{x}_m^A \beta^A + \alpha^A s_m^B - \lambda^A p_m^A + \xi_m^A\right)} \tag{5}$$

$$D_j^B\left(\mathbf{p}^B, \mathbf{s}^A, \mathbf{x}^B | \Omega\right) \equiv \frac{\exp\left(\mathbf{x}_j^B \beta^B + \alpha^B s_j^A - \lambda^B p_j^B + \xi_j^B\right)}{1 + \sum_{m=1}^{J} \exp\left(\mathbf{x}_m^B \beta^B + \alpha^B s_m^A - \lambda^B p_m^B + \xi_m^B\right)} \tag{6}$$

where α^A and α^B denote the (dis)utility of interacting with agents on the other side, λ^A and λ^B the disutility of price, $\mathbf{x}_j^A$ and $\mathbf{x}_j^B$ platform characteristics, ξ_j^A and ξ_j^B unobserved platform attributes

[13] In Section 4 I explain how I set the market size and how it affects cost and profit estimates.

that agents observe but researchers do not, and Ω is a set of parameters to estimate. Agents may choose the outside option of joining no platform and receive zero mean utility and the taste shock.

Competitive Bottleneck Model In the competitive bottleneck model, while one group, say group A, joins a single platform (single-homes), the other group, group B, deals with multiple platforms (multi-homes). Media advertising is a prominent example of the competitive bottleneck model and is also an empirical application in this paper. Group A agents are readers who consume media content and may or may not like advertising. Their platform demand can be described by a discrete choice model such as equation (5). Group B agents are advertisers who advertise on multiple platforms to reach as many readers as possible.

Following Armstrong (2006), I assume that multi-homing agents join a platform as long as their net benefits of joining it are positive. They may join multiple platforms if their net benefits of joining each platform are positive. I also assume that group B agents receive utility only from interacting with group A agents. Thus, unlike group A agents who receive utility from platforms' other attributes, group B agents do not have a reason to join a platform if it does not have agents from the other side.

Let α_i^B denote group B agents' type which is independently and identically distributed from $G\left(\alpha^B|\theta\right)$ and δ_j^B be a platform-specific "quality" perceived by group B agents. This quality represents a platform's attributes other than the number of agents it attracts from the other side. Given membership fee p_j^B, a type-α_i^B agent will join platform j as long as

$$\alpha_i^B \delta_j^B n_j^A - p_j^B \geq 0 \tag{7}$$

where n_j^A is the number of group A agents platform j attracts.[14] This equation shows that for the same number of group A agents, group B agents receive different values depending on their

[14]In equation (7), ad price is linear in circulation, which makes advertising demand a function of ad price per reader. This equation can be modified to allow ad price to be non-linear in circulation, but the distribution of α_i^B needs to be fixed to allow for a more flexible relationship between ad price and circulation.

types or willingness to pay for the interaction. It also shows that the platform quality can enhance or diminish group B agents' utility for all other things held fixed. In the media advertising case, this equation implies that advertisers advertise in a platform as long as advertising profitability is higher than the ad price they pay, and the advertising profitability can differ depending not only on the number of readers but also on who advertisers are and which platform they are on.[15]

Suppose platforms only know the distribution of α_i^B. Since each group B agent is ex ante identical, platform j will charge the same price p_j^B and the number of group B agents joining platform j is determined by

$$N_j^B\left(\mathbf{p}^B, \mathbf{s}^A, \delta^B, M^A, M^B|\Omega\right) = \left(1 - G\left(\frac{p_j^B}{\delta_j^B s_j^A M^A}|\theta\right)\right) M^B \tag{8}$$

Thus, group B agents' demand for platform j can be defined as

$$D_j^B\left(\mathbf{p}^B, \mathbf{s}^A, \delta^B, M^A, M^B|\Omega\right) \equiv \frac{N_j^B\left(\mathbf{p}^B, \mathbf{s}^A, M^A, \delta^B|\Omega\right)}{M^B}$$

Equation (8) shows that demand for platform j on the multi-homing side is not a function of other platforms' prices or attributes, indicating that each platform acts as a monopolist towards multi-homing agents. However, as shown below, platforms still compete indirectly on the multi-homing side through agents on the other side of the market. That is, when a platform changes its price on the multi-homing side, it affects demand for other platforms through changes in membership allocation on the single-homing side.

2.2 Price Elasticity

Because of the two-sidedness a few issues arise in the markup imputation. The first issue is how to compute the price elasticity in the presence of the feedback loop triggered by a price perturbation.

[15] In Rysman (2004), a representative advertiser chooses the ad quantity, while in my model advertisers are heterogeneous in their willingness to pay for one-page ad, and their main decision is whether to advertise in a given magazine or not. The advertiser heterogeneity explains why certain brands do not advertise in all magazines.

A solution is straightforward once the demand functions are re-written as a system of implicit functions. Let $F_1^A, F_1^B, F_2^A, F_2^B, ..., F_J^A, F_J^B : \mathbf{R}^{2J+2J} \to \mathbf{R}^1$ be

$$F_j^A(\mathbf{s}, \mathbf{p}) \equiv D_j^A\left(\mathbf{p}^A, \mathbf{s}^B, \delta^A | \Omega\right) - s_j^A = 0 \quad (9)$$

$$F_j^B(\mathbf{s}, \mathbf{p}) \equiv D_j^B\left(\mathbf{p}^B, \mathbf{s}^A, \delta^B | \Omega\right) - s_j^B = 0 \quad (10)$$

for $j = 1, ..., J$ where $\mathbf{s}$ are endogenous variables and $\mathbf{p}$ are control variables. An underlying assumption is that platforms control prices and market shares are determined by specified demand functions given prices. This implies that agents treat the number of participants from the other side as a platform attribute and platforms expect agents to behave in this way. This excludes the case where agents coordinating their membership decisions with agents on the other side. This is a reasonable assumption in many empirical settings, including media advertising where the number of agents is large enough to make coordination difficult.[16]

Since these functions are continuously differentiable, I can use the implicit function theorem

[16] Rochet and Tirole (2006) also treat the coordinated membership decision case as a rare case and exclude it from their analysis. See section 4 in Rochet and Tirole (2006).

to compute the price elasticity. For a price change by platform j

$$\begin{pmatrix} \partial s_1^A/\partial p_j^A & \partial s_1^A/\partial p_j^B \\ \partial s_1^B/\partial p_j^A & \partial s_1^B/\partial p_j^B \\ \vdots & \vdots \\ \partial s_J^A/\partial p_j^A & \partial s_J^A/\partial p_j^B \\ \partial s_J^B/\partial p_j^A & \partial s_J^B/\partial p_j^B \end{pmatrix} = - \begin{pmatrix} \partial F_1^A/\partial s_1^A & \partial F_1^A/\partial s_1^B & \cdots & \partial F_1^A/\partial s_J^A & \partial F_1^A/\partial s_J^B \\ \partial F_1^B/\partial s_1^A & \partial F_1^B/\partial s_1^B & \cdots & \partial F_1^B/\partial s_J^A & \partial F_1^B/\partial s_J^B \\ \vdots & \vdots & \ddots & \vdots & \vdots \\ \partial F_J^A/\partial s_1^A & \partial F_J^A/\partial s_1^B & \cdots & \partial F_J^A/\partial s_J^A & \partial F_J^A/\partial s_J^B \\ \partial F_J^B/\partial s_1^A & \partial F_J^B/\partial s_1^B & \cdots & \partial F_J^B/\partial s_J^A & \partial F_J^B/\partial s_J^B \end{pmatrix}^{-1}$$

$$\times \begin{pmatrix} \partial F_1^A/\partial p_j^A & \partial F_1^A/\partial p_j^B \\ \partial F_1^B/\partial p_j^A & \partial F_1^B/\partial p_j^B \\ \vdots & \vdots \\ \partial F_J^A/\partial p_j^A & \partial F_J^A/\partial p_j^B \\ \partial F_J^B/\partial p_j^A & \partial F_J^B/\partial p_j^B \end{pmatrix}, \quad (11)$$

provided that the inverse matrix is non-singular. Notice that, were it not for the two-sidedness, this inverse matrix on the right hand side of (11) would not be needed to calculate the price elasticity.

Notice also that in the competitive bottleneck model $\partial s_j^B/\partial p_k^B$ for $j \neq k$ is not necessarily equal to zero, although $\partial F_j^B(.)/\partial p_k^B = 0$ for $j \neq k$. A non-zero cross-price elasticity on the multi-homing side means a price change by one platform for multi-homing agents affects their demand for other platforms.

Other studies in the literature usually approximate the price elasticity by accounting for only the direct impact of a price change on s_j^A and s_j^B. That is,

$$\begin{aligned} \frac{\partial s_j^A}{\partial p_j^A} &\approx \frac{\partial D_j^A(.)}{\partial p_j^A} \quad (12) \\ \frac{\partial s_j^B}{\partial p_j^A} &\approx \sum_{k=1}^{J} \frac{\partial D_j^B(.)}{\partial s_k^A} \frac{\partial D_k^A(.)}{\partial p_j^A} \\ \frac{\partial s_j^A}{\partial p_j^B} &\approx \sum_{k=1}^{J} \frac{\partial D_j^A(.)}{\partial s_k^B} \frac{\partial D_k^B(.)}{\partial p_j^B} \end{aligned}$$

This is a particularly poor approximation for the competitive bottleneck model because it ignores possible indirect competition between platforms on the multi-homing side. In Appendix I, I numerically evaluate the accuracy of this approximation using Monte Carlo simulations.

2.3 Multiplicity in Membership Allocation

Another challenge in the markup imputation is handling multiplicity in market shares (membership allocations). Suppose that the demand functions, $D_j^A(\mathbf{p}^A, \mathbf{s}^B, \delta^A|\Omega)$ and $D_j^B(\mathbf{p}^B, \mathbf{s}^A, \delta^B|\Omega)$, are such that given $(\mathbf{p}^A, \mathbf{p}^B)$, there always exist two sets of $(\mathbf{s}^A, \mathbf{s}^B)$ that satisfy equations (1) and (2). Although researchers observe $(\mathbf{s}^A, \mathbf{s}^B)$ in data, they do not know which set of membership allocations it belongs to. A simple solution to this problem would be to assume a selection rule for observed $(\mathbf{s}^A, \mathbf{s}^B)$ such as choosing the one that maximizes an industry-wide profit.

However, the allocation multiplicity could still present a challenge in running counterfactual exercises. Consider a merger simulation where two platforms merge and set new prices. While searching for new equilibrium prices, all possible sets of $\left(\mathbf{s}^A, \mathbf{s}^B\right)$ should be found for every trial value of prices before selecting the one that maximizes joint profits. This task is equivalent to finding all solutions of a system of nonlinear equations as many times as the number of trial sets of prices, which is a non-trivial, if not impossible, task.

Nevertheless, there are sufficient conditions that researchers can check to determine if there exists a unique set of $(\mathbf{s}^A, \mathbf{s}^B)$ for given prices. One of them is Gale-Nikaido (1965) Univalence Theorem which (roughly) states that a function from a convex set $X \subset R^m$ to R^m is one to one if the Jacobian of this function is negative quasidefinite for all $x \in X$.[17] This theorem implies that equations (9) and (10) have a unique (interior) solution when the Jacobian of these equations is negative quasidefinite for all non-boundary values of $\mathbf{s}$ (for all $0 < s_j < 1$, $j = 1, ..., J$).

[17] An $m \times m$ matrix A is negative quasidefinite if $B = A + A^T$ is negative definite.

In the two platform case the Jacobian matrix is

$$J=\begin{pmatrix} -1 & \partial D_1^A/\partial s_1^B & 0 & \partial D_1^A/\partial s_2^B \\ \partial D_1^B/\partial s_1^A & -1 & \partial D_1^B/\partial s_2^A & 0 \\ 0 & \partial D_2^A/\partial s_1^B & -1 & \partial D_2^A/\partial s_2^B \\ \partial D_2^B/\partial s_1^A & 0 & \partial D_2^B/\partial s_2^A & -1 \end{pmatrix}$$

In the two-sided single-homing example in Section 2.1,

$$\begin{aligned} \frac{\partial D_j^A}{\partial s_j^B} &= \alpha^A D_j^A \left(1-D_j^A\right) \\ \frac{\partial D_j^A}{\partial s_k^B} &= \alpha^A D_j^A D_k^A, \qquad j\neq k \end{aligned}$$

and $\partial D_j^B/\partial s_j^A$ and $\partial D_j^B/\partial s_k^A$ are similarly defined. One can show that this Jacobian is negative quasidefinite for all market shares for $\left\{\left(\alpha^A,\alpha^B\right)|-2\leq\alpha^A\leq 2 \text{ and } -2\leq\alpha^B\leq 2\right\}$. Recall that α^A and α^B represent consumers' preferences for interacting with agents on the other side. In the competitive bottleneck model, while $\partial D_j^A/\partial s_j^B$ and $\partial D_j^A/\partial s_k^B$ are defined the same as in the two-sided single-homing model,

$$\begin{aligned} \frac{\partial D_j^B}{\partial s_j^A} &= \frac{p_j^B}{\delta_j^B M^A \left(s_j^A\right)^2} g\left(\frac{p_j^B}{\delta_j^B s_j^A M_A}|\theta\right) \\ \frac{\partial D_j^B}{\partial s_k^A} &= 0, \qquad j\neq k \end{aligned}$$

where $g\left(.\right)$ is the *pdf* of the group B agent's type distribution. As in the former model the uniqueness also depends on the preference for interacting with the other side agents and the bigger that preference is, the less likely the membership allocation is unique.

