Privacy in oligopolistic markets with asymmetric costs

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July 31, 2019

1. Privacy in oligopolistic markets

The amount of data collected in the internet and the openness of people to disclose information makes it easier and faster for companies to assess customers' willingness to pay than ever before. If the seller can observe the appreciation of the buyer, the seller can set a custom price to skim the consumer's rent. In an oligopoly where several companies compete for the favor of consumers, much of the added value benefits customers. This paper presents the results of *Consumer Privacy in Oligopolistic Markets: Winners, Losers, and Welfare* by Taylor and Wagman (2014) and introduces the possibility that companies have different unit costs.

When consumers enjoy privacy, firms cannot set individual prices for customer, so they have to use uniform prices. Without privacy, all information are common knowledge and firms can price discriminate by setting prices according to the customers type. On the one hand more information about the customer can make it easier for the firm to skim the customer rent, but on the other hand can lead to stronger competition among firms.

In many oligopolistic markets, differences in unit costs are weakening the competitive pressure for the cost efficient companies. In a free market in which there are no state regulations on data protection for the consumer, the consequences of privacy for competition are ambivalent. On the one hand, companies could estimate the consumer's product value from the data collected and thus consumers could suffer from price discrimination. On the other hand, the public available information on the consumer's product valuation can lead to a more differentiated price adjustment of products and thus to greater competition between companies.Taylor and Wagman (2014) have shown that the listed effects are dependents on the given market setting and therefore no clear conclusions can be drawn for all markets. Taylor and Wagman (2014) have also considered a market with vertical differentiation, but lack to allow different unit costs in their model. Thus, in this paper I want to enhance their model by introducing the possibility of different unit costs to simulate a more realistic market situation.

Therefore I present in section 2 common concepts of privacy, following by section 3 in which I summarize the model of Taylor and Wagman (2014). In section 4 I extend the vertical differentiation model by asymmetric costs and in section 5 the results of the extended model are compared to the basic model.

2. Concepts of privacy

Acquisti et al. (2016) summarized the broad theoretical and empirical research on privacy and conclude that it is hard to characterize a single unifying theory on privacy and that privacy can both enhance and detract social welfare, depending on the individual context.

> ”Privacy is difficult to define. It means different things to different people. It has been described as the protection of someone’s personal space and their right to be left alone Warren and Brandeis (1890); the control over and safeguarding of personal information Westin (1968); and an aspect of dignity, autonomy, and ultimately human freedom Schoeman (1992)” (Acquisti et al., 2016).

In this paper the definition of privacy by Taylor and Wagman (2014) is adopted, which has the effect of ”disallowing firms to tailor prices to individual consumers” (Taylor and Wagman, 2014). Furthermore in this paper consumers have no choice to hide or share their type, but it is assumed that information on consumers are already collected without costs and a regulator can enforce data protection or disclosure.

Effects of legislatives such as the in 2018 introduced General Data Protection Regulation, which is an EU law on data protection and privacy on the welfare are not easy to evaluate empirically and theoretically. Both Calzolari and Pavan (2006) and Kim and Wagman (2015) showed that regulation on exchange of customer data can be harmful to consumers and welfare. It may be even in the interest of the company to self-commitment to privacy-protection policies, because it maximizes their profits Taylor (2004). Conitzer et al. (2012) consider a model where consumer can choose to hide their information for some costs, and show that both consumer surplus and welfare are highest under a medium level of privacy.

3. Taylor & Wagman 2014

Consumer Privacy in Oligopolistic Markets: Winners, Losers, and Welfare by Taylor and Wagman (2014) compare four basic oligopoly models with and without a privacy regime. Linear city model (LCM), Circular city model (CCM), Vertical differentiation model (VDM), and Multi-unit symmetric demand model (MDSM). The results are ambiguous, it strongly depends on the framework, who benefits and who losses from privacy, such that no overall conclusion over all model can be done.

