International Journal of Industrial Organization xxx (2014) xxx–xxx

Contents lists available at ScienceDirect

International Journal of Industrial Organization

journal homepage: www.elsevier.com/locate/ijio

Consumer privacy in oligopolistic markets: Winners, losers, and welfare☆

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ARTICLE INFO

Available online xxxx

JEL classification:
L13
D8
L5
L15
D43

Keywords:
Privacy
Competition
Oligopoly
Consumer information

ABSTRACT

Motivated by the unprecedented availability of consumer information on the Internet, we characterize the winners and losers from potential privacy regulation in the context of four commonly-used oligopoly models: a linear city model, a circular city model, a vertical differentiation model, and a multi-unit symmetric demand model. We show that while there are winners and losers as a result of privacy enforcement, the parties who stand to benefit and the parties who stand to lose, as well as whether social welfare is enhanced or diminished, largely depends on the specific economic setting under consideration.

1. Introduction

The commercial success of the Internet has led to the proliferation of databases containing incredible amounts of consumer information. Firms, governments, data aggregators, and other interested parties can now record and analyze data about consumers at unprecedented levels of detail and speed. Nearly all US consumers now use online media to shop (BIA, 2013), and 61% of US consumers own smartphones (Deloitte, 2013). Over two thirds of online adults in the US are now registered on social networks (Pew, 2013), and 200 million individuals in North America alone have created Facebook accounts (Facebook, 2013). Coupled with the advancements in online technologies and consumers' increasing demand for them are a concomitant release of consumer information and a sharp rise in public debate about the dramatic erosion of consumer privacy.

Recent studies have focused primarily on the protection of information about a consumer's preferences or type, and the relationship between privacy and pricing. See Acquisti et al. (2014), Goldfarb and Tucker (2012), Tucker (2012), and Fudenberg and Villas-Boas (2006) for recent surveys. Fudenberg and Tirole (1998) examine the case where a firm's ability to identify consumers varies across goods. Villas-Boas (2004) and Chen and Zhang (2009) study "price for information" strategies, where firms price less aggressively in order to learn more about their customers and price discriminate in later periods. Acquisti and Varian (2005) and Conitzer et al. (2012) study models in which merchants have access to "tracking" technologies and consumers have access to "anonymizing" (or record-erasing) technologies, and show that welfare can be non-monotonic in the degree of privacy. Taylor (2004), Calzolari and Pavan (2006), and Kim and Wagman (2013) examine the exchange of consumer information among companies that are interested in discovering their reservation prices, and Burke et al. (2012) and Wagman (2014) show that even in competitive markets firms may collect excessive amounts of information about individuals.

Existing studies of the economics of privacy address several questions: Is there a demand for privacy without a taste for (or an intrinsic value of) privacy? Which consumers benefit from privacy and which consumers do not? What is the impact of consumer privacy on firms' profits and what are the overall welfare implications? The above works tackle these questions in settings where firms incur some costs in order to learn about consumer-specific characteristics; that is, costs associated with information acquisition about consumer

☆ We thank the participants at the 2013 European Association for Research in Industrial Economics (EARIE) conference in Évora, Tommaso Valletti, and two anonymous referees. Taylor is grateful for the support through NSF SES-1132187. Wagman is grateful for the support from the Yahoo! Faculty Research and Engagement Program.
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http://dx.doi.org/10.1016/j.ijindorg.2014.02.010
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preferences or types. For instance, a firm may offer introductory prices in order to induce consumers to buy and then infer information about their interests and willingness to pay — for its own products and possibly for related offerings.

In this paper, motivated by the unprecedented existing availability of consumer information, we take the alternate approach of assuming that information about consumers is already available. That is, a setting where such data has already been collected. We then re-examine the above questions in the context of oligopolistic markets, and, especially, ask: Given this unprecedented availability of consumer information, who stands to win and who stands to lose from making this information (in)accessible to firms? The answer, we show, is that it depends. To demonstrate this, we examine several work-horse oligopoly models and show that who benefits and who loses from privacy largely depends on the specific model under consideration.

In particular, we examine four fundamental models that are commonly used in the literature: (i) a linear city model (LCM), (ii) a circular city model (CCM), (iii) a vertical differentiation model (VDM), and (iv) a multi-unit symmetric demand model (MSDM). The effects of enforcing consumer privacy – in our case, by disallowing firms to tailor prices to individual consumers – are summarized in Table 1.

As indicated in Table 1, the effects of privacy are not equal across models, although the outcome is often less efficient (higher deadweight loss) with privacy, and the preference for privacy among consumers usually varies — in particular, consumers with high demand parameters for a given product tend to prefer privacy, whereas those with low demand parameters tend to prefer no privacy. Moreover, it is clear that across all four models, privacy hurts some, helps others, and does not always increase social welfare.

Our findings thus caution that studies of consumer privacy must be understood within their individual context and industries, and that their conclusions depend on the specific competitive landscapes at play — and may not necessarily apply more broadly. Furthermore, our findings demonstrate that rather than a single piece of regulation to address the decline in consumer privacy, a nuanced approach that is tailored to specific markets may be more appropriate.