When this sufficient condition is not satisfied, one may use various computational methods to try to find all sets of membership allocations in every iteration of price search. Unfortunately, no computational methods can guarantee finding all solutions of a system of nonlinear equations, unless it is a system of polynomial equations (see Judd, Renner, and Schmedders, 2012). Nevertheless, one can use such a method as continuation homotopy methods to find as many membership allocations as possible and select one of them based on a criterion such as maximizing the industry-wide profit.[18] I discuss computational issues associated with the allocation multiplicity in detail in Section 5 and Appendix II.

3 Estimation

Estimating a demand system of two-sided markets (equations (1) and (2)) is equivalent to estimating a system of equations with two endogenous variables. The two endogenous variables are the price variable, which is a usual endogenous variable in demand estimation, and platforms' membership share on the other side of the market, which is $\mathbf{s}^B$ in the demand equation for group A and $\mathbf{s}^A$ in the demand equation for group B in equations (1) and (2). For the second endogenous variable, researchers should find additional instrumental variables that are not correlated with demand shocks but correlated with platforms' market shares on the other side. With such instrumental variables, one can use the generalized method of moments (GMM) to consistently estimate the demand system.

The presence of multiple membership allocations does not make the demand estimation more challenging than the standard GMM estimation. No matter how many sets of allocations there may be, researchers do observe one of them in each market. Given this observed set of allocations, all they need for identification is valid instrumental variables. This even means that researchers do not need to use both sides to consistently estimate demand for either side, although the efficiency improves by simultaneously estimating the two equations.

It is interesting to compare the multiplicity that arises in the two-sided market model with

[18] Bajari, Hong, Krainer, and Nekipelov (2012) use all-solution homotopy to find all equilibria in static games of incomplete information.

multiple equilibria in static entry games of incomplete information. Consider a static entry game of incomplete information with two firms. Firm 1's probability of entry is a function of firm 2's probability of entry, and vice versa, and these probability functions look similar to equations (5) and (6) if the type I extreme value distribution is assumed. The key difference, however, is that researchers do not observe the entry probabilities and should compute them as a solution to the entry game when estimating the entry model. However, they are not guaranteed to obtain the equilibrium that satisfies the same selection rule in every market.

Once demand estimates are obtained, I can solve equations (3) and (4) for the marginal costs as

$$\begin{pmatrix} c_j^A \\ c_j^B \end{pmatrix} = \begin{pmatrix} p_j^A \\ p_j^B \end{pmatrix} + \begin{pmatrix} M^A \partial s_j^A / \partial p_j^A & M^B \partial s_j^B / \partial p_j^A \\ M^A \partial s_j^A / \partial p_j^B & M^B \partial s_j^B / \partial p_j^B \end{pmatrix}^{-1} \begin{pmatrix} s_j^A M^A \\ s_j^B M^B \end{pmatrix}$$

when platform j owns a single platform. Note that in the case of multiple membership allocations the estimated marginal costs are assumed to satisfy a selection criterion that researchers choose for their counterfactual exercises.

4 Empirical Application: Magazine Advertising

4.1 Data

I use data on magazines published in Germany from 1992 to 2010 to estimate the competitive bottleneck model described in Section 2.1. Magazines are platforms that serve readers on one side and advertisers on the other side. Advertisers care about the size of the reader base, while readers may or may not like advertising.

My empirical analysis is focused on TV magazines, which are categorized by Germany's Information Association for the Determination of the Spread of Advertising Media, a non-profit public institution equivalent to the US Audit Bureau of Circulation. The data used in this paper are the same data used in Kaiser and Song (2006) and Chandra and Kaiser (2014) and include quarterly information on copy prices, ad prices, the number of ad pages, the number of content pages, circulation, and other characteristics.[19] The number of content pages, the number of ad pages, and circulation are aggregated for each quarter, while the per-issue copy price and the per-page ad price are averaged for each quarter. Magazines are published at different frequencies. About 65% of TV magazines are published weekly, 28% bi-weekly and the remaining 7% monthly. In the absence of information on regions in which TV magazines are sold, I assume all TV magazines are sold nationally.

Table 1 shows the summary statistics at a yearly level. The table shows a circulation-weighted average and a standard deviation for each variable. I first average each variable across magazines using circulation as weights for each quarter and then simply average this weighted average across quarters for each year. For the number of magazines I report the number of magazines sold in the first quarter of each year. The ad price is an average price that advertisers pay for one page of advertising per issue. Magazines charge different prices depending on whether advertising is in color or not, but I use the average of these two prices because the data do not provide information on the number of colored ad pages. The table shows that one page of advertising is sold at around thirty thousand euros, while each copy is sold at around one euro.

I treat all magazines as if they were selling a bundle of issues in each quarter. For example, I assume monthly magazines are selling a bundle of three issues and bi-weekly magazines are selling a bundle of seven issues, and so on. This assumption implies that consumers decide which magazine to read each quarter and buy all issues of the magazine they choose in a given quarter. To be consistent with this assumption, I multiply the copy price by the number of issues and divide quarterly circulations by the number of issues in calculating market shares. For example, if the data show a monthly magazine sold 1.5 million copies in a quarter, my assumption implies that 500,000 consumers bought three issues of this magazine and paid the copy price three times in that

[19]The data were collected and generously shared by Ulrich Kaiser at the University of Zurich (ulrich.kaiser@business.uzh.ch). He collected the data from http://medialine.focus.de, which had been updating the data quarterly from 1972. The website no longer exists.

quarter.

I make the same assumption for advertisers. If an advertiser chooses to advertise in a monthly magazine in a given quarter, he buys one ad page in each issue and pays the per-page ad price three times that quarter. This means that the number of advertisers is the number of ad pages divided by the frequency. For example, 300 ad pages in a given quarter by a monthly magazine means 100 advertisers advertised in this magazine in that quarter.[20]

Table 1 shows that the TV magazine circulation dropped sharply over the sample period. The average circulation was over 2 million in the early 1990s but dropped to about 1.4 million in 2010. The number of ad pages also dropped sharply during this period. The average number of ad pages dropped from 375 pages in 1992 to 157 pages in 2010. Given such dramatic changes, I include the time fixed effects to account for a declining demand for TV magazines in Germany when estimating the magazine-level demand.

TV magazines in Germany typically earn much larger revenues from selling ad space than from selling copies. Over the sample period, the average quarterly revenue from selling copies was about 1.5 million euros, while the advertising revenue was 7.5 million euros. In the one-sided market model the copy price must cover the marginal cost of publication for magazines to stay in business. This is not necessary in the two-sided market model. Magazines can still make profits, while charging readers below the marginal cost, and my estimation results below show that that is what TV magazines in Germany do to stay in business.

During the sample period seven publishers published 19 magazines in total, seven of which remained in the market for the entire sample period. Table 1 shows that the number of magazines increased from 10 to 17 by 2005 and dropped to 15 in 2006 and stayed at that level until the end of the sample period. However, the market became much more concentrated in the late 2000s. In 1992 six publishers published ten magazines, and added five magazines by 2000. Then, Gong

[20] An alternative approach would be to assume that consumers and advertisers make decisions for each issue. Under this assumption I need to make slight modifications in calculating market shares. However, it does not significantly change empirical results.

Verlag GmbH & Co. KG (GVG), which had been publishing a weekly magazine *DieZwei* and a biweekly magazine *TVdirekt*, was acquired by WAZ Verlagsgruppe (WAZ). In 2002 Michael Hahn Verlag (MHV) entered the market with a monthly magazine *nurTV* and soon exited the market in 2005, selling its magazine to WAZ. In 2004 Hubert Burda Media (HBM) acquired Verlagsgruppe Milchstrasse's (VM) and took over its two TV magazines. From 2006 only four publishers, Axel Springer Verlagsgruppe (ASV), Bauer Media KG (BMK), HBM and WAZ, remained in the market.[21] Almost all publishers publish a mixture of different frequency magazines. For example, WAZ publishes two weekly magazines, one bi-weekly magazine and one monthly.

The weekly magazine is the most competitive segment in the TV magazine market, whereas the monthly segment is the least competitive. In the third quarter of 2009, one of the periods for which merger simulations are run, the weekly segment had nine magazines, the bi-weekly four magazines, and the monthly only two magazines. The two monthly TV magazines were sold by BMK and WAZ.

The bi-weekly segment sells more magazines and advertising space than the other two segments. The weekly and the monthly segments are similar in terms of the number of readers and advertisers they capture. In the third quarter of 2009 the total sales of bi-weekly magazines were close to three times as large as those of weekly or monthly magazines. On the advertising side, while the monthly and the weekly magazines have less than 10 pages of advertisements per issue on average, the bi-weekly magazines have more than 30 pages of advertisements per issue.

The TV magazine publishers also publish magazines in other magazine markets such as women, business and politics, adult, automotive, etc. An exception is WAZ, which only publishes women's magazines and pet magazines other than TV magazines. I exploit this multi-market feature in constructing instrumental variables. For example, the prices of magazines in different magazine markets that are published by the same publisher can be used as IVs for the price variable, because they are likely to be correlated through common publisher cost factors, but demand shocks

[21] Two magazines published by Hubert Burda Media are excluded from the sample from 2006 because their attribute data are missing. This explains a drop in the number of magazines from 17 to 15 in 2006 in Table 1.

are unlikely to be correlated across the markets.

4.2 Demand Estimation: Competitive Bottleneck Model

I use the competitive bottleneck model to estimate magazine demand for readers and advertisers. In this model readers are assumed to single-home while advertisers multi-home.[22] The multi-homing assumption for advertisers is reasonable because the same advertisement often appears in multiple magazines. The single-homing assumption for readers is also reasonable for the TV magazine market, because its main content is TV programs and consumers would not need multiple TV magazines for the same TV program.[23] The Monte Carlo simulations in Appendix I show that platforms charge much higher prices to multi-homing agents than single-homing counterparts when the mean platform quality is the same for both groups of the agents. This is consistent with the magazine data described above.

For the reader side, I partition the whole set of TV magazines into multiple disjoint subsets based on the frequency of publication and estimate a nested logit demand model. Out of 19 magazines that have ever been published during the sample period, 11 magazines are weekly, 6 magazines bi-weekly, and 2 magazines monthly. This nested logit model allows readers' preferences to be more highly correlated across TV magazines published at the same frequency and thus allows for more reasonable substitution patterns as compared to the simple logit model.[24]

The indirect utility of reader i for magazine j in group g in period (market) t can be written as

$$u^A_{ijt} = \mathbf{x}^A_{jt}\beta^A + \alpha^A s^B_{jt} - \lambda p^A_{jt} + \xi_{jt} + \zeta_{igt} + (1-\tau)\,\varepsilon_{ijt}$$

[22] As explained in Section 4.1, TV magazines are published on three different frequencies, and because of the way that I aggregate data, the single-homing assumption means that readers choose at most one TV magazine title per quarter.

[23] Although the competitive bottleneck model is considered as the standard model for media advertising in the two-sided market literature, some recent studies allow readers to multi-home as well. See Anderson, Foros, Kind and Peitz (forthcoming) and Fan (2013).

[24] I also estimated a random coefficient logit model, a.k.a. the BLP model, but none of the random coefficient estimates were statistically significant.

where $\mathbf{x}_{jt}^A$ is a vector of observed magazine attributes relevant for readers, s_{jt}^B the share of advertisers who advertise in magazine j, p_{jt}^A magazine copy price, ξ_{jt} unobserved demand factors, and ε_{ijt} represents the idiosyncratic shock from the Type I extreme value distribution.[25] ζ_{ig} is reader $i's$ utility that is common to all TV magazines in group g. Cardell (1997) shows that if ε_{ijt} is an extreme value random variable, $\zeta_{igt} + (1-\tau)\,\varepsilon_{ijt}$ is also an extreme value random variable and that τ determines the degree of the within-group correlation of utility. The outside option ($j = 0$) is not to buy any TV magazine and its utility is set to zero. The characteristics variables I include in $\mathbf{x}^A$ are the magazine dummies, the time fixed effect, and the number of content pages. I use the magazine-level dummy variable for 16 magazines that were sold for more than 24 quarters.[26].

With the distributional assumption on ε_{ijt} I have the following demand equation for readers.

$$\log\left(s_{jt}^A\right) - \log\left(s_{0t}^A\right) = \mathbf{x}_{jt}^A\beta + \alpha^A s_{jt}^B - \lambda p_{jt}^A + \tau \log\left(s_{jt|g}^A\right) + \xi_{jt} \tag{13}$$

where s_{0t}^A denotes the share of the outside option and $s_{jt|g}^A$ the within-group market share. Both the copy price and the advertiser share are endogenous variables that are correlated with unobserved demand factors. The within-group market share is an endogenous variable by construction.

