To Partner or Not to Partner? The Partnership Between Platforms and Data Brokers in Two-sided Markets

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Abstract

Data has become an important competitive asset, especially for online advertising platforms, and the huge demand for data has spawned a new data broker industry. Platforms usually partner with data brokers to acquire external data to enhance their targeting capabilities, but this practice has stoked consumer privacy concerns. This study develops a game-theoretic model to examine the economic mechanism underlying the partnership between competing platforms and a data broker in a two-sided market. Interestingly, our analysis shows that the increase in consumer privacy concerns caused by the data broker may incentivize platforms to partner with the data broker rather than discouraging them. The driving force is that due to negative cross-side network effects, increased privacy concerns can be a strategic lever to soften price competition on the advertiser side. However, when both platforms partner with the data broker, a prisoner's dilemma situation may arise in equilibrium even though the data broker can greatly improve the targeting capabilities. We find that the platform-data broker partnership hurts consumer surplus when platforms adopt a pure ad-sponsored model without charging consumers, but it may benefit consumer surplus when platforms adopt a mixed model with ad-sponsored and subscription-based revenue. We consider several model extensions to seek additional insights, including the data broker charging an endogenous commission fee and cases where the consumer or advertiser can multihome (join more than one platform). Managerial and policy implications of the findings are discussed.

Keywords: platforms, data brokers, platform-data broker partnership, privacy concerns

1. Introduction

Data has become a strategic asset for many businesses and industries (DalleMule and Davenport 2017). The huge demand for data has spawned an emerging data broker industry, which was valued at USD 232 billion in 2019 and is expected to reach USD 345 billion in 2026[1]. Major data brokers in the market include Acxiom, Experian, Oracle, and Lotame, which actively collect consumer data from various online and offline sources (e.g., social media, web history, offline purchase history). Data brokers aggregate and process the collected data to generate consumer insights and then share those with other companies for purposes such as targeted advertising and personalized pricing.

Given the importance of data, online advertising platforms (e.g., Facebook, TikTok, and publisher websites) have begun to partner with data brokers (Venkatadri et al. 2019). These platforms are funded by digital advertising in a two-sided market, in which they provide online services to consumers while collecting consumer data for selling targeted ads to advertisers. By partnering with data brokers, platforms can improve their targeting capabilities by acquiring external data and analytic services. For instance, Facebook used to partner with several data brokers (e.g., Acxiom, Experion), allowing for the data collected online by Facebook to be linked against data collected offline by data brokers. This enables platforms to refine their targeting based on information compiled by these partners, such as offline demographic and behavioral information like addresses, income, and purchase history. Other examples include the partnership between TikTok and Oracle, where TikTok can gain better user insights by leveraging Oracle's data analytics service (Goetzen 2020). According to recent media

[1] https://www.knowledge-sourcing.com/report/global-data-broker-market

reports (Lotame 2020), partnering with data brokers has become an important competitive strategy for platforms to increase their competitive edge in the advertising market.

The platform-data broker partnership, while beneficial to advertisers, may hurt consumers. According to a survey by eMarketer (2019), 77% of US internet users are concerned that targeted advertising based on their personal data may invade privacy. Recently, the emergence of platform-data broker partnerships has *exacerbated* consumer privacy concerns because the linking of the data from two parties may leak more sensitive information about users to advertisers (Venkatadri et al. 2018). In line with recent privacy regulations such as the California Consumer Privacy Act (CCPA) and EU's General Data Protection Regulation (GDPR), platforms must disclose with whom they share consumer data. Hence, platform-data broker partnerships are much more visible to consumers than ever before. However, consumers are unclear about whether and how data brokers may utilize their personal data for any other purpose. Due to the untransparent operations of the data broker industry, platform-data broker partnerships have triggered greater concerns over invasion of privacy (Ram and Murgia 2019; Sherman 2020). Moreover, increasingly common data breach incidents have also heightened privacy concerns about the platform-data broker partnership. One of the most notorious examples is the Facebook Cambridge Analytica Scandal, where Facebook exposed user data to an external data broker for political advertising. Typically, when platforms sell more targeted ads, consumers are more vulnerable to privacy invasion as their data may be shared with more advertisers (i.e., negative cross-side network effects). The increased privacy concern may lead to loss of users and reduced platform usage, which indirectly affect the platforms' competitiveness on the advertiser side (i.e., revenue-generating side). As a consequence, platforms' ad pricing and advertiser demands may also be affected.

Faced with tremendous pressure from consumer privacy groups and regulatory authorities, some platforms have stopped partnering with data brokers (Tau 2020). For instance, Facebook announced it would terminate its partnership with data brokers in 2018 after the Cambridge Analytica Scandal (Ingram and Fioretti 2018). Evidently, such a decision is made to save the firm's image and reputation in reaction to a wave of criticism. Nevertheless, when surveying the market, we find that many other platforms are still closely partnering with data brokers to share consumer insights with advertisers or marketing agencies. For instance, Snapchat has partnered with Oracle to improve its ad targeting since 2017 (Maytom 2017). Besides these examples, many publisher websites have partnered with Lotame to enhance targeting capabilities. These diverse partnership strategies motivate our investigation of platforms' incentives to partner with the data broker given the potential merits (i.e., improved targeting level) and demerits (i.e., increased privacy concerns) in a two-sided market. Moreover, in view of the ongoing debate about the data broker industry, it is important to examine the welfare implications of platform-data broker partnerships.

In particular, we address the following research questions in this study: (i) How does the partnership with a data broker affect platforms' pricing strategies and profits? (ii) When should competing platforms partner with a data broker? (iii) How does the partnership between the data broker and platforms affect the consumer surplus, advertiser surplus, and social welfare? To answer these questions, we build a game-theoretic model in which two competing platforms provide services to consumers while selling targeted ads to advertisers. Partnering with the data broker can improve platforms' targeting capabilities, but it also invokes greater consumer privacy concerns, and platforms need to pay a commission to the data broker for each ad sale. In the main model, we assume platforms adopt a pure ad-sponsored model without charging consumers. In the extension, we consider the case where platforms adopt a mixed model of subscription-based (i.e., charge consumers a price) and ad-sponsored revenue. We also consider other extensions in which the data broker sets the commission rate endogenously, and the consumers or advertisers can join multiple platforms (i.e., multihoming).

Our analysis yields several interesting and important insights. First, we find that the increase in consumer privacy concerns caused by data brokers may incentivize rather than discourage platforms from partnering with the data broker. This counterintuitive result can be explained from the perspective of the negative cross-side network effect in two-sided markets. To elaborate, when partnering with the data broker invokes greater privacy concerns about targeted advertising, platforms are compelled to compete for advertisers less aggressively to avoid consumer churn. Hence, both platforms will charge a higher ad price, which softens the price competition and leads to higher profits. This result has an important implication: *increased privacy concerns caused by platform-data broker partnership can be a strategic lever to soften price competition on the advertiser side*. This privacy concern-induced higher price is consistent with trends observed in the industry. In practice, many publishers are trying to increase ad prices and reduce the number of ads in response to consumers' growing privacy concerns about targeted ads, which has proven to boost revenue for some publishers (Bishop 2018; Marshall 2017). Our research provides a possible explanation of why platform-data broker partnerships still prevail in the market despite growing consumer privacy concerns about data brokers.

Another important factor motivating the platforms to partner with the data broker is that the latter can help improve platform targeting capabilities, which aligns with our expectations. However, it is intriguing to find that partnering with the data broker may lead to a prisoner's dilemma for platforms;

that is, platforms may be worse off than if they both commit not to partner with the data broker. This happens when the data broker induces high, but not too high, privacy concerns. In this case, platform competition will be eased, but not substantially, so the incremental revenue from partnering with the data broker cannot compensate for the commissions paid to the data broker. This result resonates well with recent field studies and industrial reports, which indicate that although partnering with a data broker can increase platforms' competitive advantage in targeting capabilities, their profits may even decrease because the data broker extracts a large proportion of ad revenue (CMA 2020; Neumann 2019). Overall, our findings confirm that platforms should carefully assess consumer privacy concerns about data brokers and the commission charged by the data broker before making such partnership decisions.