A regime with privacy compared to a regime without privacy

	LCM	CCM	VDM	MSDM
Total Industry Profits	+	=	+	-
Consumer Surplus	-	-	-	+
Consumers prefer Privacy	no	some	some	some
Deadweight Loss	=	+	+	+ -

Table 1: Summary of results by Taylor and Wagman (2014)

3.1. Linear city model (LCM)

Taylor and Wagman (2014) begin with a linear city model by Hotelling (1929), where two firms A and B are located at the extremes of a unit interval 0 and 1. Consumer are uniformly distributed and the parameter $\alpha \in [0,1]$, specifies the distance of a consumer to firm A at point 0. Therefore the distance to firm B at point 1 is $1-\alpha$. Firms have unit costs c and consumers have unit-demand with valuation v and they have transportation costs of t per unit distance. Hence the utility function for a consumer at location α of buying from firm A is $U^A(\alpha) = v - p_A - t\alpha$, and from buying from firm B is $U^B(\alpha) = v - p_B - t + t\alpha$. The assumption $v > c + \frac{3t}{2}$ ensures that the market is covered in equilibrium.

3.1.1. Equilibrium with Privacy

Under privacy firms can not observe the location α of the consumers and have to set uniform prices. They maximize their profit over the marginal consumer at location $\alpha^* = \frac{1}{2} + \frac{p_B - p_A}{2t}$, and in equilibrium the marginal consumer is right in the middle of both firms at point 0.5. Both prices are the same $p_A^* = p_B^* = p^* = c + t$, and the outcome is efficient DWL = 0.

3.1.2. Equilibrium without Privacy

Without privacy firms observe the location of the consumer and are able to set individual prices for each consumer. Because firms compete for each consumer individually prices are driven downward to:

	$p_A(\alpha)$	$p_B(\alpha)$
$\alpha \leq \frac{1}{2}$	$c + t(1-2\alpha)$	c
$\alpha \geq \frac{1}{2}$	c	$c - t(1-2\alpha)$

Table 2: Prices in a LCM without privacy

3.1.3. Summary of results

Under a regime of consumer privacy, firms compete for the marginal consumer and charge uniform prices. Without consumer privacy, firms compete for each consumer individually and charge location based prices. Consumers located at 0 and 1, are able to buy from one of the firms without transportation cost and they are charges the same price with and without privacy. But with increasing transportation costs, consumer benefit more from the individual pricing, because of increased individual competition. The outcome is efficient in both regimes, because consumers buy from the closer firm either while. But because individual pricing is driving prices for consumers between both firms further down, a regime without privacy transfers rents from the firms to consumers with high travel costs. Overall privacy increases industry profits, decreases consumer surplus and there are no consumers which prefer privacy. Both with and without data protection there is no deadweight loss in a LCM.

3.2. Circular city model (CCM)

Taylor and Wagman (2014) are analyze a circular city model according to Salop (1979) and Vickrey et al. (1999), with a unit circumference and identical firms which can enter for entry costs $f > 0$ and produce for unit costs $c > 0$. Firms are located such, that they have equal distance to each other. Similar to the LCM consumers have unit demands with valuation v and bear transportation costs t per unit distance. Hence the utility function for a consumer at location $\alpha \in (0, \frac{1}{n})$ of buying from one of the closest firms i or j is $U^i(\alpha) = v - p_i - t\alpha$ and $U^j(\alpha) = v - p_j - \frac{t}{n} + t\alpha$. It is assumed that $v > c + \frac{3}{2}\sqrt{tf}$ to ensure that the market is covered in equilibrium.

3.2.1. Equilibrium with Privacy

Under privacy firms maximize their profits over the the marginal consumer $\alpha = \frac{1}{2n} + \frac{p_j - p_i}{2t}$ who is indifferent between buying from the two closest firms i and j. Twice as many firms as efficient enter the market $n = \sqrt{\frac{t}{f}}$ and firms make no profits. The symmetry of the model leads to set all firm prices which satisfy $p = c + \frac{t}{n}$. Firms enter excessively and a deadweight loss of DWL $= \frac{\sqrt{tf}}{4}$ occurs.