For the advertiser side, I assume that an advertiser, whose type is α_i^B, buys one ad page if its net profit from advertising is positive. The advertising profit is defined as

$$\pi_{ijt}^B = \alpha_i^B \delta_{jt}^B n_{jt}^A - p_{jt}^B$$

where p_{jt}^B is the per-page ad price magazine j charges to advertisers, n_{jt}^A the number of readers who choose magazine j, and δ_{jt}^B advertisers' per-reader profit resulting from one page advertising. This modeling approach adopts the standard assumption in the two-sided market literature that advertisers' advertising decision regarding one magazine is independent of its advertising decision

[25] The share of advertisers is the same as the share of ad pages in this paper. Because I do not observe advertisers' identity in the data, I assume that each advertiser decides whether to buy one page ad or not.

[26] With the magazine fixed effects that add two more dummy variables, about a third of the dummy estimates are insignificant. However, all other estimates do not change substantially.

regarding other magazines. As explained in sections 2.1 and 2.2, although this assumption implies there is no direct competition among magazines to attract advertisers, a change in a magazine's ad price can still affect the amount of advertising in other magazines through indirect network externalities. In other words, as long as readers care about advertising, the cross-price elasticity is not zero on the advertiser side even in the absence of direct competition among magazines for advertisers.[27]

Given the distribution of advertiser type, $F(\alpha|\theta)$, the share of advertisers advertising in magazine j, s_{jt}^B, is determined by

$$s_{jt}^B = \left(1 - F\left(\frac{p_{jt}^B}{\delta_{jt}^B n_{jt}^A}|\theta\right)\right) \tag{14}$$

where θ is a "non-linear" parameter in the GMM estimation. I assume that the advertiser type is distributed log normal and that the mean platform quality, obtained by inverting equation (14), is a linear function of platform characteristics relevant to advertisers, *i.e.*,

$$\delta_{jt}^B(\theta) = \mathbf{x}_{jt}^B \beta^B + e_{jt} \tag{15}$$

where $\mathbf{x}_{jt}^B$ denotes platform characteristics relevant to advertisers. The characteristics variables I include in $\mathbf{x}_{jt}^B$ are the magazine dummies for the 16 magazines that were sold for more than 26 quarters, the time fixed effect, and the number of content pages.

Note that because the utility of not advertising is assumed to be zero (see equation (7)), the location parameter in θ is normalized to be zero, *i.e.*, $F(\alpha|\theta) \sim LN\left(0, \sigma^2\right)$. The reason for this normalization is easier to see when it is assumed $\log\left(\delta_{jt}^B\right) = \mathbf{x}_{jt}^B \gamma + e_{jt}$. Under the log normal

[27]The cross-price elasticity on the advertiser side is positive when readers like advertising and negative when readers dislike advertising.

assumption, equation (14) can be re-written as

$$s_{jt}^{B}=1-\Phi\left(\frac{1}{\sigma}\left(\log\left(\frac{p_{jt}^{B}}{\delta_{jt}^{B}n_{jt}^{A}}\right)-\mu\right)\right)$$

where $\Phi\left(.\right)$ is the *cdf* of the standard normal distribution. From this equation, one can show that

$$\log\left(\frac{p_{jt}^{B}}{n_{jt}^{A}}\right)=\mu+\mathbf{x}_{jt}^{B}\gamma+\sigma\left(\Phi^{-1}\left(1-s_{jt}^{B}\right)\right)+e_{jt}$$

which can be interpreted as an inverse demand function for the multi-homing agents. This transformation shows that μ is not separable from the constant term in $\mathbf{x}_{jt}^{B}$.

Lastly, I need to set the market size for each side of the market, M^A and M^B, *i.e.*, the number of agents who can potentially join platforms. As explained in Section 2, platform markup is a function of the relative market size of the advertiser side to the reader side, among other things. As the advertiser-side market size grows, advertisers' willingness to pay is estimated to be larger, which results in a higher platform markup.[28] Thus, the market-size assumption is much less innocuous than in one-sided market models.

I account for the effects of the market size on publishers' long-run variable profits in choosing the market size. An arbitrarily large advertiser-side market size can push down platforms' implied advertiser-side marginal cost below zero. A market size below a certain level, on the other hand, can increase the implied marginal cost beyond a point of making publishers break even in the long run.[29] Thus, I choose the smallest integer for the number of potential advertisers that makes all but one publishers' net present value of variable profits for the entire sample period non-negative.[30]

[28] A larger market size for advertisers makes the share of advertisers who choose to advertise smaller, which pushes those advertisers' "positions" under the willingness-to-pay distribution towards the right tail.

[29] Platforms' variable profits are not guaranteed to be positive as the loss on the reader side can be larger than the profits on the advertiser side. See the next section for details.

[30] Merger simulation results do not appear sensitive to different market sizes as long as all but one publishers' net present value of variable profits are non-negative. However, when the advertiser-side market size becomes smaller such that fewer publishers make profits over the sample period, the magnitude of price changes resulting from a merger becomes smaller. In Appendix III I show how estimation and simulation results are affected by different choices of the market size.

One publisher who fails to break even is GVG who was acquired by WAZ in 2001. For the reader side I assume that the number of potential readers is 40 million, about half of the total population in Germany.

I use the GMM to simultaneously estimate equations (13) and (15). Moment conditions are the demand residuals in these two equations, $(\boldsymbol{\xi}, \boldsymbol{e})$, are not correlated with the number of content pages, the time (quarter) fixed effects, and the magazine dummy variables. For the endogenous variables I use the same and rival publishers' (average) copy and ad prices and the amount of advertising in other magazine segments such as women's magazines, automotive magazines, computer magazines, business and politics magazines, and adult magazines as instruments. An identifying assumption is that prices and the amount of advertising are correlated across these magazine segments through common cost shocks, but demand shocks are not correlated across these segments.

As the simplest case, consider a publisher publishing magazines in two different magazine segments. When this publisher receives a cost shock, its copy prices in both segments are affected, resulting in price correlation across the segments. But when the publisher receives a demand shock in one segment, its impact will likely be confined to that segment. The same argument can be applied to advertising. Hence, under the assumption that demand shocks or per-period magazine-level unobserved attributes are not correlated across the segments, the price and advertising in other segments can be used as instruments.[31]

I test if these instruments are weak IVs with the first stage F-test. For the reader side the F-statistic on the excluded instruments is 188.22 for the price variable, 26.00 for the advertiser share variable, and 69.66 for the log of the within-group market share variable. For the advertiser side the dependent variable in the first stage F-test is the derivative of δ_{jt}^{B} with respect to σ and the F-statistic on the excluded instruments differs depending on the weight used in the GMM estimation. For the two weighting matrices I chose, the F-statistic is over 10: it is 32.94 with $(\mathbf{Z}'\mathbf{Z})^{-1}$ as a weighting matrix where $\mathbf{Z}$ is an IV matrix and 14.76 with the optimal weighting matrix. I also test

[31] The same identification strategy is used in Kaiser and Song (2009).

the overidentifying restrictions and accept them with the test statistics close to zero.

4.3 Demand Estimates

Table 2 reports estimation results for the competitive bottleneck model where the nested logit and the IV logit models are used as the readier-side demand model. In the IV logit model I treat the price and the advertising variables as endogenous and use the same instruments as in the nested logit model. For both models the number of potential readers is set to 40 million, and I iterate estimating marginal cost and variable profits for a range of integers for the advertiser-side market size until I find the smallest integer that makes all but one publishers' long-run variable profits non-negative. In the nested logit model this integer is estimated to be 170 with $(\mathbf{Z}'\mathbf{Z})^{-1}$ as a weighting matrix and 152 with the optimal weighting matrix, meaning that there are 170 (152) potential advertisers and each magazine can have up to 170 (152) pages of advertising per issue. Note that ad pages reported in Table 1 are the aggregated number in each quarter, and per-issue ad pages are no larger than 148. The magazine dummy variables and the time fixed effects are included in all estimations but are not reported in Table 2.

For each model I report OLS regression results, labeled *OLS*, and results for GMM with $(\mathbf{Z}'\mathbf{Z})^{-1}$ as a weighting matrix, labeled *System IV*, and GMM with the optimal weighting matrix, labeled *GMM*. Note that the system IV estimation is the same as estimating the two demand equations separately. All estimates reported in Table 2 are statistically significant at the 5 percent significance level, and their magnitude is not substantially different between the nested logit model and the IV logit model. However, the estimate for the within-group correlation is 0.32 in *System IV* and 0.29 in *GMM*, implying a higher degree of substitution among magazines published with the same frequency and, thus, supporting the nested logit model as a better model for readers' magazine choices. In what follows I focus on the nested logit model.

The price coefficient for readers is -0.11 in the OLS regression and goes down to -0.13 in *System IV* and to -0.14 in *GMM*. The price parameter for advertisers is the standard deviation of the log normal distribution of α_i^B, which is advertisers' willingness to pay per reader. Its estimate is 1.43 in *System IV* and 1.36 in *GMM* respectively. The estimate for readers' ad preference is 1.42 in the OLS regression and goes up to 3.33 in *System IV* and to 2.86 in *GMM*, implying that readers of TV magazines like advertising.[32] These estimates imply that readers appreciate about seven additional advertisers (ad pages) per issue as much as a one euro discount in a quarter. The content page variable has a positive coefficient for readers but has a negative coefficient for advertisers. These estimates suggest that for given content quality, adding more content pages does not hurt copy sales, while it may drive away some advertisers.

The magazine dummy variables capture time-invarying magazine quality. For readers it represents the mean utility or popularity that is not explained by the amount of advertising and the number of content pages. For advertisers it represents per-reader profitability. Estimates show that magazines with higher per-reader profitability for advertisers do not necessarily provide higher quality contents to readers, and vice versa. For example, the most profitable magazine for advertisers is the lowest quality magazine for readers. The correlation coefficient between the two rankings of the dummy estimates, one for readers and the other for advertisers, is 0.20 with the system IV estimates and 0.26 with the GMM estimates. Note, however, that due to the indirect network externality a change in a platform's quality on one side affects its market share on the other side of the market, and thus the return of investment to improve platform quality should be assessed in the framework of the two-sided market as well.

4.4 Elasticity and Markup

Table 3 summarizes price elasticities calculated using the GMM estimates in the nested logit model (the last column of Table 2). The left panel shows the own-price elasticities in the one-sided model ($\frac{\partial D_j^A}{\partial p_j^A}\frac{p_j^A}{s_j^A}$ and $\frac{\partial D_j^B}{\partial p_j^B}\frac{p_j^B}{s_j^B}$), which do not account for the feedback loop effect. The right panel shows the

[32]The fact that the advertising coefficient goes up with IVs does not necessarily mean that the advertising variable is negatively correlated with the demand residual. When there are multiple endogenous variables, it is not straightforward to predict the sign of inconsistency based on the OLS estimates.

price elasticities in the two-sided model, including the own-price elasticities for readers ($\frac{\partial s_j^A}{\partial p_j^A}\frac{p_j^A}{s_j^A}$) and advertisers ($\frac{\partial s_j^B}{\partial p_j^B}\frac{p_j^B}{s_j^B}$) and the cross-group price elasticities ($\frac{\partial s_j^A}{\partial p_j^B}\frac{p_j^B}{s_j^A}$ and $\frac{\partial s_j^B}{\partial p_j^A}\frac{p_j^A}{s_j^B}$). The latter measures a percent change in the number of readers (advertisers) of magazine j from one percent change in its ad (copy) price.

Table 3 shows that the same demand estimates result in markedly different price elasticities, depending on whether the two-sidedness is accounted for. Compared to the one-sided model, the median own-price elasticity is 73 percent higher (in absolute term) for readers and 65 percent higher for advertisers. The comparison of the own-price elasticity distribution shows that this relationship holds true for most observations, but it can be reversed as the comparison of the own-price elasticities at the 20 percent quintile shows.

The cross-group elasticities show that advertisers are much more sensitive than readers to a price change on the other side of the market. The median cross-group elasticity with respect to copy prices, $\left(\frac{\partial s_j^B}{\partial p_j^A}\frac{p_j^A}{s_j^B}\right)$, is -5.26 while it is -0.52 with respect to ad prices, $\left(\frac{\partial s_j^A}{\partial p_j^B}\frac{p_j^B}{s_j^A}\right)$.[33] This implies that the reader-side markup is more sensitive to price changes on the other side of the market than the advertiser-side markup. To show this, I re-arrange equations (3) and (4) as follows:

$$\begin{aligned}
\left(p_j^A - c_j^A\right) &= -p_j^A\left(\frac{\partial s_j^A}{\partial p_j^A}\frac{p_j^A}{s_j^A}\right)^{-1} - \left(p_j^B - c_j^B\right)\left(\frac{\partial s_j^B}{\partial p_j^A}\frac{p_j^A}{s_j^B}\right)\left(\frac{\partial s_j^A}{\partial p_j^A}\frac{p_j^A}{s_j^A}\right)^{-1}\frac{n_j^B}{n_j^A} \\
\left(p_j^B - c_j^B\right) &= -p_j^B\left(\frac{\partial s_j^B}{\partial p_j^B}\frac{p_j^B}{s_j^B}\right)^{-1} - \left(p_j^A - c_j^A\right)\left(\frac{\partial s_j^A}{\partial p_j^B}\frac{p_j^B}{s_j^A}\right)\left(\frac{\partial s_j^B}{\partial p_j^B}\frac{p_j^B}{s_j^B}\right)^{-1}\frac{n_j^A}{n_j^B}
\end{aligned}$$

where $n_j^A = s_j^A M^A$ and $n_j^B = s_j^B M^B$ and plug the median elasticities into these equations to have

$$\begin{aligned}
\left(p_j^A - c_j^A\right) &= 0.29p_j^A - 1.50\left(p_j^B - c_j^B\right)\frac{n_j^B}{n_j^A} \\
\left(p_j^B - c_j^B\right) &= 0.45p_j^B - 0.24\left(p_j^A - c_j^A\right)\frac{n_j^A}{n_j^B}
\end{aligned}$$

[33] Whether readers like or dislike advertising changes the sign of the cross-group elasticity. If readers dislike advertising, $\partial s_j^A/\partial p_j^B$ becomes positive. If readers are indifferent about advertising, it becomes zero.