Our results also reveal important welfare implications by examining consumer surplus, advertiser surplus, and social welfare. We find that the platform's business model plays a crucial role in whether partnering with data broker benefits or hurts consumers. When platforms adopt a pure ad-sponsored model, partnering with a data broker always hurts consumers due to the increased privacy concerns. However, when platforms adopt a mixed model of subscription-based and ad-sponsored revenue, a platform-data broker partnership can benefit consumers because it will intensify the price competition on the consumer side, resulting in a lower consumer price and thus higher consumer surplus. The caveat here is that although the ad-sponsored model does not charge consumers, it can harm them in the context of platform-data broker partnerships. Hence, policymakers should take into account the platform's business model when scrutinizing the impact of platform-data broker partnerships on consumer surplus. Looking at advertiser surplus and social welfare, we show that advertisers and society can be better off when the improvement in targeting capabilities outweighs the increase in consumer privacy concerns.

The remainder of this paper is organized as follows. We review relevant literature in Section 2. In Section 3, we describe our model framework, followed by the model analysis and the equilibrium results about platforms' partnership strategies in Section 4. Section 5 extends the model with several alternative model setups. Finally, the paper concludes in Section 6 with a discussion of managerial implications, limitations of the study, and future research directions.

2. Literature Review

This study relates to the growing literature on two-sided platform markets. Starting with pioneer works by Caillaud and Jullien (2003) and Rochet and Tirole (2003), a rapidly increasing number of studies have investigated pricing strategies for two-sided platforms (Armstrong 2006; Hagiu 2009; Parker and Van Alstyne 2005; Rochet and Tirole 2006). Given the presence of cross-side network effects, a major implication from these studies is that platforms can maximize profits by subsidizing one side and charging a high price on the other side. This result is derived in the setting where both sides of two-sided platforms singlehome (i.e., agents on both sides are allowed to join only one platform) (Belleflamme and Peitz 2019), or where agents on one side singlehome and the other side can multihome (i.e., join multiple platforms); the latter setting is called a competitive bottleneck (Armstrong 2006; Armstrong and Wright 2007). In the setting where agents on both sides multihome, however, Bakos and Halaburda (2020) show that it may not be optimal for platforms to subsidize one side because there is no strategic interdependence between two sides in this case. Most research in this stream considers that both sides of the market have positive cross-side network effects on the other side. In our context, cross-side network effects are positive in one direction (i.e., consumers to advertisers) but negative in the other due to privacy concerns (i.e., advertisers and data brokers to consumers).

Some studies examine the implications of nonprice factors on platform competition under cross-side network effects (Hagiu and Spulber 2013; Anderson et al. 2014; Dou and Wu 2021). For instance, Hagiu and Spulber (2013) examine platform incentives to invest in first-party content as a strategic nonprice control and how such content interacts with the platforms' pricing strategies. Dou and Wu (2021) investigate how piggybacking, in which platforms can import exclusive external users, affects platforms' optimal pricing and subsidization strategies. The current study contributes to this literature by introducing the partnership with data brokers as a nonprice control for platforms and showing the interplay between cross-side network effects and price competition.

Recently, some studies have focused on two-sided *media* markets (e.g., Ambrus et al. 2016; Anderson et al. 2018; Athey et al. 2014), which are closer to our research context. One of the studies most relevant to ours is Gopal et al. (2018), which examines the impact of privacy concerns on publisher websites' incentives to share user information with third parties (e.g., advertisers). In their model, third parties generate negative network effects on the consumer side, driven by user privacy concerns as in Casadesus-Masanell and Hervas-Drane (2015). Although we also consider consumer privacy concerns, our study departs from theirs in that we focus on the partnership between platforms and the data broker as a strategic variable for platforms. We characterize the conditions when partnering with the data broker can improve profit and when it leads to a prisoner's dilemma outcome for platforms. Moreover, in Gopal et al. (2018), platforms charge prices from both sides (advertisers and consumers), and there is no competition on the advertiser side. In contrast, in our setting, platforms can adopt an ad-sponsored model without charging consumers, and we model the platform competition on the advertiser side.

This study also contributes to the literature on online data markets (Bergemann and Bonatti 2019), in which data brokers play a strategic role in deciding how to sell data to downstream firms (e.g., advertising platforms in this study). Prior literature examines data brokers' data sharing strategies in various contexts, where data can be used to price discriminate (Bounie et al. 2021; Braulin and Valletti 2016; Montes et al. 2019), predict market demand (Bimpikis et al. 2019), and improve consumer targeting (Bergemann, and Bonatti 2015; Zhang et al. 2020). Different from these papers that focus on a one-sided market where the interactions between firms and consumers are considered, we focus on a two-sided market where the platform-data broker partnership benefits the advertiser side but hurts the consumer side. Our study sheds light on the implications of platform-data broker partnership on different stakeholders, including platforms, advertisers, consumers, and the data broker.

Finally, this study broadens the literature on the economics of privacy (see Acquisti et al. 2016 for a comprehensive literature survey). A recent strand of literature examines the implications of consumer privacy in the context of price discrimination (Chen et al. 2020; Conitzer et al. 2012) and personalized service provision (Chellappa and Shivendu 2010). Close to our context, several papers examine the impact of privacy concerns when platforms collect consumer data for targeted advertising. For instance, Gal-Or et al. (2018) study the role of privacy concerns on platform competition, finding that a higher privacy concern can intensify platform competition because it reduces the targeting differentiation of competing platforms. Dimakopoulos and Sudaric (2018) examine how privacy concerns and platform competition affect platforms' decisions on how much data to collect. They find that the data collection level can be inefficiently high if the competition is weak. Our study contributes to this literature by examining how consumer privacy concerns affect the partnership between platforms and the data broker, which is a growing trend in practice but rarely studied. Our analysis provides insights into the economic mechanisms that explain the platform-data broker partnership.

3. Model

We consider a two-sided market consisting of three types of players, i.e., two symmetric competing platforms (denoted by $i = A, B$), a unit mass of consumers, and a unit mass of advertisers. Platforms provide services to consumers while collecting their data and selling targeted ads to advertisers. Thus, platforms compete for both the consumer side (called the X side) and the advertiser side (called the Y side). Following the prior literature (Bakos and Halaburda 2020; Dimakopoulos and Sudaric 2018), we employ a two-sided Hotelling model to capture the competition between platforms. Specifically, consumers and advertisers are uniformly distributed along two Hotelling lines, i.e., $x \sim U[0,1]$ for the X side, $y \sim U[0,1]$ for the Y side. Platforms are located at the endpoints of the two Hotelling lines, with platform A being at 0 and platform B being at 1. In the main model, we assume both consumers and advertisers singlehome. In the extension, we consider the case where consumers or advertisers can multihome. Below, we describe the platform profits, consumer utility, and advertiser payoff.

3.1. Platforms

By analyzing consumer data, platforms can learn consumer preferences and build consumer profiles. These insights and knowledge enable the platform to develop targeting capabilities to find relevant consumers, thereby attracting advertisers to purchase ad slots on their platforms. We denote platforms' baseline targeting capabilities as β. Typically, a higher targeting capability can increase advertisers' willingness to pay for a higher ad price. In the main model, we assume platforms adopt a pure ad-sponsored business model without charging consumers, which is commonly adopted by many advertising platforms (e.g., Facebook and YouTube). In Section 5.1, we also consider platforms adopting a mixed model with both ad-sponsored and subscription-based revenue.

To further improve targeting capabilities, platforms can partner with data brokers who collect a wide variety of consumer data from online and offline sources. For instance, Facebook used to partner with several data brokers (e.g., Acxiom, Experion, and Oracle), allowing for the data collected online by Facebook to be linked to data collected offline by data brokers. This partnership enables platforms to refine their targeting based on information compiled by these partners, such as offline demographic and behavioral information like homeownership or purchase history. As a result, after partnering with the data broker, the platforms' targeting capability can be enhanced, which is denoted by $\beta + \delta$, where δ is the targeting improvement enabled by the data broker.