3.2.2. Equilibrium without Privacy

Without privacy firms compete with the two closest firms for each consumer with individualized prices, and prices are driven downwards see Table 2. The firm which is closer to

	$p_i(\alpha)$	$p_j(\alpha)$
$\alpha \leq \frac{1}{2n}$	$c + t\left(\frac{1}{n} - 2\alpha\right)$	c
$\alpha \geq \frac{1}{2n}$	c	$c - t\left(\frac{1}{n} - 2\alpha\right)$

Table 3: Prices in a CCM without privacy

the consumer charges the cost of production plus difference in transportation costs to the next firm. More firms as efficient enter the market $n = \sqrt{\frac{t}{2f}}$ and they make no profits. Firms enter excessively a deadweight loss of $\text{DWL} = \left(\frac{3}{2\sqrt{2}} - 1\right)\sqrt{tf}$ occurs.

3.2.3. Summary of results

Compared to a regime with privacy in a regime without information asymmetry less firms enter the market, and therefore the DWL $\left(\frac{3}{2\sqrt{2}} - 1\right)\sqrt{tf} < \frac{\sqrt{tf}}{4}$ is smaller. Privacy doesn't alter industry profits, because firms enter the market until they make zero profits, but decreases overall consumer surplus. Consumer with low travel costs prefer privacy, while consumers with high travel costs prefer no privacy. With data protection there is a bigger deadweight loss.

3.3. Multi-unit symmetric demand model (MDSM)

In the multi-unit symmetric demand model products of two firms sell products to consumers which are complements. The degree of complementary is measured by b, where high values are strong complements and low values are weak complements. If the the degree of complementary is low, firms act as near-monopolists and both consumer surplus and welfare is lower without privacy. But if the products are strong complements, consumer surplus is still lower without privacy, but welfare increases, because the allocation of products is getting more efficient without privacy. Overall privacy leads to decreasing total industry profits and increasing consumer surplus. If consumer prefer privacy or not depends on their demand parameters. But it depends on the degree of complementary, if the deadweight loss increases or decreases.

3.4. Vertical differentiation model (VDM)

Taylor and Wagman (2014) model which is based on (Tirole, 1988, p.96f) is presented and extended by a second dimension of asymmetry precisely different unit cost. Two firms L and H, sell products which are differentiated by their quality low q_L and high q_H, which satisfy $0 < q_L < q_H$. Both firms L and H have the same unit production cost c. The willingness to pay for quality θ is uniformly continuous distributed between $\underline{\theta}$ and $\overline{\theta}$ thus $\mathcal{U}(\underline{\theta}, \overline{\theta})$. The quality of the product q_j, the price of the product p_j and the consumer type θ determines the the utility for each consumer $U(q_j, p_j, \theta) = \theta q_j - p_j$ for $j \in [L, H]$.

3.4.1. Equilibrium with privacy

With privacy firms have to set a uniform prices, and it is not possible to price discriminate individually. The marginal consumer type θ^* who is indifferent between purchasing the high and the low quality product is $\theta^* = \frac{\overline{\theta} - \underline{\theta}}{3}$. Consumers with a valuation below (above) θ^* are buying the low (high) quality product of firm L (H). Because the marginal consumer determines the demand of firm L and H, they maximize their profits taking this into account, therefore the objective functions of the firms are $\max_{p_H} \pi_H = (\overline{\theta} - \theta^*)(p_H - c_H)$ and $\max_{p_L} \pi_L = (\theta^* - \underline{\theta})(p_L - c_L)$.

3.4.2. Equilibrium without privacy

Without privacy consumer types are common knowledge and if arbitrage is infeasible, so that firms compete for each customer individually. As a result, the following holds:

$$p_L = c, \qquad \theta \in [\underline{\theta}, \overline{\theta}] \tag{1}$$

$$p_H = c + \theta\Delta_q, \qquad \theta \in [\underline{\theta}, \overline{\theta}] \tag{2}$$

As firm L and H compete for each customer individually, the objective functions of the firms are $\max_{p_H} \pi_H =$. In equilibrium without privacy all customers buy from firm H and no deadweight loss occurs.