These equations show that the first-order effect of a change in the advertiser-side markup by 1 euro, say from a cost shock, results in a 1.5 euro lower markup for readers while the same change in the reader-side markup induces only a 0.24 euro lower markup for advertisers. Of course, in order to obtain the equilibrium markup these equations should be solved simultaneously.

As explained above, the cross-price elasticity on the advertiser side is non-zero, $(\frac{\partial s_j^B}{\partial p_k^B})(\frac{p_k^B}{s_j^B}) \neq 0$, $j \neq k$, as long as readers care about advertising. Because readers like advertising in TV magazines, the cross-price elasticity is positive, which means that magazines, despite being modeled as monopolists towards advertisers, compete against each other.

Table 4 reports the per-issue marginal cost and markup. The left panel reports the marginal cost and markup of selling TV magazine copies in the one-sided model. Estimates show that the median marginal cost is 0.49 euros and 80 percent of magazines are produced at lower than 0.70 euros. These estimates imply that it costs about 0.50 euros to produce an over 100-page magazine and 0.65 euros to produce a 200-page magazine. The median percentage markup is 54 percent with more than 40 percent of magazines having higher than a 60 percent markup.

The right panel of Table 4 reports the marginal cost and markup that account for the two-sidedness. Although the same demand estimates are used, the cost and markup estimates are drastically different. The median cost is now 3.50 euros, which results in a negative markup (-2.50 euros). In fact, 90 percent of TV magazines (in terms of the number of observations) are estimated to incur a loss from selling their copies. However, most of this loss is recovered from selling advertising space. The median magazine earns about 13,000 euros from selling one ad page. The median percentage markup for advertising is 67 percent. Combining the two sides, the average per-magazine profit is 3.8 million euro per quarter with 5.4 million euro loss from selling magazine copies and 9.2 million euro profit from selling advertising space.[34,35]

However, the results also show that TV magazines do not always incur a loss from selling

[34] The estimated profits also suggest that a higher advertising profit likely accompanies a larger loss on the reader side. For four publishers, a correlation between these two profits over time is lower than -0.95.

[35] Note that readers still pay below marginal costs even if they dislike advertising. In such a case the advertiser-side markup would be even higher because publishers charge more to advertisers to compensate readers' dis-utility.

copies. Eight magazines made profits on the readers' side in at least one quarter during the sample period. Four of these magazines are published by BMK, which owns the highest number of magazines. This suggests that a publisher can still set magazine copy prices above costs when it has substantial market power. Nevertheless, this is not a common feature of the TV magazine segment in Germany; it only happens in 10 percent of all observations.

5 Merger Simulations

In this section I analyze how equilibrium outcomes such as price, market share, and welfare change when two publishers merge. From the first quarter of 2006 until the end of the sample period, three publishers, ASV, BMK and WAZ, published 15 TV magazines.[36] Among these three publishers, BMK was the largest TV magazine publisher with the highest number of TV magazines and largest market shares on both sides of the market, while the other two were similar in terms of the number of magazines and their market shares. In the third quarter of 2009, for example, BMK published 7 TV magazines, sold 7.6 million copies, and had 787 ad pages in total. ASV had 4 TV magazines, sold 3.4 million copies, and had 470 ad pages, and WAZ had 4 magazines, sold 2 million copies, and had 337 ad pages.

Among these three publishers I consider three hypothetical pairwise mergers. Because BMK is the most dominant publisher, a merger between BMK and either of the other two will make the market substantially more concentrated, while a merger between ASV and WAZ would make the market more or less equally divided. If these mergers were simulated in the one-sided market framework, antitrust agencies would find the merger involving BMK relatively more concerning.[37]

Before presenting simulation results, it would be helpful to consider a simple theoretical example to understand how merger effects in two-sided markets would be different from one-sided

[36]HBM also published two TV magazines during this period but because of missing information I do not include them in my analysis. In the fourth quarter of 2005, HBM's within market share was about 15 percent.

[37]An important assumption in this exercise is that a merged publisher keeps all magazines and do not change their characteristics other than prices and the amount of advertising.

markets. Suppose two single-product publishers that are competing *á la* Bertrand merge. If the advertising side is ignored, the first-order condition with respect to publisher 1's copy price would be

$$\frac{\partial \pi_{1+2}}{\partial p_1^A} = s_1^A M^A + (p_1^A - c_1^A)\frac{\partial s_1^A}{\partial p_1^A} M^A + (p_2^A - c_2^A)\frac{\partial s_2^A}{\partial p_1^A} M^A = 0$$

where subscripts 1 and 2 indicate magazines (publishers) and superscript A indicates the reader side. The one-sided market Bertrand-Nash model predicts prices increase when firms selling substitutes merge as they internalize substitution effects post merger. That is, the merged publisher accounts for $(p_2^A - c_2^A)\frac{\partial s_2^A}{\partial p_1^A} M^A$ in setting p_1^A post merger.

When the advertising side is accounted for, the first-order condition changes to

$$\begin{aligned}\frac{\partial \pi_{1+2}}{\partial p_1^A} = s_1^A M^A &+ (p_1^A - c_1^A)\frac{\partial s_1^A}{\partial p_1^A} M^A + (p_2^A - c_2^A)\frac{\partial s_2^A}{\partial p_1^A} M^A \\ &+ (p_1^B - c_1^B)\frac{\partial s_1^B}{\partial p_1^A} M^B + (p_2^B - c_2^B)\frac{\partial s_2^B}{\partial p_1^A} M^B = 0\end{aligned} \tag{16}$$

where superscript B indicates the advertising side. The last two terms are the derivatives of s_1^B and s_2^B with respect to p_1^A and are added to the first-order condition of the on-sided market model.

Pre merger, publisher 1 sets its copy price to maximize the readier-side profits given the amount of advertising, which is captured by $s_1^A M^A + (p_1^A - c_1^A)\frac{\partial s_1^A}{\partial p_1^A} M^A$. It also accounts for the effect of a change in its copy price on advertisers' likelihood of buying ad pages in magazine 1, which is captured by $(p_1^B - c_1^B)\frac{\partial s_1^B}{\partial p_1^A} M^B$. Note that $\frac{\partial s_1^B}{\partial p_1^A}$ is negative because a higher copy price would decrease the size of the reader base, which would subsequently decrease the number of advertisers advertising in magazine 1.

Post merger, the merged publisher would adjust the copy price of magazine 1 to account for profits associated with magazine 2 it acquired. First, the merged publisher accounts for the effect of a change in magazine 1's copy price on the sales of magazine 2. This effect is the same substitution effect as in the one-sided market model and captured by $(p_2^A - c_2^A)\frac{\partial s_2^A}{\partial p_1^A} M^A$. Second, the merged publisher accounts for the effects of a change in magazine 1's copy price on the amount of advertising in magazine 2. Magazine 1's higher copy price would result in more advertising for magazine 2 as it increases the size of magazine 2's reader base. That is, magazine 2 becomes more valuable to advertisers as some readers switch to magazine 2 when magazine 1 increases its copy price. Both the first and the second effects would lead the merged publisher to raise the copy price of magazine 1 post merger. Note that the effect of internalizing the substitution effects would be larger than one-sided market models because of the second effect.

The merged publisher has similar post-merger pricing strategies for the advertising side. The post-merger profit maximizing condition with respect to magazine 1's ad price is given by

$$\begin{aligned}\frac{\partial \pi_{1+2}}{\partial p_1^B} &= s_1^B M^B + (p_1^B - c_1^B)\frac{\partial s_1^B}{\partial p_1^B} M^B + (p_2^B - c_2^B)\frac{\partial s_2^B}{\partial p_1^B} M^B \\ &+ (p_1^A - c_1^A)\frac{\partial s_1^A}{\partial p_1^B} M^A + (p_2^A - c_2^A)\frac{\partial s_2^A}{\partial p_1^B} M^A = 0\end{aligned} \tag{17}$$

Pre merger, publisher 1 sets its ad price to maximize advertising profits given the size of the reader base, which is captured by $s_1^B M^B + (p_1^B - c_1^B)\frac{\partial s_1^B}{\partial p_1^B} M^B$. It also accounts for the effect of the amount of adverting on readers' likelihood of buying magazine 1, which is captured by $(p_1^A - c_1^A)\frac{\partial s_1^A}{\partial p_1^B} M^A$. If the latter effect is negative, the publisher would add a premium to its ad price, and if this effect is positive, as in the German TV magazine market, the publisher would offer a discount.

Post merger, the merged publisher would adjust magazine 1's ad price to account for profits associated with magazine 2 it owns now. First, the merged publisher accounts for the effect of a change in magazine 1's ad price on the size of the reader base for magazine 2. A higher ad price for magazine 1 reduces the amount of advertising in this magazine and leads some readers to switch to magazine 2. This effect, captured by $(p_2^A - c_2^A)\frac{\partial s_2^A}{\partial p_1^B} M^A$, strengthens the merged publisher's incentive to raise ad prices post merger. Second, the merged publisher accounts for the effect of a change in magazine 1's ad price on the amount of advertising in magazine 2. Recall that each magazine acts as a monopolist towards multi-homing advertisers, but a change in one magazine's ad price can still affect their advertising demand for other magazines through the indirect network externality.

That is, $(p_2^B - c_2^B)\frac{\partial s_2^B}{\partial p_1^B}M^B$ is not zero when readers care about advertising. A higher ad price for magazine 1 makes magazine 2 more valuable for advertisers as some of magazine 1 readers are induced to switch to magazine 2. This effect also strengthens the merged publisher's incentive to increase ad prices.

It appears that the first-order price effects of a merger are such that the merged publisher would want to raise both copy and ad prices post merger.[38] However, the merged publisher would not want to raise prices on both sides of the market at the same in equilibrium unless the effects of internalizing the substitution effects are substantially strong. This can be seen by re-writing the post-merger profit maximizing condition as

$$\begin{aligned}(p_1^A - c_1^A) = &-s_1^A\Big(\frac{\partial s_1^A}{\partial p_1^A}\Big)^{-1} - (p_2^A - c_2^A)\frac{\partial s_2^A}{\partial p_1^A}\Big(\frac{\partial s_1^A}{\partial p_1^A}\Big)^{-1} \\ &- (p_1^B - c_1^B)\frac{\partial s_1^B}{\partial p_1^A}\frac{M^B}{M^A}\Big(\frac{\partial s_1^A}{\partial p_1^A}\Big)^{-1} - (p_2^B - c_2^B)\frac{\partial s_2^B}{\partial p_1^A}\frac{M^B}{M^A}\Big(\frac{\partial s_1^A}{\partial p_1^A}\Big)^{-1}\end{aligned}$$

The first two terms on the right hand side are the same as the first-order condition of the one-sided market. The last term, which is positive because $\frac{\partial s_2^B}{\partial p_1^A}$ is positive and $\Big(\frac{\partial s_1^A}{\partial p_1^A}\Big)^{-1}$ is negative, captures an additional substitution effect stemming from the advertising side. The third term on the right hand side, which is negative, shows that ad prices and copy prices are not necessarily strategic complements. That is, the merged publisher would want to decrease magazine 1's copy price as it increases its ad price, for other things being constant. Because selling fewer magazine copies hurts the sales of advertising space, publishers would want to balance an increase in the copy price with lower ad prices. Magazine 1's copy price can be either higher or lower post merger, depending on whether the effects of internalizing the substitution effect are larger or smaller than the downward pricing pressure on copy prices resulting from a higher ad price. The same logic can be applied to explain why ad prices can go down post merger.

Note that while merger simulations for one-sided markets typically focus on price changes

[38] Affeldt, Filistrucchi, and Klein (2013) show that platform mergers would result in upward pricing pressure on both sides of the market.

with all product characteristics fixed, mergers in two-sided markets would result in changes in product characteristics on both sides of the market, i.e., the amount of advertising for readers and the size of the reader base for advertisers. Thus, in two-sided markets the price effects resulting from platform mergers include price changes in response to changes in product characteristics. If the merged publisher ends up losing readers for magazine 1, for example, it would decrease the ad price for this magazine to compensate advertisers for the lost audience. If the merged publisher ends up gaining readers, it would increase its ad price as this magazine becomes more valuable to advertisers.