Note that when platforms partner with the data broker to improve targeting capabilities, platforms pay a commission to the data broker (i.e., a proportion of advertising revenue), which can be considered as a referral fee. The commission rate is denoted by γ, and we assume γ is not too high to ensure platforms have incentives to partner with the data broker. In practice, such a revenue-sharing model is widely used between platforms and data brokers (CMA 2020). Platforms can choose whether to partner with the data broker, denoted by Y (partner) or N (not partner). Table 1 summarizes the platforms' decision matrix. There are four different partnerships between platforms and the data broker. The first (second) argument at each strategy profile represents the platform A's (B's) decision.

Platform A / Platform B	N	Y
N	(N, N)	(N, Y)
Y	(Y, N)	(Y, Y)

Table 1. Platforms' Decision Matrix

The platforms' profit functions are as follows, (i) when the platform i does not partner with the data broker, $\pi_i = p_i D_i$; (ii) when the platform i partners with the data broker, $\pi_i = (1-\gamma) p_i D_i$, where p_i is the ad price charged for advertisers, D_i is platform i's advertiser demand, and γ is the commission rate. In the main model, we assume the commission rate is exogenous. In Section 5.2, we consider the case of the data broker deciding the commission rate endogenously.

3.2. Consumers

Consumers derive a value (denoted by v_c) from consuming the platforms' content services. In this process, platforms collect consumer data such as names, contact details, search history, IP addresses, and number of clicks. Platforms may share the data with advertisers to help advertisers deliver targeted ads to consumers, which has infringed on consumer privacy (Mayer and Mitchell 2012). A recent survey indicates that the majority of respondents resent targeted ads due to perceived privacy intrusions[2]. Thus, although the service is free of charge, consumers incur privacy costs when using the platforms' service.

Following the prior literature (Lin 2022), we consider two components of a consumer's privacy cost: (i) intrinsic privacy cost (denoted by κ), which reflects a consumer's intrinsic preference for privacy, and (ii) variable privacy cost, which relates to how much consumer information is disclosed to other firms. For variable privacy cost, as platforms sell targeted ads to more advertisers, consumers will perceive a higher disutility as their information is more likely to be leaked to more third parties (King 2019; Tucker 2012). Therefore, consistent with Gopal et al. (2018), we model the consumers' variable privacy cost caused by targeted advertising as αy_i, where α denotes the consumer privacy concerns, and y_i represents the number of advertisers served by platform i.

[2] https://www.mediapost.com/publications/article/338009/consumers-dislike-targeted-ads-resent-privacy-int.html?

As we mentioned before, platforms can choose to partner with the data broker to improve their ad targeting capabilities. Typically, platforms and data brokers share the data they have with each other to generate more fine-grained targeting features regarding consumers (Venkatadri et al. 2019). From the consumers' perspective, however, such a partnership will exacerbate privacy concerns about targeted advertising because more sensitive information can be leaked to advertisers or third parties without consumer control (Molitorisz 2018). For instance, in the Facebook Cambridge Analytica scandal, Facebook was severely criticized by consumer privacy groups for sharing consumer data with third-party data brokers for political advertising. Therefore, when partnering with the data broker, the consumers' privacy concerns will be higher, which we denote as $\alpha + \rho$, where ρ is the increase in privacy concerns caused by the data broker[3].

Taking all these aspects together, a consumer located at x will obtain the utility $U_i(x)$ when adopting platform i:

$$U_A(x) = v_c - \kappa - (\alpha + \mathbb{I}_A \rho) y_A - tx,$$
$$U_B(x) = v_c - \kappa - (\alpha + \mathbb{I}_B \rho) y_B - t(1 - x)$$

where v_c is the intrinsic service value, which is assumed to be the same for both platforms (Anderson Jr et al. 2014). The second term κ denotes the consumers' intrinsic privacy cost. The third term $(\alpha + \mathbb{I}_A \rho) y_A$ $((\alpha + \mathbb{I}_B \rho) y_B)$ represents the privacy costs caused by targeted advertising and the data broker[4],

[3] Since, in our context, the platform-data broker partnership mainly affects the ad targeting process, we focus on the impact of this partnership on consumers' variable privacy cost incurred from targeted advertising. However, it should be noted that our key insights remain unchanged if platforms-data broker partnership also increases intrinsic privacy cost.

[4] Note that consumer disutility from advertisements can also be interpreted along other dimensions, such as the nuisance cost. Given that platforms increasingly display targeted ads based on consumer data, empirical evidence shows that perceived privacy intrusions have become a primary cause of consumer disutility (Mckeon 2019). Hence, in our context, we follow the literature to interpret this disutility as a consumer privacy concern (Gopal et al. 2018).

and $\mathbb{I}_A$ ($\mathbb{I}_B$) is an indicator function that equals one if platform A (B) partners with the data broker and zero otherwise. This specification implies that the consumers' privacy cost increases when platforms sell targeted ads to more advertisers (Gopal et al. 2018; Mckeon 2019), which reflects the *negative* cross-side network effects on the consumer side. The expressions tx and $t(1-x)$ denote the misfit cost for a consumer at x to adopt platform A and B. When t increases, consumers are less willing to switch between platforms, so t can also measure the degree of competition intensity, with a higher t indicating that the competition is less intense on the consumer side (Anderson et al. 2014).

3.3. Advertisers

Advertisers derive benefits from displaying ads on platforms. Such benefits depend on the platforms' targeting capabilities and the number of consumers on the platform. Formally, an advertiser located at y will obtain the following payoff $U_i(y)$ when displaying an ad on platform A or platform B:

$$U_A(y) = v_s + (\beta + \mathbb{I}_A\delta)x_A - p_A - \theta y$$
$$U_B(y) = v_s + (\beta + \mathbb{I}_B\delta)x_B - p_B - \theta(1-y)$$

where v_s represents the standalone value advertisers can derive from adopting the platform. Here, $(\beta + \mathbb{I}_i\delta)$ represents platform i's targeting capabilities, $\mathbb{I}_i$ is the indicator function used to indicate whether platform i partners with the data broker, and x_i is the number of consumers adopting that platform. Hence, $(\beta + \mathbb{I}_i\delta)\, x_i$ can be considered as the fraction of users that can be targeted by platform i. The ad price charged by platform i is p_i. Finally, θy and $\theta(1-y)$ denote the advertisers' misfit cost, where θ can measure the competition intensity on the advertiser side. Note that as the number of consumers increases, advertisers will obtain a higher payoff, which reflects the positive cross-side network effects on the advertiser side.

As illustrated in Figure 1, the timeline of the model has three stages. In stage 1, competing platforms decide whether to partner with the data broker. In stage 2, the platforms determine the price for advertisers simultaneously. In stage 3, both consumers and advertisers decide which platform to join based on the platforms' pricing and partnering decisions in stage 1 and stage 2.

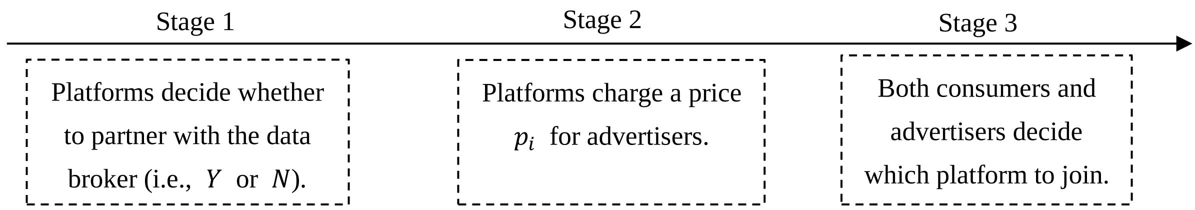


Figure 1. Sequence of events

4. Equilibrium Analysis

We use the backward induction approach to derive the subgame perfect Nash equilibrium. Based on platforms' decisions in stage 1 (i.e., Y or N), there are four subgames: $(N,\ N)$, $(Y,\ N)$, $(N,\ Y)$, $(Y,\ Y)$. Since the platforms are symmetric, $(Y,\ N)$ is equivalent to $(N,\ Y)$, so we will focus on the $(Y,\ N)$ case. We first determine platforms' pricing equilibrium in stage 2 in Section 4.1. Then, in Section 4.2, by comparing three subgames, we examine which can be the equilibrium in stage 1.