$$\pi_L = 0 \tag{3}$$

$$\pi_H = \frac{1}{2}(\overline{\theta}^2 - \underline{\theta}^2)\Delta_q \tag{4}$$

$$CS = (\overline{\theta} - \underline{\theta})(\frac{1}{2}q_L(\overline{\theta} + \underline{\theta}) - c) \tag{5}$$

3.4.3. Summary of results

The outcome is efficient without privacy, but there is deadweight loss with privacy. Consumer with high valuation of quality $\theta > \frac{2\overline{\theta}-\underline{\theta}}{3}$ prefer privacy, while the consumers with low valuation $\theta < \frac{2\overline{\theta}-\underline{\theta}}{3}$ do not. Overall profits increase and consumer surplus decreases under privacy. Firm H is able to monopolize the market with individual pricing under no privacy, but cannot get monopoly profits, because of the potential entry of firm L.

> **Corollary 1.** *"Under vertical differentiation, consumers with types $\theta > \frac{2\overline{\theta}-\underline{\theta}}{3}$ prefer the privacy regime, and those with types $\theta < \frac{2\overline{\theta}-\underline{\theta}}{3}$ prefer no privacy. Overall profits decrease whereas consumer surplus increases under no privacy."(Taylor and Wagman, 2014)*

4. Vertical differentiation model with asymmetric cost (VDMAC)

The framework of the model follows the vertical differentiation model presented in section 3.4, but the unit production costs are not the same for firm L and H. Lets assume that it might be more costly to produce high quality q_H than low quality q_L, such that $0 < c_L \leq c_H$. This assumption is plausible, because high quality products usually need better materials and/or more working hours, than low quality products. For example the production of a Rolls Royce is more costly than a production of a Mercedes, because they use more expensive wood and it takes more time to build the the high quality interior. Notice that the model presented in section 3.4 is the special case of $c_L = c_H = c$, but one can analyze the effect of increasing or decreasing costs difference $\Delta_c = c_H - c_L$.

4.1. Equilibrium with privacy

Under the privacy regime firms have no information about consumers' types hence they set uniform prices. The marginal consumer type θ^* is indifferent between purchasing product L and H if and only if $\theta^* q_H - p_H = \theta^* q_L - p_L$. That is at

$$\theta^* = \frac{p_H - p_L}{q_H - q_L} \tag{6}$$

Consumer with with willingness to pay below (above) θ^* purchase product L (H). Firms L and H maximize profits taking the marginal consumer into account.

$$\max_{p_H} \pi_H = (\overline{\theta} - \theta^*)(p_H - c_H) \tag{7}$$

$$\max_{p_L} \pi_L = (\theta^* - \underline{\theta})(p_L - c_L) \tag{8}$$

Proposition 1. *In equilibrium with privacy, prices are given by* $p_L^* = \frac{(\overline{\theta} - 2\underline{\theta})\Delta_q}{3} + c_L + \frac{\Delta_c}{3}$ *and* $p_H^* = \frac{(2\overline{\theta} - \underline{\theta})\Delta_q}{3} + c_H - \frac{\Delta_c}{3}$*, and the marginal type is* $\theta^* = \frac{\overline{\theta} + \underline{\theta}}{3} + \frac{\Delta_c}{3\Delta_q}$*. The minimum and maximum consumer utilities are* $U(q_L, p_L; \underline{\theta}) = \underline{\theta} q_L - \frac{(\overline{\theta} - 2\underline{\theta})\Delta_q}{3} - c_L - \frac{\Delta_c}{3}$ *and* $U(q_H, p_H; \overline{\theta}) = \overline{\theta} q_H - \frac{(2\overline{\theta} - \underline{\theta})\Delta_q}{3} - c_H + \frac{\Delta_c}{3}$*. Profits satisfy* $\pi_H = \frac{\Delta_q}{9}(2\overline{\theta} - \underline{\theta} - \frac{\Delta_c}{\Delta_q})^2$*, and* $\pi_L = \frac{\Delta_q}{9}(\overline{\theta} - 2\underline{\theta} + \frac{\Delta_c}{\Delta_q})^2$*. The outcome is inefficient, with deadweight loss* $(\overline{\theta}^2 + 2\overline{\theta}\underline{\theta} - 8\underline{\theta}^2)\frac{\Delta_q}{18} + \frac{\Delta_c}{18}(2(\overline{\theta} + \underline{\theta}) + \frac{\Delta_c}{\Delta_q})$ *.*