Of course, the various price effects described so far are the first-order effects. One needs to run merger simulations to fully analyze how prices change in the post-merger equilibrium. Table 5 shows price changes in the post-merger equilibrium in the three possible pairwise mergers for the third quarter of 2009 as an example. For a given pairwise merger I plug the cost estimates obtained in the previous section into the profit maximization conditions and find new equilibrium prices and market shares.[39] The search algorithm consists of two parts. While an outer part of the search algorithm searches for prices that satisfy the new profit maximization conditions with a different ownership structure, an inner part searches for market shares that satisfy the membership allocation equations for given prices. I use the Newton's method for the outer part search and use the fixed-point homotopy method for the inner part search. In the presence of multiple membership allocations I select a set of allocations that maximizes an industry-wide profit.[40] For comparison I also include price changes for the one-sided market, which ignores the advertising side, on the left panel of the table (under *One-Sided*). In the table the magazines are grouped by their publishers and then sorted in the descending order of copy price.

Unsurprisingly, the one-sided market model predicts that any pairwise merger would result in substantial price increases in the bi-weekly segment. Prices are predicted to go up by more

[39] I use the GMM estimates of the nested logit model reported in the last column of Table 2.
[40] See Appendix II for computational details.

than 35% on average post merger in that segment.[41] When ASV and WAZ merge, a predicted price increase is relatively modest for this segment but the average price increase is still 27%. The substantial price increase in this segment is a result of BMK publishing two bi-weekly magazines, while ASV and WAZ each publishes one bi-weekly. Thus, when BMK merges with ASV or WAZ, a merged entity owns three out of four bi-weekly magazines.

The one-sided market model also predicts that the monthly segment would experience a significant price increase, close to a 40% increase, when BMK and WAZ merge. Because BMK and WAZ each sells one of the two monthly TV magazines, a merger between them would "monopolize" the monthly segment. However, the ASV and BMK and the ASV and WAZ mergers would result in relatively modest price increases in this segment, a 7.2% increase for the former and a 2.6% for the latter.

Predicting merger outcomes without accounting for the advertising side is misleading. Accounting for a merged publisher's incentives associated with advertising revenues is particularly important for industries where firms use advertising revenues to subsidize their customers. In the TV magazine market in Germany, for example, advertising revenues are about 5 times larger than the revenues obtained from selling magazines.

Three patterns of price changes stand out in the merger simulations of the two-sided market model presented on the right panel of Table 5. First, copy prices increase much more modestly than what the one-sided market model predicts. They even decrease in some cases. There are exceptions, however. In the BMK and WAZ merger case, the copy price of the monthly magazines is predicted to go up more than what the one-sided market model predicts. These mixed results are not surprising given the first-order price effects described in the example above. The modest price changes are a result of the internalization of the substitution effects being attenuated by the downward pricing pressure coming from the other side of the market. The price changes that are more substantial than what the one-sided market model predicts are a result of the internalization

[41] The average price change is calculated using magazine sales as a weight.

of the substitution effects dominating this downward pricing pressure. It appears that the degree of the within-segment competition is a good indicator for how modest price changes would be and whether copy price increase or decrease post merger. In the weekly segment where the number of TV magazines is the highest, copy prices always decrease post merger.

Second, ad prices tend to move in the opposite direction to copy prices post merger. This pattern is consistent with the prediction that merged publishers would have an incentive to balance a price increase on one side of the market with a price decrease on the other side of the market. When a magazine gains readers from a lower copy price, a merged publisher would want to charge a higher ad price as that magazine becomes more values to advertisers, and vice versa. This pattern is seen in all but six magazines of the merged publishers.

Third, merged publishers may raise both copy prices and ad prices, which is seen in six cases where copy prices and ad prices do not move in the opposite directions. These six cases are associated with the monthly TV magazines in all three pairwise mergers and some bi-weekly magazines in the BMK and WAZ merger. The price increase is particularly significant with the monthly magazines in the BMK and WAZ merger, which again suggests that the within-segment competition is a good indicator for significant price increases post merger. The BMK and WAZ merger results in a 2 to 1 merger for the monthly TV magazine segment.

Table 6 shows changes in sales and the amount of advertising for the same magazines and period as in Table 5. The left panel shows that in the one-sided market setting the sales of merged publishers' magazines always decrease due to higher copy prices. The right panel of Table 6, on the other hand, shows that while the sales of merged publishers' magazines almost always move in the opposite direction to copy prices, the amount of advertising usually moves in the same direction as ad prices. This is because changes in the size of the reader base shift around the demand curve for advertisers substantially enough to offset the price effects.

Table 7 shows welfare changes for readers and advertisers for the same magazines and period as in Table 5. This table shows that a merger between two publishers could be much less harmful for readers than what the one-sided market model predicts and that readers may even benefit from it because copy prices can go down post merger.[42] For the third quarter of 2009 the one-sided model predicts that readers' welfare decreases by 23 percent in the ASV and BMK merger case, 19 percent in the BMK and WAZ merger case, and 14 percent in the ASV and WAZ merger case respectively, and the magnitude of copy price increases roughly determines which merger is more harmful for readers. On the other hand, the two-sided market model predicts a 0.7 percent welfare drop for readers in the ASV and BMK merger case, a 10 percent drop in the BMK and WAZ merger case, and a 2 percent drop in the ASV and WAZ merger case, which are substantially smaller changes than in the one-sided market model. It is also interesting that the merger that reduces readers' welfare most in the one-sided market model, i.e., the ASV and BMK merger case, is predicted to reduce readers' welfare the least in the two-sided market model. The main reason is that the merged publisher lowers copy prices in the ASV and BMK merger case more than in the other two merger cases.

Welfare effects on advertisers are also ambiguous. Two-thirds of magazines raise ad prices in any pairwise merger, as shown in Table 5. However, advertisers benefit from a merger when the price effect is dominated by the benefit of having more readers as a result of lower copy prices. I measure net welfare effects on advertisers by calculating the average advertiser's surplus for magazine j by

$$E\left(\alpha_i^B | i \in j\right) \delta_j^B n_j^A - p_j^B$$

where $E\left(\alpha_i^B | i \in j\right)$ denotes the average value of α_i^B conditional on advertising in magazine j, and then multiplying it by the number of advertisers for that magazine.

This magazine-level welfare calculation shows that the average surplus almost always increases for magazines that raise ad prices and that because these magazines usually attract more advertisers, advertisers' total surplus for these magazines also increases. However, the market-level

[42]Simulations show that in the symmetric duopoly case a merged publisher, which becomes a monopolist post merger, decreases all magazines' copy prices and, as a result, readers benefit from the merger.

surplus can still go down if magazines that lower ad prices (and lose advertisers) are the ones that carry a disproportionately large amount of advertising. Table 7 shows that in the ASV and BMK merger case, for example, the market-level surplus goes down by 3.7 percent as three out of the four magazines that lower ad prices carry about 650 out of 1,600 ad pages in total. Advertisers' market-level surplus moves in either direction in the other two merger cases, although changes are small; it goes up by 0.4 percentage points in the BMK and WAZ merger case and goes down by 0.1 percentage points in the ASV and WAZ case.

6 Conclusions

In this paper I develop a structural model of two-sided markets where two groups of agents interact through platforms and estimate platform demand and markup using TV magazine data in Germany. My model has two key features of the two-sided market. First, both groups care about the presence of the other group, so indirect network externalities are present on both sides of the market. Second, platforms charge access fees on both sides.

The empirical results show that most TV magazines set copy prices below marginal costs to attract readers and make profits from selling advertising space. When the advertising side is ignored, the same demand estimates imply high markup on the reader side. In the counterfactual exercise I show that platform mergers do not necessarily increase copy prices and, as a result, readers are not as worse off as the one-sided market model predicts post merger. Advertisers, on the other hand, are usually predicted to experience higher ad prices post merger, but they are not necessarily worse off as lower copy prices can increase the size of the reader base.

Some extensions are worth consideration. First, I assume there is no intra-platform competition but it can be an important factor in agents' membership decisions. For example, advertisers' platform valuation may decrease with the number of other advertisers on the same platform. This is equivalent to a congestion problem in industries where (direct) network effects are strong. With intra-platform competition a few interesting issues arise including whether platforms would choose exclusive dealing and how prices on the other side are affected. Second, my model is confined to markets where platforms only charge fixed access fees and is not directly applicable to markets where platforms charge usage or per-transaction fees as in, for example, the credit card industry. Rochet and Tirole (2003) develop a model where platforms charge usage fees and Rochet and Tirole (2006) extend it to integrate usage and membership fees in a monopoly platform setting. Incorporating more flexible fee structures is certainly an important topic for future empirical research.

References

[1] Affeldt P., L. Filistrucchi, and T. Klein (2013), "Upward Pricing Pressure in Two-sided Markets," *The Economic Journal*, 123, 505-523.

[2] Anderson, S.P., Ø. Foros, H.J. Kind and M. Peitz (forthcoming), "Media Market Concentration, Advertising Levels, and Ad Prices," *International Journal of Industrial Organization.*

[3] Argentesi, E. and L. Filistrucchi (2007), "Estimating Market Power in a Two-sided Market: The Case of Newspapers," *Journal of Applied Econometrics*, 22, 1247-1266.

[4] Armstrong, M. (2006), "Competition in Two-sided Markets," *RAND Journal of Economics*, 37, 668-691.

[5] Bajari P., H. Hong, J. Krainer, and D. Nekipelov (2012), "Estimating Static Models of Strategic Interactions," *Journal of Business and Economic Statistics*, 28, 469-482.

[6] Berry, S. (1994), "Estimating Discrete Choice Models of Product Differentiation," *RAND Journal of Economics*, 25, 242-262.

[7] Berry, S., J. Levinsohn, and A. Pakes (1995), "Automobile Prices in Market Equilibrium," *Econometrica*, 63, 841-890.

[8] Cardell, Scott N. (1997), "Variance Components Structures for the Extreme-Value and Logistic Distributions with Application to Models of Heterogeneity," *Econometric Theory*, 13(2): 185-213.

[9] Chandra, A. and A. Collard-Wexler (2009), "Mergers in Two-Sided Markets: An Application to the Canadian Newspaper Industry," *Journal of Economics and Management Strategy*, 18(4), 1045-1070.

[10] Chandra, A. and U. Kaiser (2014), "Targeted Advertising in Magazine Markets and the Advent of the Internet," *Management Science*, 60(7), 1829-1843.

[11] Dertouzos, J. and W. Trautman (1990), "Economic Effects of Media Concentration: Estimates From a Model of the Newspaper Firm," *Journal of Industrial Economics*, 39(1), 1-14.

[12] Fan, Y. (2013), "Ownership Consolidation and Product Characteristics: A Study of the U.S. Daily Newspaper Market," *American Economic Review*, 103, 1598-1628.

[13] Filistrucchi L. and T. Klein (2013), "Price Competition in Two-Sided Markets with Heterogeneous Consumers and Network Effects," NET Working Paper #13-20.

[14] Filistrucchi L., T. Klein, and T. Michielsen (2012), "Assessing Unilateral Merger Effects in a Two-sided Market: An Application to the Dutch Daily Newspaper Market," *Journal of Competition Law & Economics*, 8(2), 297-329

[15] Gale, D. and H. Nikaido (1965), "The Jacobian Matrix and the Global Univalence of Mappings," *Mathematische Annalen*, 159, 81-93.

[16] Jeziorski, P. (2014), "Effects of mergers in two-sided markets: The U.S. radio industry," *American Economic Journal: Microeconomics*, 6(4): 35-73.

[17] Judd, K., P. Renner, and K. Schmedders (2012), "Finding All Pure-strategy Equilibria in Games with Continuous Strategies," *Quantitative Economics*, 3, 289–331.

[18] Kaiser, U. and M. Song (2009), "Do Media Consumers Really Dislike Advertising? An Empirical Assessment of the Role of Advertising in Print Media Markets," *International Journal of Industrial Organization*, 27(2), 292-301.

[19] Kaiser, U. and J. Wright (2006), "Price Structure in Two-Sided Markets: Evidence from the Magazine Industry," *International Journal of Industrial Organization*, 24, 1-28.

[20] Press, W.H., S.A. Teukolsky, W.T. Vetterling and B.P. Flannery (1996), *Numerical Recipes in Fortran 90*, Second Edition, Cambridge University.

[21] Rochet, J.-C. and J. Tirole (2003), "Platform Competition in Two-Sided Markets," *Journal of the European Economic Association*, 1, 990-1029.

[22] Rochet, J.-C. and J. Tirole (2006), "Two-Sided Markets: A Progress Report," *RAND Journal of Economics*, 37, 645-667.

[23] Rosen, J. (1965), "Existence and Uniqueness of Equilibrium Points for Concave n-person Games," *Econometrica*, 33, 520-534.

[24] Rosse, J. (1970), "Estimating Cost Function Parameters Without Using Cost Data: Illustrated Methodology," *Econometrica*, 38, 256-275.

[25] Rysman, M. (2004), "Competition between Networks: A Study of the Market for Yellow Pages," *Review of Economic Studies*, 71, 483-512.

[26] Rysman, M. (2009), "The Economics of Two-Sided Markets," *Journal of Economic Perspective*, 23, 125-143.