4.1. Platforms' pricing decisions in stage 2

4.1.1. When neither platform partners with the data broker $(N,\ N)$

We begin by analyzing the case where neither platform partners with the data broker (i.e., $\mathbb{I}_A = 0$, $\mathbb{I}_B = 0$). By solving $U_A^{NN}(x)|_{\mathbb{I}_A=0} = U_B^{NN}(x)|_{\mathbb{I}_B=0}$, $U_A^{NN}(y)|_{\mathbb{I}_A=0} = U_B^{NN}(y)|_{\mathbb{I}_B=0}$, we can derive the indifferent consumer type x^{NN*} and the indifferent advertiser type y^{NN*}: $x^{NN*} = \frac{t+\alpha-2\alpha y_A}{2t}$, $y^{NN*} = \frac{2\beta x_A - p_A + p_B + \theta - \beta}{2\theta}$. The platforms' advertiser demands are $D_A^{NN} = y^{NN*}$ and $D_B^{NN} = 1 - y^{NN*}$. Hence, the platforms' optimal profits are $\max_{p_A^{NN}} \pi_A^{NN} = p_A^{NN} D_A^{NN}$, $\max_{p_B^{NN}} \pi_B{}^{NN} = p_B^{NN} D_B^{NN}$. By maximizing platforms' profit functions, we can derive the equilibrium prices and profits in (N, N) case.

Lemma 1. *When neither platform partners with the data broker, the platforms' equilibrium ad prices and profits are:* $p_A^{NN*} = p_B^{NN*} = \frac{\alpha\beta}{t} + \theta$, $\pi_A^{NN*} = \pi_B^{NN*} = \frac{\alpha\beta}{2t} + \frac{\theta}{2}$.

There are several observations from Lemma 1. First, it is interesting to find that when consumer privacy concerns (α) increase, platforms charge a higher ad price and obtain higher profits. This result is driven by the negative cross-side network effects on the consumer side. When α increases, consumers are more sensitive to targeted advertising due to higher privacy concerns. To avoid the loss of consumers, which is important for the advertiser side, platforms have incentives to limit the number of advertisers. Here, increasing ad prices is an effective way to control the advertiser demand, so both platforms would choose to increase ad prices, which softens the price competition on the advertiser side and leads to higher profits. Second, when platforms' targeting capabilities increase (β), platforms can charge a higher price and achieve higher profits. This is because a higher targeting capability brings more value to advertisers, which enhances their willingness to pay.

Further, we find that the platforms' prices increase with advertiser side misfit cost (θ). This result is expected because a higher θ implies that the competition intensity on the advertiser side is less intense. However, interestingly, when the misfit cost of the consumer side (t) increases, platform prices and profits decrease. This happens because when t increases, consumers have a stronger preference between the two platforms. In this case, having more advertisers on the platform would not drive many consumers to switch to the rival platform. Hence, platforms have incentives to reduce their prices to attract more advertisers, which, in turn, intensifies the price competition, resulting in lower prices and profits. This result implies that a less-competitive environment on the consumer side can lead to more intense competition on the advertiser side. This finding differs from the prior literature that assumes platforms conduct two-sided pricing (Bakos and Halaburda 2020; Dou and Wu 2021); those studies show that one side's misfit cost only affects the price of the same side, not the price of the opposite side.

4.1.2. When only one platform partners with the data broker $(\boldsymbol{Y},\ \boldsymbol{N})$

We now consider an asymmetric partnership decision by the two platforms. Without loss of generality, we assume platform A partners with the data broker while platform B does not (i.e., $\mathbb{I}_A = 1$, $\mathbb{I}_B = 0$). In this case, the platform's targeting capabilities will be improved, but the consumers' privacy concerns increase when using platform A. By solving $U_A^{YN}(x)|_{\mathbb{I}_A=1} = U_B^{YN}(x)|_{\mathbb{I}_B=0}$, $U_A^{YN}(y)|_{\mathbb{I}_A=1} = U_B^{YN}(y)|_{\mathbb{I}_B=0}$, we can derive the indifferent consumer type x^{YN*} and the indifferent advertiser type y^{YN*}: $x^{YN*} = \frac{t+\alpha-(2\alpha+\rho)y_A}{2t}$, $y^{YN*} = \frac{(2\beta+\delta)x_A-p_A+p_B+\theta-\beta}{2\theta}$. Hence, the platforms' optimal profits are $\max_{p_A^{YN}} \pi_A^{YN} = (1-\gamma)p_A^{YN}y^{YN*}$, $\max_{p_B^{YN}} \pi_B^{YN} = p_B^{YN}(1-y^{YN*})$. By maximizing platforms' profit functions, we can derive the equilibrium prices and profits in the $(Y,\ N)$ case.

Lemma 2. *When only platform A partners with the data broker, the platforms' equilibrium ad prices and profits are as follows:*

(i) $p_A^{YN*} = \frac{t(\delta+6\theta)+(2\beta+\delta)(3\alpha+\rho)}{6t}$, $p_B^{YN*} = \frac{(2\beta+\delta)(3\alpha+2\rho)-t(\delta-6\theta)}{6t}$

(ii) $\pi_A^{YN*} = \frac{(1-\gamma)(t(\delta+6\theta)+(2\beta+\delta)(3\alpha+\rho))^2}{18t(4t\theta+(2\beta+\delta)(2\alpha+\rho))}$, $\pi_B^{YN*} = \frac{((2\beta+\delta)(3\alpha+2\rho)-t(\delta-6\theta))^2}{18t(4t\theta+(2\beta+\delta)(2\alpha+\rho))}$

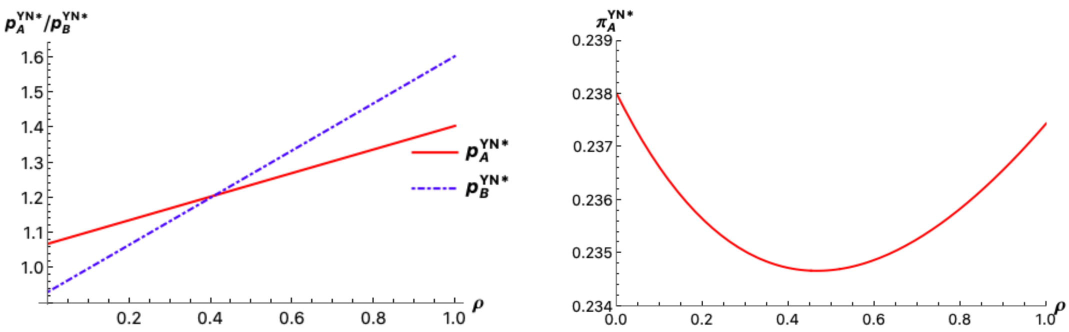
Based on Lemma 2, the following corollary summarizes the comparative static analysis of the increased privacy concerns ρ and the improvement in targeting capabilities δ induced by the data broker.

Corollary 1. *When only platform A partners with the data broker, the equilibrium outcomes have the following properties:*

(i) $\frac{\partial p_B^{YN*}}{\partial \rho} > \frac{\partial p_A^{YN*}}{\partial \rho} > 0$; $p_A^{YN*} > p_B^{YN*}$ *when* $\rho < \frac{2t\delta}{2\beta+\delta}$, *otherwise,* $p_A^{YN*} < p_B^{YN*}$ *when* $\rho < \frac{2t\delta}{2\beta+\delta}$;

(ii) $\frac{\partial \pi_B^{YN*}}{\partial \rho} > 0$; $\frac{\partial \pi_A^{YN*}}{\partial \rho} < 0$ *when* $\rho < \frac{t(\delta-2\theta)}{2\beta+\delta} - \alpha$, *otherwise,* $\frac{\partial \pi_A^{YN*}}{\partial \rho} > 0$ *when* $\rho > \frac{t(\delta-2\theta)}{2\beta+\delta} - \alpha$;

We derive several important insights from Lemma 2 and Corollary 1. First, when partnering with the data broker, the increase in consumer privacy concerns (i.e., ρ) incentivizes the platform A to increase its price. Foreseeing the price increase of platform A, platform B can also increase its price accordingly (See Figure 2(a)). Interestingly, we find that platform B's price has a higher increasing rate as ρ increases (i.e., $\frac{\partial p_B^{YN*}}{\partial \rho} > \frac{\partial p_A^{YN*}}{\partial \rho} > 0$). This is because when ρ increases, platform A will lose consumers due to the higher increase in privacy concerns, while platform B will gain consumers. Given the presence of cross-side network effects, platform B provides relatively high value on the advertiser side, which enables platform B to increase its price more. We show that when ρ is greater than a threshold (i.e., $\rho > \frac{2t\delta}{2\beta+\delta}$), platform B's price is even higher than that of platform A.