The remainder of this paper is organized as follows. Sections 2 through 5 present the linear city model, the circular city model, the vertical differentiation model, and the multi-unit symmetric demand model respectively, and Section 6 concludes.

2. Linear city model

We begin by considering the celebrated linear city model (Hotelling, 1929) on the unit interval, where firm A is located at 0 and firm B at 1. Both firms' unit costs are $c > 0$, and consumers' locations (addresses), $\alpha \in [0,1]$, specify their distances from 0 and are uniformly distributed. Consumers have unit-demands with valuations v, incur transportation costs t per unit distance, and the market is assumed to be covered in equilibrium, which is ensured by $v > c + \frac{3t}{2}$.

2.1. Equilibrium with privacy

When firms have no information about consumers' types, they set uniform prices. A consumer of type α^* is indifferent between purchasing from firms A and B if and only if $v - p_A - t\alpha^* = v - p_B - t(1 - \alpha^*)$. That is, given

$$\alpha^* = \frac{1}{2} + \frac{p_B - p_A}{2t}. \quad (1)$$

Consumers located below (above) α^* purchase from A (B). Taking the marginal consumer into account, firms A and B maximize profits with their objectives specified by $max_{p_A}\pi_A = \alpha^*(p_A - c)$ and $max_{p_B}\pi_B = (1-\alpha^*)(p_B - c)$, respectively.

Proposition 1. *In equilibrium with privacy, prices satisfy $p_A^* = p_B^* = c + t$ and the marginal type is $\alpha^* = \frac{1}{2}$. Profits satisfy $\pi_A + \pi_B = t$, consumer surplus is $v - c - \frac{5t}{4}$, and the outcome is efficient. The minimum and maximum consumer utilities are $U(\frac{1}{2}) = v - c - \frac{3t}{2}$ and $U(0) = U(1) = v - c - t$, respectively.*

Proof. Substituting Eq. (1) into $max_{p_A}\pi_A = \alpha^*(p_A - c)$ and $max_{p_B}\pi_B = (1-\alpha^*)(p_B - c)$ and taking the first-order conditions yields $p_A = (c + t + p_B)/2$ and $p_B = (c + t + p_A)/2$. Solving for the equilibrium prices yields $p_A^* = p_B^* = c + t$, resulting in $\alpha^* = \frac{1}{2}$ and $\pi_A = \pi_B = \frac{t}{2}$, whereas $CS = 2\int_0^{\frac{1}{2}}[v - c - t - t\alpha]d\alpha = v - c - \frac{5t}{4}$. Since all consumers buy from the closer firm, the outcome is efficient. ■

2.2. Equilibrium without privacy

If consumer types are common knowledge and arbitrage is infeasible, then firms compete for each consumer, and prices are driven downward as follows:

	$p_A(\alpha)$	$p_B(\alpha)$
$\alpha \le 0.5$	$c + t(1-2\alpha)$	c
$\alpha \ge 0.5$	c	$c+t(2\alpha-1)$

As indicated above, the resultant prices are the cost of production plus the difference in transportation costs. We have the following result.

Proposition 2. *In equilibrium without privacy, profits satisfy $\pi_A + \pi_B = \frac{t}{2}$, consumer surplus is given by $v - c - \frac{3t}{4}$, and the outcome is efficient. The minimum and maximum consumer utilities are $U(0) = U(1) = v - c - t$ and $U(\frac{1}{2}) = v - c - \frac{t}{2}$, respectively.*

Proof. In equilibrium, $\pi_A = \pi_B = \int_0^{\frac{1}{2}} t(1-2\alpha)d\alpha = \frac{t}{4}$ and $CS = 2\int_0^{\frac{1}{2}}[v - c - t(1-\alpha)]d\alpha = v - c - \frac{3t}{4}$. Since all consumers buy from the closer firm, the outcome is efficient. ■

Notice that in comparison to the outcome with complete privacy where firms charge uniform prices, all consumers are better off with individualized pricing (consumers located at points 0 and 1 are offered the same prices under both privacy regimes and are indifferent, whereas other consumers are strictly better off without privacy). Rather than compete for the marginal consumer, firms now compete for each consumer on an individual basis. Consequently, prices decrease and some rents are transferred from firms to consumers.

3. Circular city model

Consider a circular city model (Salop, 1979; Vickrey, 1999) with unit circumference and identical firms with unit production costs $c > 0$ and

Table 1
Summary of results.

	LCM	CCM	VDM	MSDM
Total industry profits	Higher	Same	Higher	Lower
Consumer surplus	Lower	Lower	Lower	Higher
Deadweight loss	Same	Higher	Higher	Higher/lower
Consumers prefer privacy	None	Some	Some	Some

Please cite this article as: Taylor, C., Wagman, L., Consumer privacy in oligopolistic markets: Winners, losers, and welfare, Int. J. Ind. Organ. (2014), http://dx.doi.org/10.1016/j.ijindorg.2014.02.010