[27] Tirole, J. (1998), *The Theory of Industrial Organization*, The MIT Press.

[28] Watson, L.T., M. Sosonkina, R.C. Melville, A.P. Morgan and H.F. Walker (1997), "Algorithm 777: HOMPACK90: A Suite of Fortran 90 Codes for Globally Convergent Homotopy Algorithms," *ACM Transactions on Mathematical Software*, 23(4), pp. 514–549.

[29] White A. and G. Weyl (2012), "Insulated Platform Competition," unpublished manuscript, University of Chicago.

Table 1: Summary Statistics

	No. of	Magazine Price†		Ad Price‡		Circulation (in 1,000)		Content Pages		Ad Pages	
Time	Magazines	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
1992	10	0.96	0.20	24,879	13,457	2,233	974	1,066	178	375	168
1993	11	1.00	0.29	26,253	13,122	2,041	912	1,072	165	351	153
1994	12	1.00	0.30	27,082	12,454	1,976	860	1,081	191	318	167
1995	14	1.02	0.28	26,353	12,419	1,830	814	1,100	215	275	147
1996	14	1.00	0.27	26,870	12,606	1,894	844	1,131	238	278	155
1997	12	1.03	0.27	28,140	13,134	1,953	840	1,160	200	304	193
1998	12	1.04	0.28	29,539	13,900	1,917	845	1,178	254	308	200
1999	15	1.04	0.26	26,377	13,658	1,673	752	1,125	313	295	205
2000	15	1.06	0.28	26,682	13,779	1,646	746	1,135	307	317	220
2001	15	1.08	0.29	27,371	13,930	1,642	752	1,122	290	261	177
2002	15	1.16	0.27	27,949	13,802	1,583	736	1,093	326	254	163
2003	16	1.18	0.26	28,646	13,732	1,508	708	1,079	361	232	143
2004	16	1.21	0.25	29,026	13,728	1,434	676	1,127	373	246	141
2005	17	1.20	0.27	29,239	14,035	1,430	676	1,122	388	234	121
2006	15	1.17	0.26	30,216	14,409	1,480	723	1,150	400	227	117
2007	15	1.18	0.28	32,576	15,437	1,452	718	1,131	381	204	104
2008	15	1.21	0.29	33,236	16,003	1,438	716	1,126	359	174	86
2009	15	1.24	0.28	34,488	16,678	1,393	695	1,098	348	157	70
2010	15	1.25	0.28	35,220	17,212	1,398	701	1,119	350	157	68

†The average price magazines charge for one issue. ‡The average price magazines charge for one page of advertising in one issue.

Table 2: Demand Estimation Results

Variable	IV Logit			Nested Logit		
	OLS	System IV	GMM	OLS	System IV	GMM
Reader Side						
Constant	-4.434*	-4.513*	-4.420*	-3.260*	-4.188*	-4.102*
	(0.155)	(0.245)	(0.235)	(0.138)	(0.240)	(0.229)
Copy Price	-0.169*	-0.182*	-0.183*	-0.107*	-0.134*	-0.140*
	(0.006)	(0.010)	(0.009)	(0.006)	(0.016)	(0.016)
Advertising	1.832*	3.262*	2.739*	1.423*	3.329*	2.855*
	(0.140)	(0.422)	(0.347)	(0.116)	(0.436)	(0.360)
Content Page	0.072*	0.074*	0.071*	0.021*	0.048*	0.046*
	(0.007)	(0.008)	(0.008)	(0.006)	(0.010)	(0.010)
$\log\left(s_{j\|g}\right)$				0.615*	0.320*	0.292*
				(0.029)	(0.096)	(0.094)
Advertiser Side						
Constant		1.068*	1.293*		1.025*	1.293*
		(0.178)	(0.179)		(0.173)	(0.179)
Content Page		-0.039*	-0.037*		-0.037*	-0.037*
		(0.008)	(0.007)		(0.007)	(0.007)
$\alpha_i^B \sim LN\left(0, \sigma^2\right)$		1.402*	1.359*		1.432*	1.359*
		(0.121)	(0.098)		(0.123)	(0.098)
Advertiser Size		168	152		170	152

The market size for readers is set to 40 million. The dummy variables for 16 magazines (out of 19) and the time fixed effects are included in all estimations. Standard errors are reported in parenthesis.
*significant at the 5 % level.

Table 3: Price Elasticity

	One-Sided		Two-Sided			
	$\frac{\partial D_j^A}{\partial p_j^A}\frac{p_j^A}{s_j^A}$	$\frac{\partial D_j^B}{\partial p_j^B}\frac{p_j^B}{s_j^B}$	$\frac{\partial s_j^A}{\partial p_j^A}\frac{p_j^A}{s_j^A}$	$\frac{\partial s_j^B}{\partial p_j^B}\frac{p_j^B}{s_j^B}$	$\frac{\partial s_j^A}{\partial p_j^B}\frac{p_j^B}{s_j^A}$	$\frac{\partial s_j^B}{\partial p_j^A}\frac{p_j^A}{s_j^B}$
Median	-2.02	-1.33	-3.50	-2.20	-0.52	-5.26
20% QU*	-1.47	-0.94	-0.79	-2.06	-0.18	-1.03
40% QU	-1.68	-1.22	-3.01	-2.15	-0.40	-4.17
60% QU	-2.38	-1.42	-3.89	-2.33	-0.72	-5.59
80% QU	-2.67	-1.57	-6.91	-3.18	-1.84	-8.37

The (optimal) GMM estimates of the nested logit model are used. The market size for readers is set to 40 million and the market size for advertisers to 152. A refers to the reader side and B refers to the advertiser side. *QU refers to a quintile.

Table 4: Magazine Markup

Markets		One-Sided			Two-Sided		
		Cost	Markup	% Markup	Cost	Markup	% Markup
		mc	$(p - mc)$	$(p - mc)/p$	mc	$(p - mc)$	$(p - mc)/p$
Readers							
	Median	0.49	0.48	0.54	3.50	-2.50	-2.35
	20% QU*	0.17	0.43	0.38	1.67	-0.85	-1.03
	40% QU	0.44	0.47	0.48	2.73	-1.78	-1.85
	60% QU	0.53	0.48	0.65	4.42	-3.33	-2.96
	80% QU	0.65	0.99	0.76	7.13	-5.74	-4.65
Advertisers							
	Median				3,957	13,053	0.67
	20% QU				1,166	4,332	0.57
	40% QU				3,027	8,553	0.63
	60% QU				5,887	17,741	0.72
	80% QU				9,710	30,332	0.93

The (optimal) GMM estimates of the nested logit model are used. The market size for readers is set to 40 million and the market size for advertisers to 152. *QU refers to a quintile.

Table 5: Price Changes in Hypothetical Pairwise Mergers

				One-Sided			Two-Sided					
				ASV+BMK	BMK+WAZ	ASV+WAZ	ASV+BMK		BMK+WAZ		ASV+WAZ	
	Freq	Price	Ad Price	Price	Price	Price	Price	Ad Price	Price	Ad Price	Price	Ad Price
BMK1	6	1.53	51,328	38.14%	29.35%	21.87%	6.98%	-9.11%	1.10%	1.98%	0.32%	0.77%
BMK2	13	1.43	32,811	4.64%	0.86%	0.11%	-4.21%	4.07%	-0.35%	0.52%	-0.08%	0.00%
BMK3	13	1.05	33,678	6.33%	1.17%	0.15%	-8.23%	6.14%	-0.80%	0.75%	-0.11%	0.00%
BMK4	13	1.05	24,514	6.33%	1.17%	0.15%	-5.17%	3.01%	-0.40%	0.39%	-0.11%	0.00%
BMK5	6	0.96	37,275	61.02%	46.96%	35.00%	12.29%	-8.65%	1.75%	1.74%	0.51%	0.68%
BMK6	3	0.94	17,133	8.03%	36.14%	1.96%	3.11%	1.31%	58.63%	13.14%	1.09%	-0.19%
BMK7	13	0.75	16,032	8.81%	1.63%	0.21%	-7.49%	2.51%	-0.61%	0.33%	-0.15%	0.00%
ASV1	6	1.58	46,418	44.71%	9.86%	17.54%	10.44%	-14.84%	0.22%	3.54%	0.77%	-0.09%
ASV2	13	1.43	39,227	7.99%	0.12%	0.77%	-6.73%	10.26%	-0.01%	-0.03%	-0.45%	0.69%
ASV3	13	1.05	7,347	10.90%	0.17%	1.05%	-7.46%	4.75%	-0.03%	-0.02%	-0.51%	0.37%
ASV4	13	0.75	8,397	15.17%	0.23%	1.46%	-8.19%	2.79%	-0.05%	-0.01%	-0.54%	0.22%
WAZ1	13	1.05	4,967	0.18%	9.16%	4.47%	-3.82%	1.46%	-4.80%	5.57%	-2.45%	2.63%
WAZ2	13	1.05	3,343	0.18%	9.16%	4.47%	-3.50%	1.06%	-3.60%	3.91%	-1.87%	1.89%
WAZ3	6	0.96	14,565	13.04%	62.35%	31.59%	-6.35%	0.42%	61.28%	-9.33%	11.76%	-1.62%
WAZ4	3	0.95	8,930	6.25%	41.85%	3.23%	0.53%	-0.08%	70.88%	45.78%	1.96%	5.02%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million and the market size for advertisers to 152.

Table 6: Sales and Advertising Changes in Hypothetical Pairwise Mergers

				One-Sided			Two-Sided					
				ASV+BMK	BMK+WAZ	ASV+WAZ	ASV+BMK		BMK+WAZ		ASV+WAZ	
	Freq	Sales[†]	Ads	Sales	Sales	Sales	Sales	Ads	Sales	Ads	Sales	Ads
BMK1	6	1.50	233	-39.53%	-32.33%	-24.55%	-9.84%	-0.75%	2.13%	0.14%	0.83%	0.06%
BMK2	13	0.89	107	-9.65%	-1.23%	0.82%	11.88%	11.29%	1.48%	1.44%	0.00%	0.00%
BMK3	13	1.30	85	-9.65%	-1.23%	0.82%	21.56%	23.10%	2.56%	2.82%	0.01%	0.01%
BMK4	13	0.54	89	-9.65%	-1.23%	0.82%	9.39%	9.69%	1.20%	1.26%	0.01%	0.00%
BMK5	6	2.40	200	-39.53%	-32.33%	-24.55%	-18.93%	-11.44%	3.90%	2.10%	1.53%	0.83%
BMK6	3	0.63	17	-2.13%	-12.03%	0.00%	-2.07%	-5.33%	-21.86%	-46.59%	0.30%	0.79%
BMK7	13	0.30	56	-9.65%	-1.23%	0.82%	9.55%	11.72%	1.24%	1.52%	0.00%	0.01%
ASV1	6	1.70	220	-47.68%	-4.11%	-19.19%	-18.78%	-4.45%	4.49%	0.87%	-0.11%	-0.02%
ASV2	13	1.40	136	-20.15%	1.50%	-1.60%	27.38%	22.13%	-0.09%	-0.08%	1.81%	1.58%
ASV3	13	0.18	66	-20.15%	1.50%	-1.60%	17.52%	20.39%	-0.06%	-0.08%	1.32%	1.56%
ASV4	13	0.13	48	-20.15%	1.50%	-1.60%	11.11%	14.23%	-0.04%	-0.06%	0.88%	1.13%
WAZ1	13	0.20	100	6.73%	-20.42%	-10.29%	4.64%	4.77%	18.00%	18.03%	8.43%	8.60%
WAZ2	13	0.10	89	6.73%	-20.42%	-10.29%	3.42%	3.64%	12.81%	13.41%	6.15%	6.52%
WAZ3	6	1.10	115	4.28%	-43.18%	-21.58%	40.34%	46.19%	-64.34%	-73.42%	-22.15%	-25.54%
WAZ4	3	0.58	33	-1.19%	-14.99%	-0.72%	0.29%	0.52%	-37.16%	-73.93%	-3.59%	-11.45%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million and the market size for advertisers to 152. [†]In millions.

Table 7: Welfare Changes in Hypothetical Pairwise Mergers

	ASV+BMK		BMK+WAZ		ASV+WAZ	
	Readers	Advertisers	Readers	Advertisers	Readers	Advertisers
One-sided market	-23.41%		-19.30%		-13.78%	
Two-sided market	-0.73%	-3.67%	-10.41%	0.40%	-1.88%	-0.14%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million and the market size for advertisers to 152.

Appendix I: Monte Carlo Simulation

In this section I use Monte Carlo simulations to demonstrate differences between the two models of two-sided markets, focusing on equilibrium prices and market shares and the price elasticity. For both models the profit function for platform j is

$$\pi_{jt} = \left(p^A_{jt} - mc^A_{jt}\right) s^A_{jt} M_A + \left(p^B_{jt} - mc^B_{jt}\right) s^B_{jt} M_B$$

where, for each side, mc_{jt} denotes marginal cost in market t, s_{jt} its market share and M the market size. For each model I generate 100 independent markets, each with five platforms (firms). Given platform characteristics and costs, I compute prices and market shares using profit maximization conditions, assuming that platforms compete á la Bertrand.