(a) price (b) profits

Figure 2. The impact of ρ on platforms' prices and profits

Second, when ρ increases, we find that platform B's profit always increases while platform A's profit first decreases and then increases. The reason is that while platform A's price increases with ρ, its advertiser demand decreases with ρ. We find that the price increase can compensate for the demand loss, resulting in a higher profit, only when ρ is relatively large. This result indicates that a U-shaped relationship exists between platform A's profits and the increase in consumer privacy concerns (see

Figure 2(b)). Intriguingly, when ρ is relatively low, partnering with the data broker may lead to a lower profit for platform A even though its targeting capability is improved. This result implies that, in a two-sided market, a competitive advantage on one side of the market does not necessarily lead to a higher overall performance.

4.1.3. When both platforms partner with the data broker $(Y,\ Y)$

In this subsection, we analyze the case where both platforms partner with the data broker (i.e., $\mathbb{I}_A = 1$, $\mathbb{I}_B = 1$). By solving $U_A^{YY}(x)|_{\mathbb{I}_A=1} = U_B^{YY}(x)|_{\mathbb{I}_B=1}$, $U_A^{YY}(y)|_{\mathbb{I}_A=1} = U_B^{YY}(y)|_{\mathbb{I}_B=1}$, we can derive the indifferent consumer type x^{YY*} and the indifferent advertiser type y^{YY*}: $x^{YY*} = \frac{t+\alpha+\rho-2(\alpha+\rho)y_A}{2t}$, $y^{YY*} = \frac{2(\beta+\delta)x_A-p_A+p_B+\theta-\beta-\delta}{2\theta}$. Hence, the optimal platform profits are $\max_{p_A^{YY}} \pi_A^{YY} = (1-\gamma)p_A^{YY}y^{YY*}$, $\max_{p_B^{YY}} \pi_B^{YY} = (1-\gamma)p_B^{YY}(1-y^{YY*})$. By maximizing the platforms' profit functions, we can derive the equilibrium prices and profits in the $(Y,\ Y)$ case.

Lemma 3. *When both platforms partner with the data broker, the platforms' equilibrium ad prices and profits are:* $p_A^{YY*} = p_B^{YY*} = \frac{(\alpha+\rho)(\beta+\delta)}{t} + \theta$, $\pi_A^{YY*} = \pi_B^{YY*} = \frac{1}{2}(1-\gamma)(\frac{(\alpha+\rho)(\beta+\delta)}{t} + \theta)$.

Compared to the $(N,\ N)$ case, Lemma 3 states that when both platforms partner with the data broker, the platforms' equilibrium prices are higher. This is because the partnership with the data broker increases consumer privacy concerns by ρ, which incentivizes the platform to charge a higher price. Moreover, the platforms' targeting capabilities also increase by δ, which increases the advertisers' willingness to pay a higher price. The higher price helps platforms generate higher revenue from selling ads to advertisers, but the platforms must pay a commission fee to the data broker. Therefore, it is unclear whether the platforms' net profits will be higher after partnering with the data broker.

4.2. Platforms' partnership strategies in stage 1

So far, we have analyzed the platforms' equilibrium prices and profits in each subgame. In this section, by comparing platform profits across different subgames, we examine the equilibrium outcomes of the competing platforms' partnership decisions.

Proposition 1. *In equilibrium, the platforms' partnership strategies are as follows,*

(i) *when* $0 < \rho < \rho_1$ $(0 < \delta < \delta_1)$*, the equilibrium is neither platform partnering with the data broker, i.e.,* (N, N)*;*

(ii) *when* $\rho_1 < \rho < \rho_2$ $(\delta_1 < \delta < \delta_2)$*, the equilibrium is only one platform partnering with the data broker, i.e.,* (Y, N) *or* (N, Y)*;*

(iii) *when* $\rho > \rho_2$ $(\delta > \delta_2)$*, the equilibrium is both platforms partnering with the data broker, i.e.,* (Y, Y)*;*

where the expressions of δ_1*,* δ_2*,* ρ_1*, and* ρ_2 *are presented in the Appendix.*

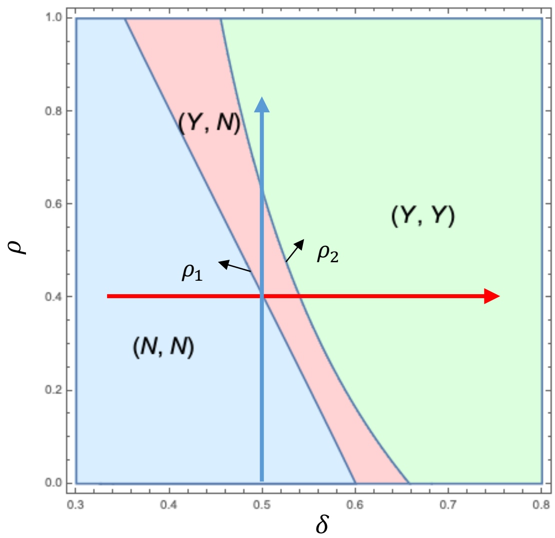


Figure 3. Platforms' equilibrium partnership strategies

The results of Proposition 1 are illustrated in Figure 3, highlighting the interactive effects of the increased privacy concerns ρ and targeting improvement δ on platforms' partnership strategies. Interestingly, platforms are more likely to partner with the data broker when the increase in consumer privacy concerns is large. As shown in Figure 3, for a given δ (e.g., $\delta = 0.5$), when ρ increases (see the vertical arrow in Figure 3), the equilibrium switches from $(N,\ N)$, to $(Y,\ N)$, to $(Y,\ Y)$. Intuitively, when partnering with the data broker leads to higher privacy concerns, we might expect platforms to forego this partnership as it would lead to a loss of consumers on the consumer side, which indirectly hurt the platform's profits on the advertiser side. However, our result shows that this intuition does not hold. The mechanism is that when the data broker triggers greater privacy concerns, consumers' negative perception towards targeted ads increases. To prevent consumer churn, platforms have incentives to compete for advertisers less aggressively, resulting in higher ad prices and higher profits. An implication of this finding is that increased privacy concerns can be a strategic tool leveraged by platforms to soften price competition on the advertiser side. Our finding echoes recent market trends observed in the industry. As consumers become increasingly concerned that targeted advertising would invade privacy, anecdotes show that publishers are trying to increase ad prices and reduce the number of ads, which has been proved to benefit the publisher's revenue (Bishop 2018; Marshall 2017).

As a result, when ρ increases from small to moderate value, one platform will start partnering with the data broker because this change can reduce price competition and improve its targeting capability. Meanwhile, the other platform still does not partner with the data broker because avoiding the partnership can help attract more consumers and thus attract more advertisers. This leads to an asymmetric partnership strategy for two symmetric platforms. Finally, when ρ becomes large, the other platform will also benefit from partnering with the data broker, which allows the platform to charge a higher price, further mitigating the price competition. Due to the effect of relaxed competition, our analysis reveals that a higher privacy concern induced by the data broker would prompt rather than hinder the platform-data broker partnership. This finding provides a possible explanation of why platform-data broker partnerships still prevail in the market despite growing consumer privacy concerns about the data broker.

When examining the equilibrium conditions in terms of δ, we find that when the targeting improvement is greater, the platforms are more likely to partner with the data broker. As shown in Figure 3 (see the horizontal arrow), for a given ρ (e.g., $\rho = 0.4$), as δ increases, the equilibrium switches from (N, N), to (Y, N), to (Y, Y). This result is in line with our expectations because the improvement in targeting capabilities increases the targeting benefits to advertisers, allowing platforms to charge a higher price. This result resonates with some case studies demonstrating that partnering with a data broker can help publisher websites increase their CMPs (cost-per-thousand impressions). For instance, a data broker called Zeotap partnered with a leading EU publisher to develop advanced audience targeting options, allowing the publisher to obtain 28% higher CPMs from advertisers[5].