Proof of proposition 1: Substituting (6) into (7) and (8) and taking the first order condition yields $p_H = (p_L + c_H + \overline{\theta}\Delta_q)/2$ and $p_L = (p_H + c_L - \underline{\theta}\Delta_q)/2$. Solving for the equilibrium prices yields $p_L^* = \frac{(\overline{\theta} - 2\underline{\theta})\Delta_q}{3} + c_L + \frac{\Delta_c}{3}$ and $p_H^* = \frac{(2\overline{\theta} - \underline{\theta})\Delta_q}{3} + c_H - \frac{\Delta_c}{3}$, resulting in $\theta^* = \frac{\overline{\theta} + \underline{\theta}}{3} + \frac{\Delta_c}{3\Delta_q}$, $\pi_H = \frac{\Delta_q}{9}\left(2\overline{\theta} - \underline{\theta} - \frac{\Delta_c}{\Delta_q}\right)^2$, and $\pi_L = \frac{\Delta_q}{9}\left(\overline{\theta} - 2\underline{\theta} + \frac{\Delta_c}{\Delta_q}\right)^2$. If $2\overline{\theta} - \underline{\theta} < \frac{\Delta_c}{\Delta_q}$, all consumers buy product L and the outcome efficient. Otherwise more consumer than efficient $2\theta^{**} = \frac{\Delta_c}{\Delta_q} < \theta^* = \frac{\overline{\theta} + \underline{\theta}}{3} + \frac{\Delta_c}{3\Delta_q}$buy product L and the outcome is inefficient, with deadweight loss DWL $= \int_{\underline{\theta}}^{\theta^*} \Delta_q \theta - \Delta_c \, d\theta = (\overline{\theta}^2 + 2\overline{\theta}\underline{\theta} - 8\underline{\theta}^2)\frac{\Delta_q}{18} + \frac{\Delta_c}{18}(14\underline{\theta} - 4\overline{\theta} - \frac{5\Delta_c}{\Delta_q})$.

With asymmetric costs less consumers buy the high quality product. The costs of producing a high quality product are not fully passed trough to the consumer as with symmetric costs, but consumers of the low quality product have to pay more, because the costs difference raise the hurdle to switch to the high quality product.

4.2. Equilibrium without privacy

Without privacy consumer types are common knowledge and if arbitrage is infeasible, firms compete for each customer individually.

$c_H - c_L = \Delta_c$ and $q_H - q_L \Delta_q$ In equilibrium the indifferent consumer has valuation

$$\theta^* = \frac{\Delta_c}{\Delta_q} \tag{9}$$

. Consumer with valuation bigger than θ^* buy the high quality product, and consumer with valuation below θ^* buy the low quality product. If the smallest(biggest) valuation $\underline{\theta}$ ($\overline{\theta}$) of the quality difference Δ_q is bigger(smaller) than the cost difference Δ_c, firm H(L) is able to monopolize the market.

If there are valuations of the quality difference above and below the cost difference Δ_c, the firm L and H cannot monopolize the market but both firms sell to some consumers.

$$\theta = \begin{cases} \Delta_c < \underline{\theta}\Delta_q & \text{Firm H monopolizes the market} \\ \underline{\theta}\Delta_q < \Delta_c < \overline{\theta}\Delta_q & \text{Oligopolistic market} \\ \overline{\theta}\Delta_q < \Delta_c & \text{Firm L monopolizes the market} \end{cases} \tag{10}$$