In the two-sided single-homing model, the utility functions are

$$\begin{aligned} u^A_{ijt} &= \mu^A_{jt} - \lambda^A p^A_{jt} + \alpha^A s^B_{jt} + \xi^A_{jt} + \varepsilon^A_{ijt} \\ u^A_{ijt} &= \mu^B_{jt} - \lambda^B p^B_{jt} + \alpha^B s^A_{jt} + \xi^B_{jt} + \varepsilon^B_{ijt} \end{aligned}$$

where μ_{jt} is platform $j's$ mean quality, p_{jt} its price, ξ_{jt} firm-specific unobserved quality, and ε_{ijt} an idiosyncratic error term with the type I extreme value distribution. For $\left(\mu^A_{jt}, \xi^A_{jt}, mc^A_{jt}, \lambda^A\right)$ and $\left(\mu^B_{jt}, \xi^B_{jt}, mc^B_{jt}, \lambda^B\right)$, I assume

$$\begin{aligned} \mu_{jt} &\sim U(0,2) \\ \xi_{jt} &\sim 0.1 \times N(0,1) \\ mc_{jt} &\sim U(0,1) \\ \lambda^A &= \lambda^B = 2 \\ \alpha^A &= \alpha^B = 1 \end{aligned}$$

Notice that I assume that each set of group agents likes the presence of the other group agents on a platform. I sort $\left(\mu^A_{jt}, \mu^B_{jt}, mc^A_{jt}, mc^B_{jt}\right)$ such that platform 1 has the lowest and platform 5 has the highest mean quality and marginal cost for both groups. In searching for prices and market shares that maximize the profits, I use the marginal cost as a starting point.[43]

In the competitive bottleneck model I use the same values as $\left(\mu^A_{jt}, \xi^A_{jt}, mc^A_{jt}, \lambda^A, \alpha^A\right)$ for the single-homing side. The demand of multi-homing agents is given as

$$s^B_j = \left(1 - G\left(\frac{p^B_j}{\delta_j\left(s^A_j M_A\right)} | \theta\right)\right)$$

where $G\left(\alpha^B\right)$ is the cdf of the log normal distribution with $E\left(\log\left(\alpha^B\right)\right) = 1$ and $Var\left(\log\left(\alpha^B\right)\right) = 1$, and

$$\delta_{jt} = \mu^B_{jt} + \xi^B_{jt}.$$

[43]Given these parameter values there exists unique market shares for given prices. See Section 2.3.

Table 8 shows the equilibrium prices and market shares averaged across 100 markets. The market size is set to $M_A/M_B = 10$ for both models, so there are ten times more agents in group A as in group B. Notice first sharp differences in equilibrium outcomes between the two models. In the two-sided single homing model platforms charge lower prices to the smaller group, group B, and pass this cost to the larger group. This is obvious as platforms must compete harder to attract group B agents. In the competitive bottleneck model, on the other hand, platforms charge much lower prices to group A agents with some platforms even giving subsidies (negative prices). In this model group A agents are more valuable as group B agents are willing to join multiple platforms as long as net benefits are positive. Compared to the two-sided single homing model, platforms can make substantially higher profits out of multi-homing agents, so they are more aggressive in competing for group A agents. This is consistent with the common observation in the advertising market where media platforms make profits from multi-homing advertisers and grant favorable treatments to consumers (readers or viewers) in forms of below-cost fees or even gifts. Notice that despite high prices, all platforms attract more than 30 percent of group B agents.

In Table 9 I evaluate the accuracy of the price-elasticity approximation by equation (12) (reported in columns under *Direct*) by comparing it with the correctly calculated own-price elasticity using equation (11) (columns under *Total*). The table shows that this approximation is especially poor in the competitive bottleneck model with the magnitude of average differences ranging from 38 to 63 percent for group A and 33 to 49 percent for group B. According to the approximated price elasticity, no platform sets prices at the elastic part of the demand curve on the single-homing side while all of them actually do so. The approximated price elasticity also indicates that prices charged by platforms 4 and 5 on the multi-homing side are set at the non-elastic part. The approximation is relatively better in the two-sided single homing model with average differences no larger than 3 percent, but it becomes poorer as the magnitude of α^A and α^B goes larger. For example, when $\alpha^A = \alpha^B = 2$, average differences range from 9 to 14 percent for group A and 12 to 19 percent for group B. Lastly, even the correct price elasticity indicates that all platforms except platform 5 set prices at the inelastic part for group B in the single-homing model. If markets were not two-sided, this pricing could not be profit-maximizing.

Appendix II: Computational Details of Merger Simulations

The computational algorithm used in the simulation in Section 5 consists of two parts. In an outer part it searches for new equilibrium prices in a hypothetical market structure and in an inner part it search for membership allocations that satisfy the demand equations given prices. I use a globally convergent Newton routine for the outer part search and adopt an algorithm in Fortran 90 provided by Press, et.al.(1996). For the inner part I use the fixed-point homotopy method, which is one kind of homotopy continuation methods and adopt a computational package called HOMPACK90 by Watson, et.al. (1997).

Given a system of $2 \times J$ demand equations $F(s; p) = 0$, the homotopy routine finds s that makes $F(s; p)$ zero for any p that the Newton routine tries. In the fixed-point homotopy method, in particular, a homotopy function is defined as

$$H(s, t) = (1 - t)\left(s - s^0\right) + tF(s)$$

where $0 \leq t \leq 1$ and s^0 can be any values between 0 and 1. Thus, when $t = 0$, $H(s, 0) = s - s^0 = 0$ and when $t = 1$, $H(s, 1) = F(s) = 0$.

Because there can be multiple sets of s that satisfy $F(s; p) = 0$, I use many sets of s^0 every time the homotopy algorithm is called for and check if each set of s^0 leads to the same solution. For s^0 I randomly draw from observed market shares without replacement. In the case of multiple solutions I select the one that maximizes the sum of all magazines' profits. Because I do not know the maximum number of solutions, I start with a small number of s^0 and increase the number until the maximum number of solutions does not change. In practice, I start with 20 sets of s^0 and increase it up to 100 sets. The case of multiple solutions does arise: I have found as many as 14 solutions in merger simulations.

Appendix III: The Market Size Effect

One may think there is some arbitrariness in the criterion used to choose the market size for advertisers, but it is not unreasonable to assume that most publishers made profits over the sample period, which spans from 1992 to 2010. The market size for the advertising side that makes all but one publishers' net present value of variable profits non-negative ranges from 152 to 158. There is one publisher, GVG, for which the market size needs to be larger than 158 to make it break even over the sample period. However, GVG's low profitability implied by the empirical model is not surprising, given that it was acquired by WAZ in 2001.

Moreover, in order for all publishers to make money over the sample period, the distribution of advertisers' willingness to pay needs to be stretched far right such that the advertiser-side marginal cost is estimated to be negative for a substantial portion of magazines. For example, when the advertiser-side market size is assumed to be 159, the variance of the distribution for advertisers' willingness to pay is estimated to be 115.5, and about a quarter of magazine-quarter observations are estimated to have negative marginal costs on the advertiser side. When the advertiser-side market size is assumed to be 152 as in the main specification, this variance is estimated to be 33.76, and about 16% of magazine-quarter observations are estimated to have negative marginal costs on the advertiser side.

It appears that the patterns that characterize the merger simulation results, described in Section 5, are not sensitive to different values of the market size as long as all but one publishers' net present value of variable profits is non-negative. However, when the advertiser-side market size becomes smaller such that more than one publisher fail to break even over the sample period, the magnitude of post-merger price changes becomes substantially smaller.

Tables 10 and 11 show merger simulation results for the BMK and WAZ merger when the market size on the advertiser side is 149 and 155.[44] When the advertiser-side market size is assumed to be 149, the GMM estimate for the scale parameter of the distribution for advertisers' willingness to pay is 1.23 and statistically significant at a 5% level, which implies that the variance of this distribution is 16.43. When the advertiser-side market size is assumed to be 155, this scale parameter is estimated to be 1.45 and statistically significant, which implies that the variance of this distribution is 58.59.

[44]When the market size is set to 149, three publishers are estimated to make a loss over the sample period. It would not be realistic to assume that three out of seven publishers did not make money over a 20-year period.

Estimates for the other coefficients change little, compared to those in the main specification. On the advertiser side, the coefficient for advertisers' marginal utility for content pages is -0.043, as compared to -0.037 in the main specification, when the market size is set to 149 and -0.033 when the market size is set to 155. On the reader side, the coefficient for readers' marginal utility for advertising changes most, which goes down from 2.855 in the main specification to 2.799 when the market size is 149 and goes up to 2.912 when the market size is 155. These coefficients are all statistically significant at a 5% level.

Tables 10 and 11 show that merger simulation results are not substantially different from those in the main specification when the market size is set to 155. When the market size is set to 149, it is still the case that copy prices go up much more modestly than what the one-sided market model predicts and ad prices tend to move in the opposite direction to copy prices post merger. However, it is no longer the case that the copy prices of the two monthly magazines increase more than what the one-sided market model predicts post merger. Both copy prices and ad prices go up for these two monthly magazines post merger, but the magnitude of the price increase is much smaller. A reason for the modest price increases would be that advertisers' willingness to pay for advertising space is substantially smaller at this market size such that the merged publisher would have much weaker incentives to raise copy prices to make more money from advertisers advertising on other magazines.

Appendix IV: Merger Simulations for Two Special Cases

In this section I analyze merger effects for two special cases of the two-sided market model. The first case is the setting where readers are indifferent about advertising. In this case the first order condition for ad prices becomes

$$\frac{\partial \pi_{1+2}}{\partial p_1^B} = s_1^B M^B + (p_1^B - c_1^B)\frac{\partial s_1^B}{\partial p_1^B} M^B = 0$$

because changes in ad prices have no direct effect on magazines' reader-side market shares, i.e., $\frac{\partial s_k^A}{\partial p_j^B} = 0, \forall j, k$, and the cross elasticity of ad price is zero, i.e., $\frac{\partial s_k^B}{\partial p_j^B} = 0, j \neq k$. Recall that multi-homing advertisers' demand for advertising in one magazine is independent of their demand for advertising in another magazine unless the amount of advertising affects readers' magazine choices in one way or another.

The first order condition for copy prices has the same terms as equation (16), i.e.,

$$\begin{aligned}\frac{\partial \pi_{1+2}}{\partial p_1^A} &= s_1^A M^A + (p_1^A - c_1^A)\frac{\partial s_1^A}{\partial p_1^A} M^A + (p_2^A - c_2^A)\frac{\partial s_2^A}{\partial p_1^A} M^A \\ &+ (p_1^B - c_1^B)\frac{\partial s_1^B}{\partial p_1^A} M^B + (p_2^B - c_2^B)\frac{\partial s_2^B}{\partial p_1^A} M^B = 0\end{aligned}$$

However, the magnitude of the own and the cross elasticities of copy prices is different from those in equation (16) because the effects of a change in copy prices that spill over to the advertising side do not spill back to the reader side, i.e., no feedback loop effects.

It looks as if ad prices would not change post merger under the simplified first order condition (for ad prices) because they should be the same monopoly prices pre and post merger. However, ad prices still change post merger because the reader-side market shares change and advertisers' demand for advertising shifts in response to changes in the reader-side market shares.

It is likely that publishers increase ad prices more than in the case of readers liking advertising because fewer ads resulting from higher ad prices would not adversely affect readers' demand for magazines. The first-order effect of a merger on copy prices is also likely larger because the own and the cross elasticities of copy prices are smaller (in absolute terms) in the absence of the feedback loop effects. That is, readers are less price sensitive in the absence of the feedback loop effects.

Tables 12 and 13 summarize merger effects with no feedback loop effects in the case of the BMK and WAZ merger. The results under the *Baseline* heading are those of the main specification reported in Tables 5 and 6. As expected, price effects are larger when readers do not care about advertising. While sales-weighted average price changes for the whole TV magazine industry are 11.48% for copy prices and 3.17% for ad prices in the baseline model, they are 20.13% for copy prices and 5.88% for ad prices when readers do not care about advertising. The larger price changes result in larger output changes. In the baseline model magazine sales are predicted to decrease by 5.83% and the number of ad pages are predicted to decrease by 10.46% for the whole TV magazine industry. The industry-wide sales-weighted average changes are now 6.76% for magazine sales and 16.01% for the number of ad pages when readers do not care about advertising.

It is worth emphasizing that prices can still decrease post merger with no feedback loop effects because demand for advertising still increases when copy prices decrease, i.e., $\frac{\partial s_1^B}{\partial p_1^A}$ is negative. For all magazines for which the merged publisher is predicted to decrease copy prices in the baseline model, their copy prices go down when readers do not care about advertising. In fact, their copy prices are predicted to go down further than in the baseline model because of no feedback loop effects.