Overall, our findings reveal two underlying mechanisms to explain the partnership between platforms and the data broker. First, the growing privacy concerns about the data broker industry may prompt platforms to partner with the data broker. Second, the data broker's data advantage and superior analytics capabilities, which can improve the targeting significantly, will also drive platforms to partner with the data broker.

Despite the growing popularity of the partnership between platforms and the data broker, a natural and important question is whether such a partnership increases the profit compared to the case where both platforms do not partner with the data broker. We examine this issue in the following proposition.

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[5] https://zeotap.com/resources/case-studies/eu-publisher-cpm/

Proposition 2. *When $\rho_2 < \rho < \rho_3$, both platforms partnering with the data broker is a prisoner's dilemma situation, where* $\rho_3 = \frac{\alpha(\gamma(\beta+\delta)-\delta)+t\gamma\theta}{(1-\gamma)(\beta+\delta)}$.

Proposition 2 shows that after partnering with the data broker, platforms may be worse off than if neither one partners with the data broker, leading to a prisoner's dilemma outcome. This result occurs when the increase in consumer privacy concerns is relatively high but not high enough to ease competition to a large extent (i.e., $\rho_2 < \rho < \rho_3$). When ρ is relatively high (i.e., $\rho > \rho_2$), partnership with the data broker is the dominant strategy for both platforms because the data broker can help improve the targeting capabilities, and the increase in consumer privacy concerns can ease price competition. However, as each platform partners with the data broker, the competitive advantage in the advertiser market weakens. Besides, unlike the case where platforms do not partner with the data broker, platforms must pay a commission fee to the data broker, i.e., share their advertising revenue. We show that when the increase in consumer privacy concerns is not very high (i.e., $\rho < \rho_3$), the incremental revenue due to a high price cannot offset the commission paid to the data broker. Consequently, both platforms receive a lower profit. This finding is supported by a recent field study showing that while it is prevalent for platforms to partner with a data broker, doing so can harm the platforms' profit when the third-party data cost is high (Neumann 2019).

Note that the threshold ρ_3 increases with the consumer side and advertiser side misfit cost parameters (t, θ) and the commission rate (γ). This implies that the prisoner's dilemma is more likely to happen when the competition on the consumer side or the advertiser side is less intense and when platforms need to pay a high commission fee. The intuition is that weaker competition on the consumer side intensifies the price competition on the advertiser side, and this adverse effect is more prominent when both platforms partner with the data broker. Besides this, when the advertiser side competition is less intense, the benefits of partnering with the data broker decrease. Therefore, although platforms currently are keen to partner with a data broker to improve their targeting capabilities, such a partnership may hurt them, especially when no fierce competition exists on both sides (consumer and advertiser), and the data broker has high bargaining power over the commission rate. Some industrial examples confirm the potential perils of partnering with the data broker. For instance, many publishers believe that partnering with Google Analytics 360 (Google's data service) indeed will improve their competitive advantage in targeting capabilities, but their profits may decrease because Google often charges a high fee for its data service in targeted advertising due to its dominant position (CMA 2020).

4.3. Welfare implications of the partnership between platforms and the data broker

Given that the partnership between platforms and the data broker significantly affects both the consumer side and advertiser side, another important question is how such a partnership affects consumer surplus, advertiser surplus, and social welfare. In this section, we examine this issue by comparing these welfare outcomes in the scenario where platforms do not partner with the data broker (i.e., (N, N)) with the scenario where both platforms partner with the data broker (i.e., (Y, Y)).

Proposition 3. *Compared to the scenario where platforms do not partner with the data broker, when both platforms partner with the data broker,*

(i) *consumer surplus decreases;*

(ii) *advertiser surplus increases when* ρ *is small (i.e.,* $\rho < \frac{(t-2\alpha)\delta}{2(\beta+\delta)}$*) and decreases when* ρ *is large (i.e.,* $\rho > \frac{(t-2\alpha)\delta}{2(\beta+\delta)}$*);*

(iii) *social welfare increases when* $\delta > \rho$ *and decreases when* $\delta < \rho$*.*

The results of Proposition 3 are illustrated in Figure 4. The implications are the following. First, we show that the partnership between platforms and the data broker always hurts consumer surplus. This is because such a partnership increases consumer privacy concerns. The increase in privacy concerns, such as perceived higher risks of data breaches, makes consumers bear a higher privacy cost, resulting in a lower consumer surplus. Note that in the main model, we do not consider the price on the consumer side, so the consumer surplus is not affected by platforms' pricing decisions. As we show in Section 5.1, when we incorporate a consumer-side price, the partnership between the platforms and data broker can benefit consumer surplus because the consumer price may decrease.

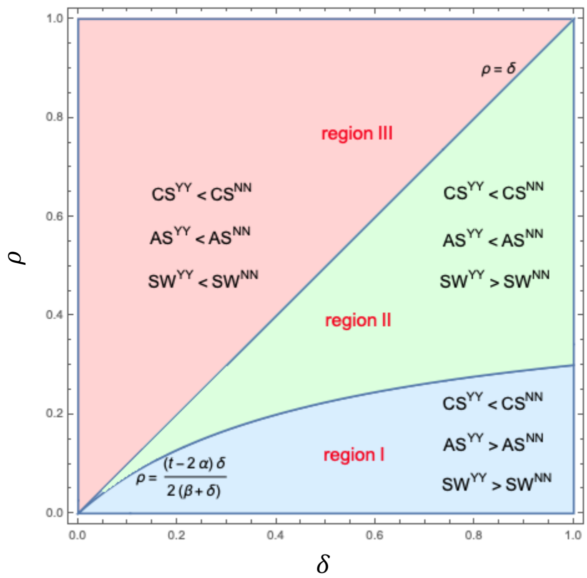

Figure 4. The welfare implications of platform-data broker partnership

Second, when the increase in consumer privacy concerns caused by the data broker is small, the partnership between platforms and the data broker benefits advertiser surplus (see region I in Figure 4). There are two opposite effects at play. On the one hand, the partnership can improve the platforms' targeting capabilities, which positively affects the advertiser surplus. On the other hand, the partnership leads platforms to charge a high price to the advertiser due to relaxed competition, which negatively affects the advertiser surplus. We show that when ρ is small, the former effect dominates, leading to a net increase in advertiser surplus. In contrast, when ρ is large, the platform charges a much higher price, which makes the latter effect dominate the former, resulting in a net decrease in advertiser surplus (see regions II and III in Figure 4).

Finally, from the whole society perspective, we find that partnerships between platforms and data brokers can improve social welfare if the targeting improvement outweighs the increase in consumer privacy concerns (see regions I and II in Figure 4). This result implies that the emerging data broker industry may not be a scourge to society if consumer privacy issues can be addressed. However, it is worth noting that in region II, the platform-data broker partnership increases social welfare, but decreases consumer surplus and advertiser surplus. In practice, policymakers can require data brokers to be more transparent about their operations, for example, to obtain consumers' consent before using their data. Overall, our finding cautions that the policymakers should scrutinize the platform-data broker partnership carefully because the platform-data broker partnership may improve social welfare at the expense of consumer surplus and advertiser surplus.

4.4. Platforms' privacy protection strategies

In the previous sections, we have examined the impact of platform-data broker partnership on platform profits and welfare outcomes. Faced with growing privacy concerns, platforms have started to take measures (e.g., restricting access, firewalls, and encryption protection) to protect the consumers' personal data and reduce their privacy concerns. Moreover, recent privacy regulations (e.g., GDPR, CCPA) also put pressure on firms to protect consumer privacy. In this subsection, we examine the platforms' motivation for privacy protection when they both establish a partnership with the data broker.

In particular, we investigate whether and when competing platforms have incentives to adopt high or low levels of privacy protection.

We assume both platforms can choose to adopt a high (H) or low (L) level of privacy protection, denoted by ϕ_i ($i \in \{H, L\}$). In total, there are four scenarios for platforms' privacy protection strategies.