As a result, if the cost difference is not to high $\Delta_c < \underline{\theta}\Delta_q$ firm H monopolizes the market. There is a corridor where the cost structure is such, that both firms are able to sell to some consumers. If $\overline{\theta} > \frac{\Delta_c}{\Delta_q} > \underline{\theta}$, there is a oligopolistic market and Firm L has a market share of $\frac{\Delta_c}{\Delta_q} - \underline{\theta}$ and firm H has a market share of $\overline{\theta} - \frac{\Delta_c}{\Delta_q}$. But if the cost difference is to high $\Delta_c > \overline{\theta}\Delta_q$ firm L monopolizes the market. Taking the point of indifference of consumer type θ into account, prices are driven downwards, which results in All customers buy the

	$p_H(\theta)$	$p_L(\theta)$
$\theta \geq \frac{\Delta_c}{\Delta_q}$	$c_L + \theta\Delta_q$	c_L
$\theta \leq \frac{\Delta_c}{\Delta_q}$	c_H	$c_H - \theta\Delta_q$

Table 4: Prices in a VDM without privacy

product which is more efficient to produce according to their valuation for quality and no deadweight loss occurs.

Proposition 2. *In equilibrium without privacy, profits satisfy* $\pi_L = \frac{\Delta_q}{2}\left(\frac{\Delta_c}{\Delta_q} - \underline{\theta}\right)^2 | \theta > \frac{\Delta_c}{\Delta_q}$ *and* $\pi_H = \frac{\Delta_q}{2}\left(\overline{\theta} - \frac{\Delta_c}{\Delta_q}\right)^2 | \theta < \frac{\Delta_c}{\Delta_q}$ *and the outcome is efficient. The minimum and maximum consumer utilities are given by* $U(q_H, p_H(\underline{\theta}); \underline{\theta}) = \underline{\theta} q_L - c_L$ *for* $\underline{\theta} > \frac{\Delta_c}{\Delta_q}$ *and* $U(q_L, p_L(\underline{\theta}); \underline{\theta}) = \underline{\theta} q_h - c_H$ *for* $\underline{\theta} < \frac{\Delta_c}{\Delta_q}$*, and* $U(q_H, p_H(\theta); \overline{\theta}) = \overline{\theta} q_L - c_L$ *for* $\overline{\theta} > \frac{\Delta_c}{\Delta_q}$ *and* $U(q_L, p_L(\overline{\theta}); \overline{\theta}) = \overline{\theta} q_h - c_H$ *for* $\overline{\theta} < \frac{\Delta_c}{\Delta_q}$ *respectively.*

Proof of proposition 2: Given firms' pricing strategies as specified in **??** and **??** , we have $\pi_L = \int_{\underline{\theta}}^{\overline{\theta}} c_H - \theta\Delta_q - c_L \, d\theta = (\overline{\theta} - \underline{\theta})\Delta_c - (\overline{\theta}^2 - \underline{\theta}^2)\frac{\Delta_q}{2}$ for $\overline{\theta} < \frac{\Delta_c}{\Delta_q}$, $\pi_L = \int_{\underline{\theta}}^{\theta^*} c_H - \theta\Delta_q - c_L \, d\theta = \frac{\Delta_q}{2}\left(\frac{\Delta_c}{\Delta_q} - \underline{\theta}\right)^2$ for $\underline{\theta} < \frac{\Delta_c}{\Delta_q} < \overline{\theta}$, and $\pi_L = 0$ for $\frac{\Delta_c}{\Delta_q} < \underline{\theta}$. $\pi_H = 0$ for $\overline{\theta} < \frac{\Delta_c}{\Delta_q}$, $\pi_H = \int_{\theta^*}^{\overline{\theta}} c_L + \theta\Delta_q - c_H \, d\theta = \frac{\Delta_q}{2}\left(\overline{\theta} - \frac{\Delta_c}{\Delta_q}\right)^2$ for $\underline{\theta} < \frac{\Delta_c}{\Delta_q} < \overline{\theta}$, and $\pi_H = \int_{\underline{\theta}}^{\overline{\theta}} c_L + \theta\Delta_q - c_H \, d\theta = (\overline{\theta}^2 - \underline{\theta}^2)\frac{\Delta_q}{2} - (\overline{\theta} - \underline{\theta})\Delta_c$ for $\frac{\Delta_c}{\Delta_q} < \underline{\theta}$.