The second special case is the setting where publishers distribute magazines for free, i.e., zero copy price. The first order condition for ad prices is the same as equation (17) except that $p_j^A = 0$ for all j's:

$$\begin{aligned}\frac{\partial \pi_{1+2}}{\partial p_1^B} &= s_1^B M^B + (p_1^B - c_1^B)\frac{\partial s_1^B}{\partial p_1^B} M^B + (p_2^B - c_2^B)\frac{\partial s_2^B}{\partial p_1^B} M^B \\ &\quad - c_1^A \frac{\partial s_1^A}{\partial p_1^B} M^A - c_2^A \frac{\partial s_2^A}{\partial p_1^B} M^A = 0\end{aligned}$$

In this case merger effects would be manifested only through higher ad prices as they are the only means that publishers can use to internalize the substitution effects. A merged publisher uses ad prices to internalize the substitution effects on the reader side through readers' preference for advertising. A higher ad price for a given magazine would lead some (ad loving) readers to switch to other magazines, but a merged publisher would recapture some of the lost readers with newly acquired magazines.

Tables 14 and 15 summarize merger effects when magazines are distributed for free in the case of the BMK and WAZ merger. The results under the *Baseline* heading are those of the main specification reported in Tables 5 and 6. Table 14 shows that ad prices increase much more substantially than in the baseline case. The industry-wide sales-weighted average ad price change is 38.14%, which is more than ten times higher than the average ad price change in the baseline model. Table 15 shows that output effects on the advertising side are much larger than in the baseline model, which is not surprising given the larger ad price effects. This table also shows that magazine sales are predicted to decrease for more magazines than in the baseline model. The industry-wide sales-weighted average sales decrease is 7.82% as compared to 5.83% in the baseline model.

The results of the two special cases of the two-sided market model suggest that analyzing merger effects with models that do not fully account for the two-sidedness of the market can have significant limitations and may lead to misleading conclusions with respect to the magnitude of merger effects.

Table 8: Average Price and Market Share in Equilibrium

	Two-sided Single Homing				Competitive Bottleneck			
	Group A		Group B		Group A		Group B	
Platform	Price	Share	Price	Share	Price	Share	Price	Share
1	0.732	0.133	0.052	0.175	0.292	0.056	0.768	0.401
2	0.891	0.132	0.207	0.172	0.145	0.079	1.905	0.347
3	1.059	0.133	0.353	0.179	-0.141	0.146	4.856	0.439
4	1.225	0.138	0.495	0.187	-0.311	0.260	11.425	0.482
5	1.401	0.134	0.689	0.177	-0.339	0.416	22.809	0.503

The market size is set to $M_A/M_B = 10$ for both models.

Table 9: Average Own-Price Elasticities

	Two-sided Single Homing				Competitive Bottleneck			
	Group A		Group B		Group A		Group B	
Platform	Direct	Total	Direct	Total	Direct	Total	Direct	Total
1	-1.274	-1.301	-0.313	-0.320	-0.903	-1.197	-1.722	-2.073
2	-1.551	-1.585	-0.464	-0.472	-0.916	-1.261	-1.445	-1.870
3	-1.842	-1.884	-0.646	-0.658	-0.937	-1.458	-1.083	-1.580
4	-2.119	-2.170	-0.873	-0.890	-0.932	-1.517	-0.955	-1.392
5	-2.430	-2.486	-1.158	-1.183	-0.764	-1.239	-0.947	-1.259

The market size is set to $M_A/M_B = 10$ for both models.

Table 10: Alternative market sizes in the case of BMK and WAZ merger: price changes

				$M_2 = 149$		$M_2 = 152$		$M_2 = 155$	
	Freq	Price	Ad Price	ΔPrice	ΔAd price	ΔPrice	ΔAd price	ΔPrice	ΔAd price
BMK1	6	1.53	51,328	0.06%	-0.17%	1.10%	1.98%	2.13%	-0.39%
BMK2	13	1.43	32,811	-0.01%	0.01%	-0.35%	0.52%	-0.88%	1.06%
BMK3	13	1.05	33,678	-0.02%	0.01%	-0.80%	0.75%	-1.87%	1.57%
BMK4	13	1.05	24,514	-0.01%	0.01%	-0.40%	0.39%	-1.03%	0.75%
BMK5	6	0.96	37,275	-0.04%	-0.02%	1.75%	1.74%	3.32%	-0.26%
BMK6	3	0.94	17,133	0.95%	0.09%	58.63%	13.14%	57.23%	13.80%
BMK7	13	0.75	16,032	-0.01%	0.00%	-0.61%	0.33%	-1.46%	0.60%
ASV1	6	1.58	46,418	0.07%	-0.19%	0.22%	3.54%	0.28%	2.97%
ASV2	13	1.43	39,227	0.00%	0.00%	-0.01%	-0.03%	-0.37%	0.20%
ASV3	13	1.05	7,347	-0.01%	0.00%	-0.03%	-0.02%	-0.46%	0.09%
ASV4	13	0.75	8,397	-0.01%	0.00%	-0.05%	-0.01%	-0.60%	0.05%
WAZ1	13	1.05	4,967	-0.07%	0.07%	-4.80%	5.57%	-8.77%	10.90%
WAZ2	13	1.05	3,343	-0.05%	0.05%	-3.60%	3.91%	-5.98%	6.70%
WAZ3	6	0.96	14,565	-0.16%	0.00%	61.28%	-9.33%	32.29%	-5.00%
WAZ4	3	0.95	8,930	1.02%	0.26%	70.88%	45.78%	68.50%	48.10%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million.

Table 11: Alternative market sizes in the case of BMK and WAZ merger: sales and ad changes

				$M_2 = 149$		$M_2 = 152$		$M_2 = 155$	
	Freq	Sales†	Ads	ΔSales	ΔAds	ΔSales	ΔAds	ΔSales	ΔAds
BMK1	6	1.50	233	-0.01%	0.16%	2.13%	0.14%	-0.36%	0.03%
BMK2	13	0.89	107	0.02%	0.03%	1.48%	1.44%	2.83%	2.47%
BMK3	13	1.30	85	0.04%	0.05%	2.56%	2.82%	5.06%	5.06%
BMK4	13	0.54	89	0.01%	0.02%	1.20%	1.26%	2.18%	2.06%
BMK5	6	2.40	200	0.32%	0.37%	3.90%	2.10%	-0.49%	-0.22%
BMK6	3	0.63	17	-0.41%	-0.89%	-21.86%	-46.59%	-21.38%	-44.42%
BMK7	13	0.30	56	0.02%	0.03%	1.24%	1.52%	2.13%	2.41%
ASV1	6	1.70	220	-0.12%	0.07%	4.49%	0.87%	3.21%	0.21%
ASV2	13	1.40	136	0.00%	0.00%	-0.09%	-0.08%	0.49%	0.38%
ASV3	13	0.18	66	0.00%	0.01%	-0.06%	-0.08%	0.30%	0.33%
ASV4	13	0.13	48	0.00%	0.00%	-0.04%	-0.06%	0.19%	0.23%
WAZ1	13	0.20	100	0.23%	0.27%	18.00%	18.03%	33.18%	28.97%
WAZ2	13	0.10	89	0.17%	0.21%	12.81%	13.41%	20.49%	19.11%
WAZ3	6	1.10	115	0.37%	0.49%	-64.34%	-73.42%	-43.81%	-47.90%
WAZ4	3	0.58	33	-0.79%	-1.61%	-37.16%	-73.93%	-36.18%	-71.54%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million.
†In millions.

Table 12: Merger effects with no feedback loop effects: price changes in the BMK and WAZ merger

				Baseline		No feedback loop effects	
	Freq	Price	Ad Price	ΔPrice	ΔAd price	ΔPrice	ΔAd price
BMK1	6	1.53	51,328	1.10%	1.98%	7.71%	-36.19%
BMK2	13	1.43	32,811	-0.35%	0.52%	-21.16%	20.21%
BMK3	13	1.05	33,678	-0.80%	0.75%	-42.54%	43.27%
BMK4	13	1.05	24,514	-0.40%	0.39%	-23.16%	12.63%
BMK5	6	0.96	37,275	1.75%	1.74%	81.85%	-27.78%
BMK6	3	0.94	17,133	58.63%	13.14%	74.83%	59.90%
BMK7	13	0.75	16,032	-0.61%	0.33%	-26.28%	8.66%
ASV1	6	1.58	46,418	0.22%	3.54%	11.82%	-28.56%
ASV2	13	1.43	39,227	-0.01%	-0.03%	-29.92%	36.89%
ASV3	13	1.05	7,347	-0.03%	-0.02%	-21.53%	11.75%
ASV4	13	0.75	8,397	-0.05%	-0.01%	-22.24%	5.78%
WAZ1	13	1.05	4,967	-4.80%	5.57%	-52.07%	59.26%
WAZ2	13	1.05	3,343	-3.60%	3.91%	-37.65%	34.15%
WAZ3	6	0.96	14,565	61.28%	-9.33%	84.18%	4.96%
WAZ4	3	0.95	8,930	70.88%	45.78%	86.11%	84.20%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million.

Table 13: Merger effects with no feedback loop effects: sales and ad changes in the BMK and WAZ merger

				Baseline		No feedback loop effects	
	Freq	Sales[†]	Ads	ΔSales	ΔAds	ΔSales	ΔAds
BMK1	6	1.50	233	2.13%	0.14%	-52.34%	-25.03%
BMK2	13	0.89	107	1.48%	1.44%	42.31%	27.84%
BMK3	13	1.30	85	2.56%	2.82%	115.49%	82.13%
BMK4	13	0.54	89	1.20%	1.26%	26.50%	19.35%
BMK5	6	2.40	200	3.90%	2.10%	-75.04%	-72.71%
BMK6	3	0.63	17	-21.86%	-46.59%	-30.16%	-77.58%
BMK7	13	0.30	56	1.24%	1.52%	20.44%	18.64%
ASV1	6	1.70	220	4.49%	0.87%	-53.47%	-36.02%
ASV2	13	1.40	136	-0.09%	-0.08%	85.42%	50.58%
ASV3	13	0.18	66	-0.06%	-0.08%	27.01%	22.90%
ASV4	13	0.13	48	-0.04%	-0.06%	13.23%	12.36%
WAZ1	13	0.20	100	18.00%	18.03%	170.66%	109.34%
WAZ2	13	0.10	89	12.81%	13.41%	87.32%	63.52%
WAZ3	6	1.10	115	-64.34%	-73.42%	-64.60%	-79.44%
WAZ4	3	0.58	33	-37.16%	-73.93%	-43.34%	-86.18%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million.
[†]In millions.

Table 14: Merger effects when magazines are free: ad price changes in the BMK and WAZ merger

				Baseline		Free magazines	
	Freq	Price	Ad Price	ΔPrice	ΔAd price	ΔPrice	ΔAd price
BMK1	6	1.53	51,328	1.10%	1.98%		74.48%
BMK2	13	1.43	32,811	-0.35%	0.52%		31.46%
BMK3	13	1.05	33,678	-0.80%	0.75%		10.28%
BMK4	13	1.05	24,514	-0.40%	0.39%		7.77%
BMK5	6	0.96	37,275	1.75%	1.74%		54.48%
BMK6	3	0.94	17,133	58.63%	13.14%		12.55%
BMK7	13	0.75	16,032	-0.61%	0.33%		3.90%
ASV1	6	1.58	46,418	0.22%	3.54%		19.70%
ASV2	13	1.43	39,227	-0.01%	-0.03%		8.86%
ASV3	13	1.05	7,347	-0.03%	-0.02%		59.97%
ASV4	13	0.75	8,397	-0.05%	-0.01%		14.88%
WAZ1	13	1.05	4,967	-4.80%	5.57%		24.36%
WAZ2	13	1.05	3,343	-3.60%	3.91%		27.01%
WAZ3	6	0.96	14,565	61.28%	-9.33%		64.78%
WAZ4	3	0.95	8,930	70.88%	45.78%		101.97%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million.

Table 15: Merger effects when magazines are free: sales and ad changes in the BMK and WAZ merger

				Baseline		Free magazines	
	Freq	Sales†	Ads	ΔSales	ΔAds	ΔSales	ΔAds
BMK1	6	1.50	233	2.13%	0.14%	-29.91%	-44.06%
BMK2	13	0.89	107	1.48%	1.44%	-11.58%	-24.94%
BMK3	13	1.30	85	2.56%	2.82%	-0.89%	-14.27%
BMK4	13	0.54	89	1.20%	1.26%	0.32%	-11.97%
BMK5	6	2.40	200	3.90%	2.10%	-3.28%	-52.47%
BMK6	3	0.63	17	-21.86%	-46.59%	-1.88%	-16.47%
BMK7	13	0.30	56	1.24%	1.52%	0.68%	-5.84%
ASV1	6	1.70	220	4.49%	0.87%	-4.59%	-23.09%
ASV2	13	1.40	136	-0.09%	-0.08%	0.34%	-13.80%
ASV3	13	0.18	66	-0.06%	-0.08%	-24.46%	-38.97%
ASV4	13	0.13	48	-0.04%	-0.06%	-1.07%	-20.72%
WAZ1	13	0.20	100	18.00%	18.03%	-3.59%	-29.48%
WAZ2	13	0.10	89	12.81%	13.41%	-4.58%	-31.32%
WAZ3	6	1.10	115	-64.34%	-73.42%	-13.79%	-48.28%
WAZ4	3	0.58	33	-37.16%	-73.93%	-13.86%	-66.72%

The (optimal) GMM estimates of the nested logit model for the third quarter of 2009 are used. The market size for readers is set to 40 million.
†In millions.