Platform A / Platform B	H	L
H	(H, H)	(H, L)
L	(L, H)	(L, L)

Table 2. Platform decisions on privacy protection

When platforms adopt privacy protection, the consumer utility can be rewritten as follows:

$$U_A(x) = v_c - \kappa(1-\phi_i) - (\alpha+\rho)(1-\phi_i)y_A - tx,$$
$$U_B(x) = v_c - \kappa(1-\phi_i) - (\alpha+\rho)(1-\phi_i)y_B - t(1-x)$$

where platforms' privacy protection could reduce consumers' intrinsic privacy concern to $\kappa(1-\phi_i)$ and consumers' privacy concerns toward targeted advertising to $(\alpha+\rho)(1-\phi_i)$. The following proposition summarizes the platforms' equilibrium privacy protection strategies.

Proposition 4. *When platforms adopt privacy protection, there exists* $\rho_2^* > \rho_1^* > 0$ *such that:*

(i) when $0 < \rho < \rho_1^*$, *both platforms adopt a high level of privacy protection, i.e.,* (H, H) *is the equilibrium;*

(ii) when $\rho_1^* < \rho < \rho_2^*$, *one platform adopts a high level of privacy protection, whereas the other platform adopts a low level of privacy protection, i.e.,* (H, L) *is the equilibrium.*

(iii) when $\rho > \rho_2^*$, *both platforms adopt a low level of privacy concern, i.e.,* (L, L) *is the equilibrium.*

where the expressions of ρ_1^* *and* ρ_2^* *are presented in the Appendix.*

Figure 5 illustrates the results in Proposition 4. Contrary to the common intuition that both platforms would adopt a high privacy protection level, Proposition 4 shows that platforms may adopt a low privacy protection level. More intriguingly, symmetric platforms may adopt asymmetric privacy protection strategies. There are two forces at play when platforms adopt privacy protection. On the one hand, adopting a high privacy protection level can help platforms improve their reputation and obtain consumer trust, which reduces the consumers' intrinsic privacy concerns about the platform (i.e., lowering the intrinsic privacy cost κ). This would benefit platforms. On the other hand, adopting a high privacy protection level reduces the consumers' privacy concerns (i.e., ρ) regarding the data broker and targeted advertising, which intensifies platform competition on the advertiser side and harms the platform. As a consequence, when κ is high and ρ is low, both platforms have incentives to adopt a high level of privacy protection to reduce consumers' intrinsic privacy cost. In contrast, when κ is low and ρ is high, platforms would rather adopt a low level of privacy protection to avoid intensified competition. In practice, consumers may have different degrees of intrinsic privacy concerns for different types of data in different industries. For instance, consumers might be more sensitive regarding their healthcare and financial data than their news browsing and online shopping data. Hence, our result suggests that platforms that deal with consumers' sensitive information, such as mobile payment platforms (e.g., Alipay and WeChat Pay) and online healthcare platforms (e.g., Haodf.com and Chunyu Yisheng), should invest heavily in privacy protection, while platforms like news websites (e.g., New York Times and Forbes) could invest less.

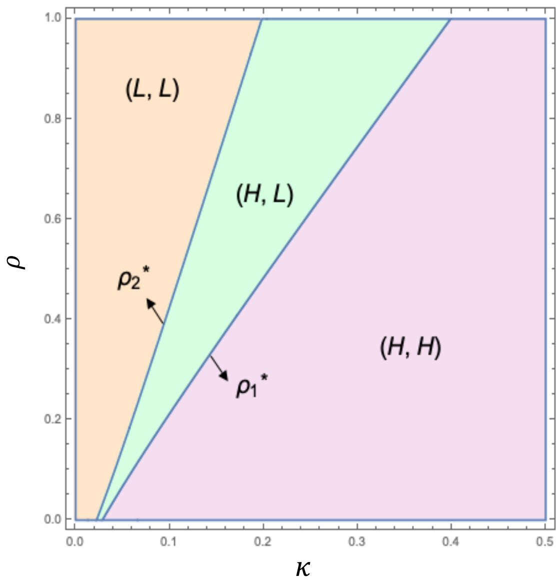

Figure 5. Platforms' Privacy Protection Strategies

Interestingly, when κ and ρ are in the middle range, platforms adopt an asymmetric privacy protection strategy, i.e., one platform (say platform A) adopts a high level of privacy protection to reduce consumers' intrinsic privacy cost, while the other platform (say platform B) adopts a low level to soften competition. In this case, adopting an asymmetric strategy can help platforms differentiate from each other. Also, if consumers' intrinsic privacy concern is not very high, adopting a low level of privacy protection will not cause much harm to platform B. Indeed, this asymmetric privacy protection strategy has been observed in real-world market practice. For example, considering social media platforms, Snapchat has adopted a higher level of privacy protection than Instagram. Specifically, Snapchat uses end-to-end encryption on photos and videos shared between its users to better protect their privacy[6]. Likewise, in the browser and email service market, Google and Microsoft adopt differentiated privacy protection strategies. Google collects consumers' data about their browsing behavior extensively and goes through the content of each Gmail to serve targeted ads, while Microsoft took steps to improve privacy features on its browser Internet Explorer (e.g., tracking protection), and has committed to not using the content of the email in Outlook for targeted ads (Gal-Or et al. 2018).

5. Extensions

In this section, we extend our main model in four ways to generalize our results and seek new insights. In Section 5.1, we consider the case where platforms also charge prices from consumers. In Section 5.2, we endogenize the data broker's commission rate and examine how this change affects the partnership between platforms and the data broker. Moreover, we study two other extensions: (i) consumer

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[6] https://www.mobileappdaily.com/snapchat-vs-instagram

multihoming and (ii) advertiser multihoming, scenarios where consumers or advertisers can join multiple platforms. Due to space considerations, we relegate the latter two extensions to Appendix A.

5.1. Platforms charge prices on the consumer side

In the main model, platforms adopt a pure ad-sponsored model, i.e., the content service is free to consumers. In this section, we extend the model to consider the scenario where platforms also charge fees on the consumer side for their content. In the real world, this corresponds to the practice of some publisher websites (e.g., New York Times, The Economist) that charge consumers a subscription price.

Letting r_A (r_B) denote the consumer prices charged by platform A (B), the consumer utility functions can be rewritten as:

$$U_A(x) = v_c - \kappa - (\alpha + \mathbb{I}_A\rho)y_A - tx - r_A,\ U_B(x) = v_c - \kappa - (\alpha + \mathbb{I}_B\rho)y_B - t(1-x) - r_B$$

Platforms now can obtain profits from both the consumer side and advertiser side, resulting in the following profit functions: (i) when platform i does not partner with the data broker, $\pi_i = r_i d_i + p_i D_i$; (ii) when platform i partners with the data broker, $\pi_i = r_i d_i + p_i D_i(1-\gamma)$, where r_i (p_i) represents the consumer (advertiser) price, and d_i (D_i) is the consumer (advertiser) demand.

Following the same procedure as in Section 4, we can derive platforms' equilibrium prices on both sides and their profits in each subgame. The detailed analytical derivation is provided in Appendix B. Below, we highlight some key insights on platforms' pricing strategies.

First, we find that the consumer price decreases with the platforms' ad targeting capabilities (β). As β increases, platforms have incentives to compete for consumers more aggressively so as to amplify the targeting value on the advertiser side, leading to a lower consumer price. This result implies that the improvement of targeting capabilities induced by the data broker can intensify price competition on the consumer side. Second, on the advertiser side, when consumer privacy concerns increase, platforms increase their ad price. The intuition is the same as the main model; that is, the increase in consumer privacy concerns incentivizes platforms to compete for advertisers less aggressively to avoid consumer churn, resulting in a higher ad price.

Therefore, when platforms adopt a mixed model of ad-sponsored and subscription-based revenue, partnering with the data broker will have different effects on the two sides. On the one hand, the targeting improvement will intensify the price competition on the consumer side, but on the other hand, the increase in consumer privacy concerns will mitigate the competition on the advertiser side. By comparing the platform profits in each subgame, we find that the equilibrium partnership strategies are qualitatively the same as the main model.