Consumer surplus, depends on the market shares of the firms and are:
$CS = \int_{\underline{\theta}}^{\overline{\theta}} \theta q_H - p_H(\theta)\ d\theta = \int_{\underline{\theta}}^{\overline{\theta}} \theta q_L - c_L\ d\theta = (\overline{\theta}^2 - \underline{\theta}^2)\frac{q_L}{2} - (\overline{\theta} - \underline{\theta})c_L$ for $\frac{\Delta_c}{\Delta_q} < \underline{\theta}$,
$CS = \int_{\underline{\theta}}^{\theta^*} \theta q_H - c_H\ d\theta + \int_{\theta^*}^{\overline{\theta}} \theta q_L - c_L\ d\theta = \overline{\theta}^2 \frac{q_L}{2} - \underline{\theta}^2 \frac{q_H}{2} + \underline{\theta} c_H - \overline{\theta} c_L - \frac{\Delta_c^2}{2\Delta_q}$ for $\underline{\theta} < \frac{\Delta_c}{\Delta_q} < \overline{\theta}$,
$CS = \int_{\underline{\theta}}^{\overline{\theta}} \theta q_L - p_L(\theta)\ d\theta = \int_{\underline{\theta}}^{\overline{\theta}} \theta q_H - c_H\ d\theta = (\overline{\theta}^2 - \underline{\theta}^2)\frac{q_H}{2} - (\overline{\theta} - \underline{\theta})c_H$ for $\overline{\theta} < \frac{\Delta_c}{\Delta_q}$.

4.3. Summary of results

Corollary 2. *Under vertical differentiation, consumers with types* $\theta > \frac{\overline{\theta}+\underline{\theta}}{3} + \frac{\Delta_c}{3\Delta_q}$ *prefer the privacy regime, and those with types* $\theta < \frac{\overline{\theta}+\underline{\theta}}{3} + \frac{\Delta_c}{3\Delta_q}$ *prefer no privacy. Overall profits decrease whereas consumer surplus increases under no privacy.*

The outcome is efficient without privacy, but there is deadweight loss with privacy, which increases in cost difference and decreases in quality difference. Consumer with high valuation of quality $\theta > \frac{\overline{\theta}+\underline{\theta}}{3} + \frac{\Delta_c}{3\Delta_q}$ prefer privacy, while the consumer with low valuation do not. If cost difference increases less consumers prefer privacy. If quality difference increases more consumers prefer privacy. For $\overline{\theta} < \frac{\Delta_c}{\Delta_q}$ and $\frac{\Delta_c}{\Delta_q} < \underline{\theta}$ firms are able to monopolize the market with individualized pricing under no privacy, but cannot get monopoly profits, because of the potential entry of firm L. Differences in production costs shift the rent from firm H to the consumers, and from the consumers to the to firm L.