Recall that in the main model, we find that consumers are worse off, and advertisers can be better off, when platforms partner with the data broker. We reexamine the welfare implications in the following proposition to check whether these results hold when platforms charge prices from consumers.

Proposition 5. *If platforms charge prices on both sides, compared to the scenario where platforms do not partner with the data broker, both platforms partnering with the data broker increase consumer surplus when* $\delta > \frac{2\beta\gamma+\rho}{2(1-\gamma)}$.

Proposition 5 shows that when platforms charge prices from consumers, the partnership between platforms and the data broker can benefit consumers when the improvement in targeting capabilities brought by the data broker is relatively large. This result differs from the main model result. The driving force is that improvement in targeting capabilities prompts platforms to reduce prices on the consumer side. Hence, although consumers suffer a privacy loss, they can receive a monetary benefit (i.e., a lower price) as compensation. This result highlights that the impact of platform-data broker partnerships on consumers depends on the business model of the platform. The takeaway for consumers is that platform-data broker partnerships may make them better off when they pay for the platforms' content, which provides implications for consumer advocates who might consider pushing to prevent this practice. As for advertiser surplus and social welfare, we show the results are similar to those for the main model.

5.2. The data broker decides the commission rate endogenously

In our main model, we assume the data broker's commission rate (γ) is exogenously given. However, in practice, the data broker may have the market power to endogenously decide the commission rate or the price of the data sold to platforms (Bimpikis et al. 2019; Montes et al. 2018). In this section, we investigate the data broker's decisions on the commission rate and how those decisions affect the partnership between platforms and the data broker.

Corollary 2. *When the data broker sets different commission rates (γ), the platforms' equilibrium partnership strategies are: (i) when $0 < \gamma < \gamma_1$, (Y, Y) is the equilibrium; (ii) when $\gamma_1 < \gamma < \gamma_2$, ($Y$, N) or (N, Y) is the equilibrium; when $\gamma_2 < \gamma < 1$, (N, N) is the equilibrium.*

Note that the expressions of γ_1 and γ_2 are presented in Appendix B. Corollary 2 shows that when γ is low, both platforms optimally partner with the data broker, while when γ is moderate, only one platform has an incentive to partner with the data broker. When γ is very high, neither platform has incentives to partner with the data broker.

Based on Corollary 2, we can find that it is never optimal for the data broker to charge a commission rate higher than γ_2. However, it is not immediately clear whether the data broker should charge a low commission rate (i.e., γ_1) to induce more partnerships or charge a relatively high commission rate (i.e., γ_2) to partner with only one platform. We address this issue in Proposition 6.

Proposition 6. *When the data broker can endogenously determine the commission rate,*

(i) *if $0 < \rho < \rho_4$, the data broker's optimal commission rate is γ_2, resulting in only one platform partnering with the data broker;*

(ii) *if $\rho > \rho_4$, the data broker's optimal commission rate is γ_1, resulting in both platforms partnering with the data broker.*

Proposition 6 reveals that the data broker's optimal commission rate depends on the extent of increased privacy concerns. When ρ is large, relaxed competition allows platforms to obtain higher profits by partnering with the data broker. In this case, the data broker can be better off by setting a low commission rate to seek partnerships with both platforms. On the contrary, when ρ is small, the platforms' profits are not higher when the data broker partners with both platforms. Hence, it is better for the data broker to set a relatively high commission rate to partner with only one platform.

Our result contrasts with prior literature showing that it is always optimal for the data broker to sell (or share) data to only one downstream firm (Montes et al. 2018). Previous studies found that the data broker selling data to both firms *intensifies* competition, which reduces the information rent that the data broker can extract from firms, leading to the conclusion that it is always better for the data broker to sell exclusively to one firm. Our results, however, show that the data broker partnering with both platforms can *mitigate* the price competition due to negative cross-side network effects in the two-sided market, which enables the data broker to extract more profit from the platforms. By incorporating consumer privacy concerns, our study provides more nuanced insights into the interactions between the data broker and platforms. The data broker thus is advised to consider the downstream market environment when devising their data offering strategies.

6. Discussion and Conclusions

Motivated by the growing popularity of platform-data broker partnerships, this study builds a game-theoretic model to investigate the economic mechanisms that underline the partnership between platforms and data brokers in a two-sided market. Our model incorporates the impact of the data broker on both the advertiser and consumer sides. We contribute to the literature by considering partnering with the data broker as a strategic variable for competing platforms and by studying how such partnering interacts with the platforms' pricing strategies. We also examine the welfare implications of platform-data broker partnerships.

This study provides important implications for both research and practice. Our analysis reveals that the increase in consumer privacy concerns caused by the data broker may incentivize platforms to partner with the data broker rather than discouraging them. The driving force for this counterintuitive result is that when consumer privacy concerns are high, platforms compete for advertisers less aggressively to avoid consumer churn, resulting in high ad prices. This result implies that partnering with the data broker can not only improve targeting capabilities but also serve as a lever for platforms to ease price competition. Therefore, platform managers should be aware that growing privacy concerns may not always hinder platforms from working with data brokers.

Despite the growing popularity of partnerships between platforms and data brokers, we find that platforms can be in a prisoner's dilemma situation when deciding whether to partner with the data broker. This situation is likely to occur when consumer privacy concerns are not extremely high, the data broker's data analytics capability is low, and the data broker charges a high commission. In this case, each platform has an incentive to partner with the data broker, but by doing so, they are worse off than if they both commit not to partner with the data broker. This finding echoes a recent field study showing that while partnering with the data broker is the dominant strategy for platforms, their profits may suffer because of a high third-party data cost and low targeting improvement enabled by the data broker (Neumann 2019). Moreover, some industrial reports reveal that publishers indeed face a dilemma regarding the use of third-party data services. For instance, publishers realized that partnering with Google Analytics 360 (Google's data service) can improve their competitive advantage in targeting capabilities, but their profits may even decrease because Google charges a high commission rate due to its market power. Therefore, our analysis suggests that platforms that intend to partner with the data broker must carefully evaluate the commission rate charged by the data broker and the data broker's potential impact on consumer privacy concerns and targeting capabilities.

From the welfare perspective, our results provide important insights into the recent debate about the regulation of the data broker industry (Sherman 2020). Contrary to the common belief that the emerging data broker industry hurts consumer surplus due to higher privacy costs, we find that platform-data broker partnership may make consumers better off, especially when platforms adopt a mixed model of subscription-based and ad-sponsored revenue. The driving force is that partnering with the data broker will intensify the platforms' price competition on the consumer side, leading to a lower consumer price. However, when platforms adopt a pure ad-sponsored model without charging consumers, the platform-data broker partnership does hurt consumers. This finding provides implications for policymakers by pointing out that the business model adopted by platforms plays a crucial role in the welfare implications of the platform-data broker partnerships. Regarding advertiser surplus and social welfare, we find that the platform-data broker partnership can be a welfare-enhancing practice if it does not trigger strong concerns about personal privacy. Thus, policymakers should take measures to alleviate the consumers' privacy concerns about the data broker, such as making the operations of the data broker more transparent. For example, obtaining consumers' consent before using their data has been considered the first step toward regulating data brokers (Kraus 2020). Overall, our findings provide interesting and testable hypotheses for future research to empirically analyze the economic impact of platform-data broker partnerships.

This study has several limitations and thus provides opportunities for future research. First, in our model, we assume the markets on both the consumer side and advertiser side are fully covered. Future research might consider a scenario where the market may not be fully covered and examine how that change affects the platforms' partnership strategies. Second, this study considers competition between two symmetric firms. Future studies can extend the model to incorporate heterogeneities between the two platforms. For instance, on the consumer side, the platforms' intrinsic service value may differ, and on the advertiser side, platforms might have different baseline targeting capabilities. It is worthwhile to investigate how these heterogeneities affect platforms' partnership strategies. Finally, in our model, we assume that the platforms' baseline targeting capability is exogenously given. Given the growing importance of targeting technology, platforms may endogenously determine their optimal investment level in targeting technology (e.g., data analytics level). Future research could investigate the interplay between investing in targeting technology and the platforms' optimal partnership decisions.

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