5. Results

	With privacy		Without privacy	
	Same unit costs	Different unit costs	Same unit costs	Different unit costs
p_H	$\frac{(2\overline{\theta}-\underline{\theta})\Delta_q}{3} + c$	$\frac{(2\overline{\theta}-\underline{\theta})\Delta_q}{3} + c_H - \frac{\Delta_c}{3}$	$c + \theta\Delta_q$	$c_L + \theta\Delta_q \vert \theta > \frac{\Delta_c}{\Delta_q}$
p_L	$\frac{(\overline{\theta}-2\underline{\theta})\Delta_q}{3} + c$	$\frac{(\overline{\theta}-2\underline{\theta})\Delta_q}{3} + c_L + \frac{\Delta_c}{3}$	c	$c_H - \theta\Delta_q \vert \theta < \frac{\Delta_c}{\Delta_q}$
θ^*	$\frac{\overline{\theta}-\underline{\theta}}{3}$	$\frac{\overline{\theta}-\underline{\theta}}{3} + \frac{\Delta_c}{3\Delta_q}$	0	$\frac{\Delta_c}{\Delta_q}$
DWL	$\frac{(\overline{\theta}-2\underline{\theta})(\overline{\theta}+4\underline{\theta})}{18}\Delta_q$	$\frac{(\overline{\theta}^2+2\overline{\theta}\underline{\theta}-8\underline{\theta}^2)}{18}\Delta_q + \frac{(2(\overline{\theta}+\underline{\theta})+\frac{\Delta_c}{\Delta_q})}{18}\Delta_c$	0	0
U^H	$\theta q_H - \frac{(2\overline{\theta}-\underline{\theta})}{3}\Delta_q - c$	$\theta q_H - \frac{(2\overline{\theta}-\underline{\theta})}{3}\Delta_q - c_H + \frac{\Delta_c}{3}$	$\theta q_L - c$	$\theta q_L - c_L \vert \theta > \frac{\Delta_c}{\Delta_q}$
U^L	$\theta q_L - \frac{(\overline{\theta}-2\underline{\theta})}{3}\Delta_q - c$	$\theta q_L - \frac{(\overline{\theta}-2\underline{\theta})}{3}\Delta_q - c_L - \frac{\Delta_c}{3}$	$\theta q_L - c$	$\theta q_H - c_H \vert \theta < \frac{\Delta_c}{\Delta_q}$
π_H	$\frac{\Delta_q}{9}\left(2\overline{\theta} - \underline{\theta}\right)^2$	$\frac{\Delta_q}{9}\left(2\overline{\theta} - \underline{\theta} - \frac{\Delta_c}{\Delta_q}\right)^2$	$\frac{\Delta_q}{2}\left(\overline{\theta}^2 - \underline{\theta}^2\right)$	$\frac{\Delta_q}{2}(\overline{\theta} - \frac{\Delta_c}{\Delta_q})^2 \vert \theta < \frac{\Delta_c}{\Delta_q}$
π_L	$\frac{\Delta_q}{9}\left(\overline{\theta} - 2\underline{\theta}\right)^2$	$\frac{\Delta_q}{9}\left(\overline{\theta} - 2\underline{\theta} + \frac{\Delta_c}{\Delta_q}\right)^2$	0	$\frac{\Delta_q}{2}(\frac{\Delta_c}{\Delta_q} - \underline{\theta})^2 \vert \theta > \frac{\Delta_c}{\Delta_q}$

Table 5: VDM vs. VDMAC

In a vertical differentiation model with asymmetric costs, the equilibrium is efficient without privacy. Consumers with high valuation prefer high costs differences, while consumers with low valuation prefer low cost differences. The high quality firms loses profits with increasing costs difference, while the low quality firm gains profits with increasing costs difference. This is because, the high quality firm is losing market share and has to lower his price, if the low quality firm lowers her price. Less consumer are buying the high quality product, buy the consumers who buy the high quality product get a bigger utility. From the perspective of the low quality firm, a increasing costs difference is beneficial, because the high quality firm bears higher costs, they have to give up some of their market share, and the low quality firm can rise their prices.

In the VDMAC a regime without privacy remains efficient. Increasing costs differences makes the DWL under privacy bigger, and therefor a regime without privacy more favorable. Asymmetric unit costs of production make is feasible for the low quality firm to produce without privacy, if the cost advantage is high enough. Without privacy asymmetric information are abolished and the allocation of goods are more efficients, therefore the deadweight loss decreases. The model could be further extended by a opt in or opt out privacy, where the consumers and not a regulator choose if they want to share information. This might be realistic, because in some of the model, not all consumers lose or gain utility by a privacy regime, so the loser would be willing to share their information. The DSGVO is similar to this, because consumers have the possibility to opt out, but consumers who expect to get lower prices are willing to share their type.

6. Conclusion

This paper shows, that differences in unit costs in a vertical differentiation model makes privacy even less efficient, and the deadweigh loss increases. Some consumer prefer privacy, while others do not. Differences in cost has no effect on efficiency under no privacy but increases the deadweight loss under privacy. But because the intrinsic value of privacy was neglected, this results can not be used outside this specific model. Moreover it is more realistic that consumers can decide to some degree if they want to share their information or not. It might be plausible that firms do not use or share the information they have collected on the consumers, if they expect lower profits without privacy.

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